TOLANI MARITIME INSTITUTE

and

Institute of Marine Engineers (India) Student Chapter, TMI , Pune

In association with

Institute of Marine Engineers (India), Pune Branch

and

The Institution of Engineers (India), Pune Local Centre

proudly presents All India Seminar

TRANSTECH'24

6 to 8 March 2024

A common platform for engineering student to present technical papers on

THEME

Revolutionizing Shipping: Trends, Technologies, and Sustainable Development.

SUB THEMES

- Human Factors and Crew Welfare
- Sustainable Coastal and Port Infrastructure
- Supply Chain Resilience and Global Trade
- Smart Shipping and Digtal Transformation
- Emerging Technologies in Maritime safety
- Green Shipping and Enviromental Sustainabilty
- Port optimization and Logistics Innovation
- Maritime Cybersecurity and Risk Management

BOOK OF PROCEEDINGS

TOLANI MARITIME INSTITUTE Estd. 1998

25 Years of Excellence

INSTITUTION'S INNOVATION COUNCIL (Ministry of Education Initiative)

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"Revolutionizing Shipping: Trends, Technologies and Sustainable Development" is the theme of Transtech' 24.

Evolution is a must. Decades ago it was reasonably easy to keep up with the pace of evolution; however today to do so, is overwhelming and yet one must so as to remain relevant. Revolutions are taking place in all walks of life and hence the shipping industry must also stay ahead. In most areas of our industry with some amount of planning one can adapt to the new order. Challenges are faced with relatively inelastic and capex heavy assets – our ships. We look forward to the presentations at this year's Transtech to give us deeper insights to our times ahead.

India is on the forefront on many accounts. In what ways can we as a nation contribute to these global changes? We hope, that the outcome of such discussions at Transtech can be looked at by the doyens in our industry to take any ideas forward.

Today as a result of modernization the turnaround time at ports is quicker; time spent on board is shorter and a lot of the time spent on board needs to be devoted to the regulatory details. The need of the hour is to have seafarers ready to hit the "sea" from the moment they set foot onboard any vessel. It is very true that the "eyes do not see what the mind does not know". We at Tolani Maritime Institute look forward to inputs from Transtech that will give us additional road maps to meet the challenges of delivering seafarers who are "ship ready".

Congratulations to all the authors, model developers of this competition and as always a special thanks to our guest speakers who contribute invaluably to the success of our seminar.

My sincere appreciation to the team who painstakingly continue to make this event possible, for the greater purpose of keeping alive our quest for knowledge and continued professional development.

Dr. Sujata Naik
Chairperson
Governing Council
Tolani Maritime Institute, Pune

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MESSAGE

The entourage of landmark events concluding in the 17th edition of Transtech is very exciting. This academic year was filled with activities for students and faculty exploring and exhibiting talents latent in them in their participation at Silver Jubilee Year and Centennial Year of our Founder Dr.N.P. Tolani, functions of TMI. There was a lot of learning too. Our students as always showed the zeal and enthusiasm and managed our programs exceedingly harmoniously much to the appreciation of the guests. Transtech'24 is being administered and managed by the students again, and I am sure it will sail through smoothly.

Our Prime Minister Mr. Narendra Modi launched Viksit Bharat @2047: "Voice of Youth" on the 11th of December 2023.

He said that in the life of any nation, history provides a time period when the nation can make exponential strides in its development journey. For India, "This Amrit Kaal is ongoing" and "this is the period in the history of India when the country is going to take a quantum leap". He gave examples of many nearby countries that took such a quantum jump in a set timeframe and turned into developed nations. "For India, this is the time, right time (Yahi Samay hai, Sahi Samay hai)", he said, adding that each and every moment of this Amrit Kaal should be utilized.

The young generation needs to take up these challenges and work on them to bring about worthwhile changes. Forums like Transtech and similar endeavors by academic institutes need to address this on priority to bring about the desired changes for our Bharat.

Transtech, over the last decade, has dealt with innovative topics and brought many students from different academic institutions across the country to come together and share their ideas. These ideas have evolved in technical paper presentations, demonstrating models and interaction with experts from the industry.

The rock-steady support from the two prestigious professional bodies, namely The Institution of Engineers (India), Pune Local Centre and The Institute of Marine Engineers (India) Pune Branch, is praiseworthy and multiplies the importance of the event.

I take this opportunity to extend my best wishes to Dr. Dhiren Dave and his organizing team for successfully organizing Transtech '24.

Let us come together, think together and grow together!

Dr. Sanjeet Kanungo

Principal

The Institution of Engineers (India)

(Established: 1920 - IncorporatedbyRoyalCharter:1935)

"A Century of Service to the Nation"

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IEI-PLC Chairman's Message

It is a matter of immense pleasure to note that Tolani Maritime Institute, Induri in association with The Institution of Engineers (India), Pune Local Centre and The Institute of Marine Engineers (India), Pune Branch is organizing Annual Seminar for Students **"TRANSTECH'24"** on the **Theme "Revolutionizing Shipping: Trends, Technologies, and Sustainable Development"** during March 6 to 8 March, 2024. The theme of the seminar is very appropriate. Transtech presents a common platform for engineering students to present technical papers on varied topics of interest. It encourages the young generation of engineers to delve into numerous activities such as paper presentation and research work, thereby empowering them with a razor-sharp thinking ability.

Transtech aims at providing an apt forum for such laudable pupils to bring out the best in them, thus leading them towards reaching the top echelons of any industry.Shipping already has been experiencing the application of new technology by adapting Industry 5.0 revolution. Digitization is no exception in the world shipping. Automation, Artificial Intelligence (AI), Machine Learning (ML), use of robots and unmanned systems in the operations are the immediate future in shipping world. As a result, people are getting tuned to the concept of technology driven, environmentally friendly, challenging and Clean ecosystem-based shipping.

I am sure and confident that during the seminar numerous emerging technologies will be discussed which will be helpful in creating tangible understanding so as to achieve Efficient and Effective Shipping. I wish the Seminar a grand success and extend my greetings to all concerned.

With Best Wishes

Er. Vasant Pandarkar
Chairman IEI-PLC

Shri Sanjeev.D.Ogale
Chairman Pune Branch
The Institute of Marine Engineers (India)
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MESSAGE

It is indeed a matter of great pride that **Tolani Maritime Institute** in the 26th Year is consistently working in association with “The Institute of Marine Engineers (India) Pune Branch” and “The Institution of Engineers (India), Pune Local Centre” are hosting “**Transtech 2024**” as a part of its Annual Event.

Transtech 2024 this year’s theme focuses on the “Revolutionizing Shipping: Trends, Technologies, and Sustainable Development”. Revolutionizing the Research in GHG and Innovative technologies in shipping include simulated training, drones and 5G. The Future of shipping industry is automated vessels and efficient ports. This Theme will further encourage the students to do research work and empowering them with thinking ability. This will also help the students to exchange ideas, and latest technical developments in various disciplines.

Transtech 2024 is now elevated to an International Conference/Seminar which will provide a common platform for engineering students to present technical papers.

The Institute of Marine Engineers (India), established in 1980 is the professional body of marine engineers in the country. It aims to promote the scientific development of Marine Engineering with exchange of ideas and co-operates with all Marine Training Institutions for the furtherance of education in Marine Engineering.

I am confident the theme will give the students the right direction in his or her pursuit of making Sustainable Development the Key to Success.

I wish the seminar a grand success and my greetings and compliments to all the organizing team.

Sanjeev Ogale
Chairman Pune Branch
The Institute of Marine Engineers (India)

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Use Of Digital Twins In Merchant Ships

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ABSTRACT:

Digital Twin is a concept which has become relevant within industries. It is a virtual representation of a real-world product or process. Which is linked with a database with the help of IoT, machine learning, etc. Simply it is a cyber-physical system that gives an automated connection between a physical entity and the digital version of that exact product. This paper focuses on the application of digital twins in merchant ships and how it can be beneficial for the deck and engine side, as well as the current research and updations on the digital twins' application in this field.

KEYWORDS:

Digital twin, Internet of things, Ships, Information Technology (IT), Operational Technology (OT)

1.INTRODUCTION

Technology is advancing rapidly in our world, and people are always looking for new and creative ways to carry out industrial jobs or services effectively and efficiently. With the development of cloud computing, the Internet of Things (IoT), big data analytics, virtual reality (VR), augmented reality (AR), and artificial intelligence (AI) with machine learning among other technologies, the world has become increasingly digitalized. As a result, the Cyber-Physical System (CPS), regarded as the pinnacle of the manufacturing and consumer services industries, was developed. It is an automated system that connects the real world with sophisticated networking technologies and computing structures. 5G and Tactile Internet technologies offer reliability and less delay, tactile internet ("Tactile Internet" typically refers to an advanced generation of the Internet that enables extremely low-latency communication. It aims to provide almost instantaneous interaction between humans, machines, and the virtual world. Achieving this involves technologies like 5G or beyond, edge computing, and high-speed data processing) have improved input and communication amongst vessel across oceans. The introduction of Digital Twin (DT) as a logical means of connecting the two domains was intended to produce a fusion between cyberspace and physical space. In a short amount of time, the idea of DT has evolved into a practical application, and several disciplines are outperforming the forecasts and assumptions made when the idea was first conceptualized.

NASA pioneered the idea of a "Twin" with the "Apollo" program, which employed two identically constructed satellites for its missions [1]. The mission scientists would be able to assess the launched vehicle's circumstances by comparing them to those of the ground twin if one physical twin underwent the actual space flight and the other stayed in a laboratory in a controlled environment. With the least amount of data transfer between the two vehicles, the same assisted them in parameter monitoring and fault analysis.

On board marine vessels, DT is already being implemented. The maritime industry has been making technological advancements with the goal of enhancing operating systems' ergonomics, pollution controls, and efficiency. Since digitalization is so effective, efficient, and performs very well, it has also emerged as a major innovation trend in the maritime industry. More tools for designing, performance evaluation, modelling, and information security are being added daily and are getting better, which helps create stronger models. The digitalization of the maritime industry can be accomplished in two ways [2]

• *From a service-driven perspective:* Building is done in accordance with the requirements of the ship owners for operation and decision-making. On board marine vessels, DT is already being implemented. The maritime industry has been making technological advancements with the goal of enhancing operating systems ergonomics, pollution controls, and efficiency. Every operation in the marine industry is carried out in the implementation of hardware and software that is appropriate for the ship, and digitalization has emerged as a major inventive trend. It functions in the required space, wherein advancements at the tactical level are given more weight.

. • *Sensor-driven Perspective*: When designing a digitalized framework to support a ship's operations, it considers the inputs that are now accessible from the sensors that are already mounted on that ship. The solution-space, which serves as the main entry point for DT-based systems in the future, is how this approach functions.

By using a service-driven approach, the marine sector will be able to benefit fully from digitalization, beginning with the vessel's design phase. Nonetheless, by using the second method, platforms already in use can be enhanced to match the current smart functionalities. According to Industry 4.0(Industry 4.0, often referred to as the Fourth Industrial Revolution, is a transformation in manufacturing and industry characterized by the integration of digital technologies. It involves the use of smart technologies like IoT (Internet of Things), artificial intelligence, big data, and automation to create a more connected and efficient industrial environment. This revolution aims to enhance productivity, optimize processes, and enable better decision-making in manufacturing and related sectors.), digitalization is also seen as an efficient, creative, and optimized way to enable goods and services. Asset-intensive sectors, like shipping, oil, gas, energy, etc., are always on the lookout for innovations that will boost productivity and cut costs while skilfully handling security and operational concerns. Key components including the automation/control system, power system, and navigation system are going completely digital, making the outdated analogue technologies obsolete. Ship's Integrated Platform Management Systems (IPMS) can connect all of the aforementioned system architectures into a centralized topology, making operations more ergonomic and raising stakeholder awareness across the board.

The goal and inspiration of rational exploitation of marine resources and environmental conservation have been achieved through discussion of the current state, problems, and prospects of DT use in the marine industry. This is in line with the trend of the marine economy's rapid expansion. This thorough analysis offers a fresh viewpoint on the condition of DT today and its uses in a number of industries, such as the marine fishing sector, offshore oil and gas industry (OOGI), shipbuilding industry (SBI), and marine emerging energy business. An in-depth discussion of the difficulties and opportunities associated with applying DT to the marine sector is a useful resource for encouraging the wise development and sustainable utilisation of marine resources.

2.WHAT IS DIGITAL TWIN?

A digital twin is the virtual replica of a product, system, or any commodity which is used to increase an object's life span and initiate smooth operations. The digital twin makes use of the data which is retrieved from IoT sensors to determine the behavior and operations. It also benefits to monitor the performance of components that will be a part of a machine or as a whole. Currently, many other features of digital twins include the ability to predict, remote monitoring, and increase the time of production. Moreover many sectors such as construction, manufacturing, energy, automotive, and health care make very much use of it.

A virtual copy or digital twin of a real system, process, or object is called a digital twin. This idea extends beyond conventional 3D modelling by utilising sophisticated analytics, simulations, and real-time data. Here's a detailed explanation:

2.1 Virtual representation: A digital twin is a computer-generated model that imitates an object or system's physical properties and qualities. This depiction can take many forms, from straightforward 3D models to intricate and dynamic simulations.

2.2 Real-time data integration: The capacity of a digital twin to include real-time data from sensors and Internet of Things (IoT) devices is one of its primary characteristics. The digital twin can replicate the physical counterpart's current state and behavior thanks to this real-time data flow.

2.3 Two-way communication: A two-way information exchange between the physical entity and its digital equivalent is frequently made possible by digital twins. Decisions made in the real world can be influenced by insights from the digital twin, and changes in the physical world can be mirrored in the digital model.

2.4 Simulation and analysis: With digital twins, it is possible to simulate and analyze a physical system or object in a virtual setting. This entails forecasting future conditions, assessing performance, and modelling different situations in order to enhance operations or identify possible problems.

2.5 Predictive capabilities: Digital twins are able to forecast future behavior and possible problems by utilizing sophisticated analytics and past data. This predictive capacity is very useful for performance optimization, failure prediction, and preventative maintenance.

2.6 Applications across industries: Applications for digital twins can be found in many different areas, such as manufacturing, healthcare, energy, and transportation. A digital twin could, for instance, represent a ship's systems, structure, and perhaps its whole lifecycle in the context of maritime transport, offering insights for better maintenance and operations.

2.7 IoT and sensor integration: Digital twins depend on the constant flow of information from sensors that are incorporated into real-world items. These sensors gather data on several parameters, including location, pressure, temperature, and more. The digital twin's accuracy and usefulness are improved by this real-time data.

2.8 Lifecycle management: A product or system's whole lifecycle, from design and manufacture to operation and maintenance, can be covered by digital twins. Every step of the process can be optimized and improved upon continuously thanks to this thorough representation.

3.DIGITAL TWIN IN THE MARINE INDUSTRY

Digital twins are just inevitable as the marine sector continues to expand in the sphere of technology. The addition of DT can lead to significant benefits in the marine sector. Industries that utilize it extensively include shipbuilding, maritime mining, offshore oil, and marine fishing industries as shown in figure 1[3]

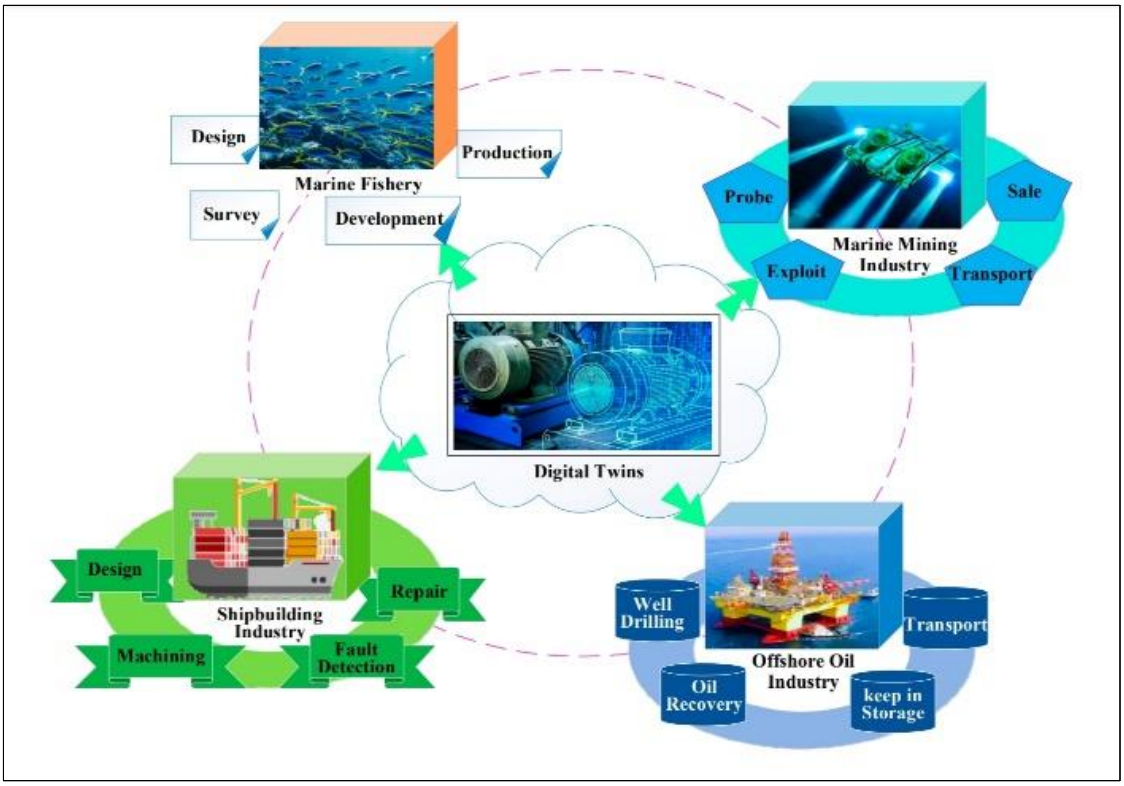

FIG 1 DIGITAL TWIN IN MARINE INDUSTRY

3.1 Ship building industry: It is possible to perform ship design, machinery repair, maintenance, defect detection on the hull and engines, and machining. It is also vital to keep this information during the ship's journey[4].
3.2 Offshore oil industry: With the aid of digital twins, information and updates on well drilling, oil recovery, stack in storage, and transportation systems can be more simply visualized and executed more effectively.
3.3 Marine mining industry: With the help of digital twins, the marine industry can easily keep track of probes, transport, and sail. As we all know, the performance of the marine mining industries is severely inadequate due to inefficiency in performance and detailing.
3.4 Marine fishery industry: DT can readily adopt and understand design, survey, development, and production in this other emerging area.

4.DIGITAL THREADS

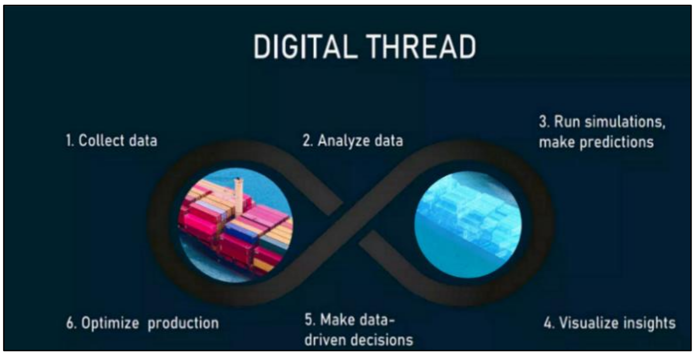

FIG 2 DIGITAL THREADS

Initially, vessel which is of any type will be manufactured with its digital twin, is connected using the digital threads. Implementation of the same is executed by different steps as shown in Figure 2

1. *Collection of data:* this includes the perfect retrieval of data from the vessel that begins with the initial phases of shipbuilding which then continues throughout its life cycle. To summarize it gathers all minute data of the vessel from ship painting works to major data such as engine status and monitoring.
2. *Analysis of data:* the previously retrieved data is stored and compared with recently received data in this section. That is the data is analysed keenly in order to filter out the best results. Henceforth, it can make out the peak differences of the result and give information to the other sections of the process. This is also a vital part of the idea where information is interacted.
3. *Run simulation:* The data that is sedimented gets sorted out and sent into the simulation part which simply means that the data is fed inside the virtual ship to see how this data is affecting the vessel. To sight an example, when a component of a machine has increased the temperature above the scale, the simulation software runs the sorted-out data and makes predictions about the same.
4. *Visual insights:* Even though the data is sorted out and executed, a set of solutions should be given in order to make the decisions.

5. DIGITAL TWINS IN MERCHANT SHIPS

For a variety of reasons, the lifespan of many ships is not easily calculated, making it difficult to forecast when certain engines and many other components will eventually fail. However, using a digital twin makes it feasible. DT applies predictive analytics to this by taking into account a number of variables, including the assembling process, the weather, and the surrounding environment. When the previously described elements are taken into account, artificial intelligence interpretation can be used to treat or diagnose a number of malfunctioning system components with ease [5]. This feature makes it simple to understand how long the components will actually last before becoming ineffective.

5.1 HOW DT WORKS IN MERCHANT SHIPS

Digital Twin Technology (DTT) is implemented in the realm of intelligent ships. As shown in Figure 3 Intelligent ships, as tangible entities in space, execute specific tasks by utilizing data from the service system, encompassing interactions within the "human-ship-environment." This data is sensed, mapped, and transmitted synchronously to the digital space[3]. Subsequently, in the data processing phase, physical and digital world data merge through cross-space fusion, undergoing denoising, feature extraction, feature fusion, data conversion, and reorganization. The resultant data is then applied to ship design, structural analysis, navigation, and management. The evolution of intelligent ships has advanced through stages of automation, digitalization, networking, and intelligence, reaching the era of machine intelligence that facilitates these advanced vessels. Through Digital Twins, intelligent ships can perceive and access diverse, real-time data, facilitating fusion analysis and achieving interconnection and integration of "people-ship-environment" elements.

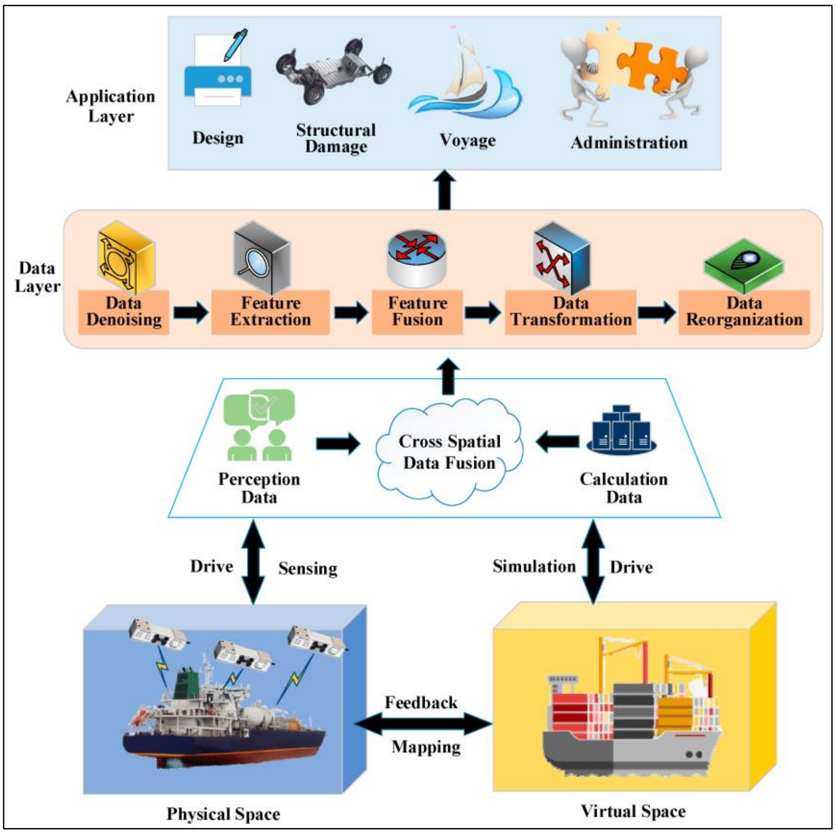

FIG 3 WORKING OF DT IN MERCHANT SHIPS.

5.2 OPTIMIZING FLEET WITH VIRTUAL TRANSITION OF SHIP CONTROL SYSTEM.

The way the marine industry operates is that shipping corporations are known to serve a variety of industries simultaneously, and the businesses they serve may approach other maritime enterprises as well. This implies that, in order to maintain an advantage, a shipping business needs to be proficient in fleet optimization based on its ability to transport cargo. The solution to this is a digital twin. It reduces the complexity of the situation by sensitively analyzing market transactions in terms of past, present, and future possibilities. The digital twin can facilitate both operational and strategic decision-making by comprehending trade trends. Sifting quickly through unusual circumstances, such weather reports, allows the digital twin to be used to ship control systems. It is possible to create a virtual vessel that functions as a stimulant for all onboard systems, simulating a physical vessel in cyberspace and achieving virtual software integration. As a result, digital twins enable testing of virtual vessels in actual scenarios and the investigation of potential changes that might be necessary for the physical pair.

5.3 ENHANCING THE PORT AND TERMINAL OPERATIONS

A port's efficiency is determined by how well the supply and demand chains are balanced, which is achieved when the transport system's integration is flexible as a whole. Today's ports handle a variety of international products and passengers, making strategic planning necessary to manage the constant outflow and inflow of port resources. Port decision-makers will breathe a sigh of relief when they see that choices about port design, terminal capacity, and constructional investments will be made in less time. Using a digital twin model that incorporates all available data, with a range of parameters and bonding.

5.4 AMPLIFIED SECURITY ENSURING SAFETY

When combined with improved cyber-physical systems, the connection multiplication properties make digital twins an effective model for addressing advanced cybersecurity threats. The marine industry has never before been impacted by IT and OT through the Internet of Things. This is because they are in full corporate mode and are eventually exposed to multiple external devices over multiple networks. Digital Twin closely monitors these resources, ensuring appropriate upkeep and management of such remotely available system data. Digital twins are being redesigned so that they can handle both external cyber-possessed security risks, like deliberate cyberattacks carried out for the benefit of a third party, and internal cyber-safety risks that arise from internal properties and complexities and live within integrated systems. Limiting risks when they are still little is the main goal since it prevents manipulation of the activities. Therefore, the ideal answer is produced by a digital twin that uses tricks like simulation- and verification-based testing.

5.5 NAVIGATION ASSISTANCE

Real-time analysis, modeling, forecasting, and decision-making are all required. In this investigation, the intended time window is approximately 10 minutes. In other words, the goal is to forecast the ship's reaction and the wave's progression in the next 20 to 30 minutes. The operators of a commercial ship may find it easier to make decisions with the help of this innovative digital twin technology. In order to mitigate any dangers resulting from excessive ship operations, more specific information can be obtained by using deterministic identifications in minutes for particular wave trains and ship displacements (or accelerations) as opposed to statistics values for ocean settings. Furthermore, the anticipated environmental loads—specifically, the wave drift force and moment can be used to ascertain the best path and speed.

5.6 FIRE SPREAD SIMULATION

With the use of digital twins, we will be able to anticipate the course of a fire before it spreads and utilize the best strategy to contain it while minimizing or completely avoiding damage to our resources. This can be accomplished by examining the items in the vicinity of the fire, determining what is combustible, and determining the fire's strong course. It also shows the fire's route. With the availability of such vast amounts of data, we can put out the fire in a relatively short amount of time and manage it more efficiently.

5.6.1 Early detection: With the use of digital twins, the crew can promptly respond before the situation worsens by being able to promptly detect and predict the fire's spread course.

5.6.2 Optimized Emergency Response: Emergency response plans can be improved with a realistic digital model of the ship, directing crew members toward the safest escape routes and enabling quicker fire containment.

5.6.3 Training and simulation: Realistic training simulations made possible by digital twins enable the crew to become more familiar with potential fire spread situations and the best ways to respond to them, which in turn improves their preparation.

5.6.4 Resource allocation: Resources can be strategically distributed by knowing how a fire might spread across the ship, ensuring that staff and firefighting equipment are sent to the most vulnerable places.

5.6.5 Reduced damage and loss: By protecting the ship and its cargo, early intervention based on digital twin insights can minimize the extent of fire damage and perhaps reduce financial losses.

5.6.6 Regulatory compliance: By offering a thorough and proactive approach to fire safety management, the use of digital twins for fire spread detection can improve adherence to safety rules.

To summarize, the utilization of digital twins in merchant ships for fire propagation path detection results in enhanced safety, expedited response times, and superior risk mitigation.

5.7 CORROSION DETECTION

One of the key benefits of using digital twins for the dictation of corrosion is to improve maintenance planning. By using a digital twin to model the ships, companies can predict when and where corrosion is likely to occur thus allowing them to plan maintenance and repair work accordingly, this can help to reduce costs and minimize the risk associated with the failure of parts and structure of ship. Inspection can be done by the company in real-time by using digital twin without the need for physical inspection of the parts.

5.8 MAINTENANCE OF MOVING PARTS

A ship is a structure comprising of many moving parts, for both loading and unloading and the propulsion of the vessel, which includes engines, electric motors, hydraulic motors, and so on. By analyzing the parameters of these specific parts we will be able to predict the lifetime of them, this can be accomplished by processing the sensor outputs, and based on these data DT creates a simulation and thus provides a visual representation of that part and will give the optimal solution.

5.9 ELECTRICAL LEAKAGES

Digital twins use sensor data and advanced analytics to identify electrical leakage in merchant ships [6]. Here's a step-by-step explanation:

Sensor deployment: The ship's electrical systems are equipped with sensors positioned at crucial locations. These sensors gather information on a number of variables, including resistance, temperature, voltage, and current, continually.
Real-time data collection: The digital twin, a virtual representation of the ship's electrical systems, receives data from the sensors in real-time. The functionality and present condition of the electrical components are covered by this data.
Data integration: The digital twin creates a thorough depiction of the ship's electrical infrastructure by integrating data from several sources. The analysis and monitoring are based on this integrated dataset.
Anomaly detection: The digital twin's sophisticated analytics algorithms examine the combined data. The purpose of these algorithms is to identify abnormalities or departures from standard operating procedures. Unexpected alterations, like unusual voltage drops or erratic current patterns, may point to possible electrical leakage.
Pattern recognition: The digital twin makes use of machine learning and pattern recognition methods to spot minute trends or patterns that might be signs of impending electrical leaks. As the system gains experience with past data, it becomes more adept at anticipating and spotting possible problems.
Alerts and notifications: The digital twin generates warnings and alarms upon detecting a possible electrical leakage or irregularity. These warnings allow for prompt response and preventive action by being delivered to either a monitoring center or the ship's crew.
Predictive analysis: Digital twins frequently use predictive analytics in addition to real-time monitoring. Proactive maintenance is made possible by the system's ability to forecast the location and timing of potential electrical leaks by examining past data and trends.
Visualization: The analysis's findings are shown visually on a user interface, giving the ship's electrical systems a representation. This makes it simple for the crew to understand the information and take the necessary action.

6. CONCLUSION

To sum up, as the situation for sustaining engines, smooth navigation, and manufacturing are more demanding, the role of digital twin hikes up. Moreover, safety becomes more assured with the incorporation of digital twins as it costs the lives of mankind. Henceforth, it facilitates a comprehensive understanding of the vessel's behavior from basic construction to the operational phases paving the way for enhanced performance, safety, and sustainability.

Moreover, new ideas which we put forward such as fire spread simulations, navigational safety, electrical leakage, corrosion detection, and maintenance of moving parts significantly escalate the overall performance including safety in merchant ships.
Digital twins serve as dynamic, real-time replicas of physical ships, enabling continuous monitoring and analysis of various parameters. This transformative technology optimizes maintenance strategies through predictive analytics, preempting potential issues and reducing downtime. Consequently, the associated cost savings and increased operational efficiency contribute significantly to the economic viability of maritime enterprises.
Furthermore, the integration of digital twins aligns with global efforts toward sustainable practices in the maritime sector. By continuously monitoring and optimizing fuel consumption, emissions, and overall energy efficiency, digital twins contribute to an eco-friendly and resource-efficient maritime operation. This is particularly crucial in an era

where environmental concerns and regulatory frameworks demand a concerted effort towards reducing the carbon footprint of shipping.
In essence, the use of digital twins in merchant ships is not just a technological advancement but a transformative force that elevates the industry to new heights of efficiency, safety, and sustainability. Embracing this innovation positions maritime enterprises at the forefront of a digital era, ensuring they navigate the complexities of global trade with resilience and foresight.

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7. REFERENCES

[1] Hehenberger, P.; Bradley, D. Mechatronic Futures: Challenges and Solutions for Mechatronic Systems and Their Designers; Springer International Publishing: Midtown Manhattan, NY, USA, 2016; ISBN 9783319321561
[2] Nuwan Sri Madusanka, Yijie Fan, Shaolong Yang and Xianbo Xiang. Digital Twin in the Maritime Domain: A Review and Emerging Trends,journal of marine scince and engineering, 2023
[3] Zhihan Lv, Haibin Lv. Digital twin in the marine industry, MDPI electronics volume 12 issue 9,2023
[4] Zoran Kunkera, Tihomir Opetuk, Neven Hadzic and Natasa Tosanovic. Using Digital Twin in a Shipbuilding Project, 2022
[5] Simon Krogstad Munkeby, On application of digital twin in ship operation and performance, Master’s thesis in Marine Technology, 2022
[6] Zhou, S.; Wu, W.; Zhang, T.; Zhang, Q. Digital twin technical system for marine power ,Chinese journal of ship research 2020,16(2)

Green Shipping and Environmental Sustainability - Ammonia Fuel Cells

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ABSTRACT

The shipping industry faces significant sustainability challenges, primarily due to its reliance on polluting heavy fuel oil, leading to carbon emissions and environmental harm. However, there is optimism in adopting alternative fuel sources, such as fuel cells, offering cleaner and more sustainable energy solutions. This transition has the potential to reduce the industry's carbon footprint, improve environmental performance, and align with global efforts to combat climate change and protect ecosystems, providing a glimpse of a more responsible and sustainable future for shipping.

KEYWORDS

sustainability; carbon; waste; fuel cells

INTRODUCTION

The maritime industry faces challenges in adopting new technologies and/or operational practices to comply with increasingly strict international, national, and local regulations aimed at reducing Sulfur Oxides (SOx), Nitrogen Oxides (NOx), Particulate Matter (PM), Carbon and Greenhouse Gas (GHG) emissions from ships

The adoption of the Initial International Maritime Organization Strategy on Reduction of Greenhouse Gas Emissions from Ships by IMO Marine Environment Protection Committee (MEPC) Resolution MEPC.304(72) in April 2018 shows IMO's dedication for the Paris Agreement. The IMO strategy includes initial targets to reduce the average carbon dioxide (CO_2) emissions per transport work from 2008 levels by at least 40 percent by 2030, and 70 percent by 2050. These targets also seek to reduce the total annual GHG emissions from shipping by at least 50 percent by 2050. Technical approaches, operational approaches and alternative fuels may be used to achieve these goals , ammonia (NH_3) is a zero-carbon fuel that may enhance the global market relatively quickly and help meet the GHG reduction target for 2050 set by the IMO. Ammonia offers ship owners and operators a zero-carbon tank-to-wake emissions profile, regardless of the source of the fuel meeting SDG (Sustainable Development Goals).

LITERATURE SURVEY

The American Bureau of Shipping[2] recognizes Low Carbon Ammonia as a potential fuel for decarbonisation in its own right. Low-carbon ammonia can have great significance in global decarbonisation, in both traditional and new ammonia markets. Existing technologies and supply chains[3] can enable efficient transportation for long distances.

With some challenges Ammonia slip is the biggest displayed as emission of NO_x -a potent GHG through Zeldovich Mechanism[4] is yet to be counteracted.
So, in near future ammonia will be seen dominating the current wave of hydrogen export projects. But to be successful, the myriad potential suppliers[1] will have to understand the true scale of the future low-carbon ammonia market.

AMMONIA AS A FUEL FOR ZERO CARBON FOOTPRINTS

Ammonia has a potential role as a marine fuel on the basis of energy system modeling. Additionally, suggestions may proceed in the motion of an innovation for an alternative ship propulsion system fueled by ammonia. Study from Kim et.al. in the Journal of Marine Science and Engineering published in march 2020 proved ammonia fueled ships to be capable of reducing GHG-emissions by 83.7% projected to marine fuel use in year 2050.The use of ammonia as a fuel is expected to grow due to its zero-carbon content, easier distribution, storage and bunkering compared to hydrogen, and its suitability with existing and emerging technologies for propulsion and power generation. The figure below shows projected marine fuel use until 2050 as the industry strives to meet the GHG (Green House Gas) emissions-reduction targets mandated by the IMO. The use of ammonia as marine fuel provides solutions for decarbonization of the global fleet.

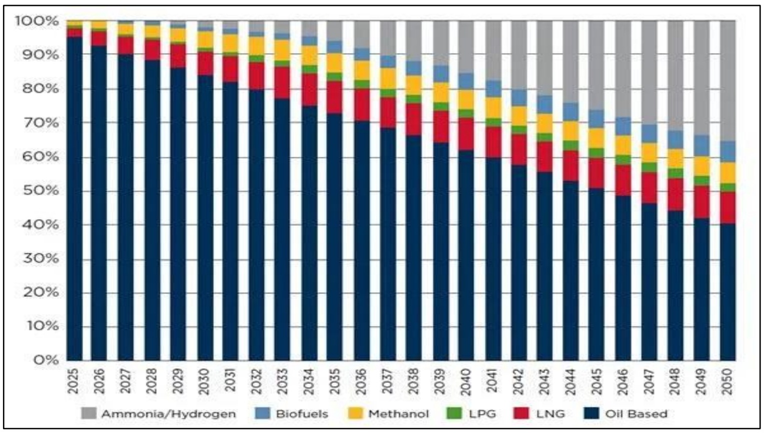

Fig 1: PROJECTED MARINE FUEL USE BY 2050

CHARACTERISTICS OF NH_3 (AMMONIA)

Ammonia is a compound of nitrogen and hydrogen and is a colorless gas with a characteristic pungent smell at atmospheric pressure and normal temperatures. At high pressure ammonia becomes liquid, hence it is easier to transport and store. Ammonia is the second most widely used chemical, supporting the production of fertilizers, pharmaceuticals, and many other chemical applications.

TABLE 1. PROPERTIES OF AMMONIA[2]

Ammonia Property	Value
Energy Density (MJ/L)	12.7
Latent Heat of Vaporization (MJ/kg)	188
Heat of Vaporization	1371
Autoignition Temperature (°C)	651
Minimum Ignition Energy (mJ)	680
Liquid Density ($kg/m^{3)}$	600
Critical Temperature (°C)	132.25
Critical Pressure (bar)	113
Flammable Range (%)	15.15 to 27.35

Low Fire Risk**:** Ammonia is a flammable gas with narrow flammability range. Its flammable range in dry air is between 15.15% and 27.35%. It has an auto ignition temperature of 651 °C. The risk of an ammonia fire is less compared to other fuels because of its narrow flammability range, relatively high ignition energy (2-3 orders of magnitude higher than common hydrocarbons) and low laminar burning rate (more than four times less than methane [< 0.010 m/s]).

Renewable Production**:** It can be produced from fossil fuels such as natural gas as feedstock, or with renewables. The reason why ammonia is considered over hydrogen as a fuel is that when used as a fuel, hydrogen is also zero carbon however, if it is produced from nonrenewable feedstock, such as nonrenewable natural gas through a process using energy not from renewable source, the process could produce significant emissions, which may be hazardous for the environment.

Storage**:** Ammonia maintains a liquid state either at -33.6 °C and 1 bar or 8.6 bar and 20 °C. Industrial scale storage uses low temperatures, which requires energy to maintain. This option may have a lower capital cost than pressurization in some cases, due to the lower storage design pressures[7]. However, pressurized storage in Type C tanks (approximately 18 bar) may be a convenient marine solution and would eliminate the need for additional re-liquefaction equipment to be installed onboard.

Bunkering**:** Ammonia can be stored at liquid form pressurized, semi-refrigerated or fully refrigerated depending on the needed volume for safe storage, varying from small pressurized 1,000-gallon nurse tanks up to liquefied 30,000-ton storage tanks at distribution terminals. During transfer from one tank to another, either “cold inbound” or “warm inbound” is chosen as a result of the transferred volume and re-refrigeration process. The capacity of an onshore full pressure non-refrigerated tank is usually limited. The overall handling can be energy intensive. Three modes of future ammonia bunkering via truck, tank or ship are envisaged.

AMMONIA VS HYDROGEN-WHICH ONE TO PICK UP FOR SGD?

Hydrogen offers a high energy content per mass, high diffusivity, and high flame speed. Hydrogen as a fuel has been demonstrated in internal combustion (IC) engines, gas turbines, and fuel cells. However, it requires cryogenic storage (-253 °C or lower) and dedicated fuel supply systems for containment. Significant technical advances are needed before hydrogen can be considered a viable, large scale, commercial fuel option, particularly for marine applications where energy content on a volumetric basis is low for hydrogen (9.93 GJ/m^3) and application would therefore significantly impact ship design. Energy loss during storage and boil off gas generation are also challenges for application. Compared to hydrogen, ammonia storage is more practical due to its energy density and liquefaction temperature (see Figure 2).

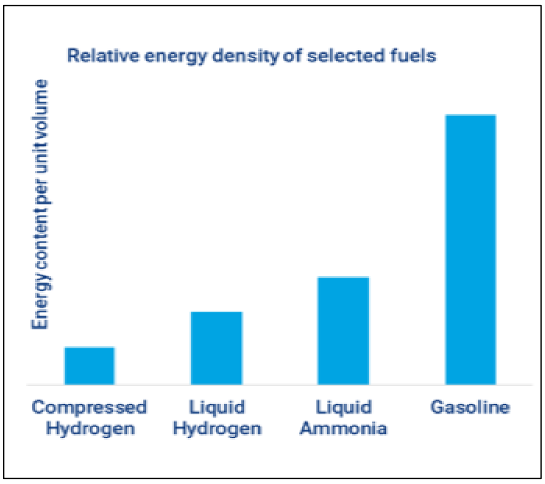

Fig2: **ENERGY DENSITY OF SELECTED FUELS (SOURCE: WOOD MACKENZIE)**

COMBUSTION AND PROPULSION

For combustion, ammonia can be burned either in an IC engine (compression ignition with pilot fuel/spark ignition) or used in fuel cells. Ammonia has a high auto-ignition temperature, a high heat of vaporization and a narrow flammability range. Due to these characteristics, ammonia typically requires a pilot fuel injection. Burning ammonia in IC engines produces water, nitrogen, unburnt ammonia, and possible additional NOx (Nitrous Oxide) due to the high temperatures and pressures involved. Even though the compound itself along with the combustion is carbon-free, these ammonia and NOx by-products need to be managed. Nitrous oxide (N_2O) is a potent GHG with a greenhouse warming potential. The NOx produced may need to be treated with an after-treatment process. These engines and aftertreatment solutions would therefore need to meet existing NOx emissions limits and regulations.

The balanced chemical equation for the combustion of ammonia is as follows:

$$4NH_3(g) + 3O_2(g) \rightarrow 2N_2(g) + 6H_2O(l) \qquad (1)$$ [4]

When ammonia is completely combusted, it only produces Nitrogen and water without involving the production of NO_x. However, NO_x emission is relatively high in practical combustion, which is a main challenge of ammonia combustion. NO_x is mainly composed of thermal NO_x and fuel NO_x. Former is usually produced by the oxidation of Nitrogen at temperature upto 1800K. The extended Zeldovich mechanism is widely used to describe the formation of thermal NO_x. The reactions of thermal NO_x have three important pathways as elaborated in the equations below:

$$N_2 + O = NO + N, \quad (2)^4$$

$$N + O_2 = NO + O, \quad (3)^4$$

and

$$N + OH = NO + H, \quad (4)^4$$

The first reaction limits the reaction rate and usually it takes place when the temperature is above 1800K. Therefore, controlling temperature is an effective way to reduce thermal NO production. Ammonia has high heat of vaporization (1,371 kJ/kg), which results in considerable evaporative cooling of the mixture after injection and reduces the cylinder temperature at the start of combustion, helping to control NOx formation. Conclusively, an appropriate combustion technology is required, also evaluation of the exhaust emissions to ensure NOx compliance with the regulatory limits needs to be done.

Solid Oxide Fuel Cells (SOFC)**:** To use NH3 in fuel cells, the hydrogen contained in the molecule must be separated out. Although it is possible to achieve this through an external reformer so that the hydrogen can be used in low temperature fuel cells such as a polymer electrolyte membrane (PEM), using ammonia directly in high-temperature fuel cells such as a solid oxide fuel cell (SOFC) can be a more efficient solution. There are also other advantages of using ammonia in SOFC, such as high electrical efficiency, the absence of NOx production and the lack of vibration. Fuel cell development is not as mature as IC engines and typically has a higher cost. These factors are expected to show gradual improvement as research continues. An additional shortcoming of SOFC compared to PEM is the sensitivity of the solid oxide ceramic materials used to heat gradients, which requires relatively long and careful start up and shut down procedures and often lasts for hours. Ideally, SOFC plants should be run continuously to minimize the risk of permanent damage. This would typically require the use of batteries for energy storage to accommodate fluctuations in load demand. As an ongoing research Viking Energy[5], an offshore vessel, retrofitted with a 2MW ammonia fuel cell, allowing it to sail completely on clean fuel for up to 3,000 hours annually. It is a proof of the concept project for long range zero-emission large ship voyages. The ammonia fuel cell system will be installed in late 2023. Yara International is contracted to supply green ammonia produced by electrolysis. This will be delivered to Viking Energy in containers for easy and safe refueling. The project also tests the viability of sustainability sourced ammonia in a solid oxide fuel cell system for a commercial ship

Propulsion and Engine: The ME-LGIP engine, which is designed to operate on LPG and closest to the expected configuration for burning ammonia, is also entering service for burning LPG on LPG carriers. The ME-LGIP engine can be used with ammonia with slight modifications to the fuel-delivery system to supply ammonia at approximately 70 bar and inject it into the cylinder at 600–700 bar. Ammonia slip will need to be carefully controlled. The high-pressure direct-injection systems used in DF (dual fuel) engines, such as the MAN ME-LGIM and ME-LGIP, can inject fuel at optimum levels and timing to avoid ammonia slip. NOx emissions can be further reduced by using exhaust gas recirculation, or SCR aftertreatment for the exhaust gas.

CHALLENGES

Combustion: Ammonia handling in ships is sufficiently feasible as it has already been handled as cargo and reductant in Selective Catalytic Reduction (SCR) systems for many years. Ammonia as fuel for IC engines is under development. A challenge inherent in its combustion is the large percentage of pilot fuel required for ignition, alternative to which can be provided through fuel cells. Slow flame velocity, ignition temperature, narrow flammability range and lower heat of combustion are issues for ammonia ignition. Engine control strategies by engine manufacturers can address these issues. The advent of electronic engine controls and existing DF technologies, including the Diesel process used by MAN Energy Solution's ME-LGI engine shows promise in addressing these issues in the near future.

Flammability: Ammonia can react with halogens, interhalogens and oxidizers and may cause violent reactions or explosions. Therefore, ammonia should be stored in a cool, well-ventilated location, away from sources of ignition, and separate from other chemicals, particularly oxidizing gases (chlorine, bromine, and iodine) and acids. Dilution systems may be utilized to avoid the flammability range of ammonia, large ammonia fires can be extinguished through water spray, fog, or foam but care needs to be taken to prevent environmental contamination from diluted water/runoff.

Corrosion: Ammonia is incompatible with various industrial materials, and in the presence of moisture reacts with and corrodes copper, brass, zinc and various alloys forming a greenish/blue color. This increases drag as the hull gets corroded increasing the ton-mile hence reducing efficiency of the fuel. Ammonia is an alkaline reducing agent and reacts with acids, halogens and oxidizing agents. Materials are to be carefully selected when ammonia is used onboard a vessel. Iron, steel and specific non-ferrous alloys resistant to ammonia should be used for tanks, pipelines and structural components where ammonia is used. Stress corrosion cracking is induced and proceeds rapidly at high temperatures in steel when oxygen levels of more than a few ppm in liquid ammonia are introduced. The IGC Code outlines the requirements for piping components, cargo tanks and equipment in contact with ammonia liquid or vapor.

TABLE 2. ADVANTAGES AND CHALLENGES OF NH

Advantages	Challenges
Carbon free – no CO_2 or soot	Toxicity
Low flammability risk	Fuel infrastructure
Produced through Renewable energy	Lack of regulations
Easily reformed to hydrogen and nitrogen	Engine development at design stage
Easily stored and transported	Cost
Established commercial product	Corrosiveness
Easily liquifiable	Increased NO_X emission

Volume occupation as a challenge: As ammonia has low energy content it will require larger tanks for storage and their location on board will be a critical design factor. When ammonia is used as a fuel, the changes in vessel arrangement are dependent on the location and type of ammonia tank/containment system. Cargo capacity also is expected to decrease based on the use of ammonia combustion engine or ammonia fuel cell arrangement employed. The additional space for fuel, due to lower energy density, may require larger vessels sizes, decreased cargo space or more frequent bunkering. Novel power generation systems such as fuel cells may also change the architecture of the current engine room. Thus decrease in cargo capacity may be compensated through fuel cells by additional space of the engine room.

Craft Design: For ammonia fueled vessels, the specific vessel arrangements will vary depending on the actual fuel pressure and temperature settings of the fuel. The prime mover selected and fuel storage conditions will also affect vessel design. The link between the fuel storage, fuel preparation and fuel consumer is much more interdependent than with conventional fuels. It is critical that equipment and system design decisions consider this interdependence. For ammonia fueled ships, the main systems the require different or additional concepts in ship designs are the ammonia fuel containment system, associated ammonia bunker station and transfer piping, a fuel supply system, boiloff gas handling, reliquefication, gas valve unit/train, nitrogen generating plant, vent piping systems and masts, and for some ammonia tank types, additional equipment for managing tank temperatures and pressure. Deluge systems, personal protective equipment, independent ventilation for ammonia spaces, emergency extraction ventilation and closed fuel systems may also be required. A practical ammonia tank location that does not compromise safety or cargo capacity and operations is a challenge.

Ammonia requires about 2.4 times more tank volume than Heavy Fuel Oil (HFO) to generate the same energy. Ammonia tanks need to comply with the requirements of the IGC (The International Code of the Construction and Equipment of Ship's carrying Liquified Gases in Bulk) and IGF(International Code of Safety for Ships using Gases or other low-flashpoint fuels) Codes on minimum distances from the hull's shell, accommodation space, design and safety requirements, etc. The IGC Code contains specific material requirements for ammonia fuel containment under Section 17.12 and these would be expected to be applied, as applicable, for marine fuel storage tanks

Fuel Supply: The purpose of the fuel supply system (FSS) is to deliver fuel at the correct temperature and pressure to the engine. The use of low flashpoint fuels and gases introduces complexity to the fuel supply and consumer systems and creates a greater interdependence between the key systems over conventional fuel systems. For fuels using cryogenic/ pressurized liquefied storage, such as ammonia, the fuel can be pumped or pressure fed, directly in liquid form. The FSS can be one of the more complex and expensive systems required for gas fueled applications. The FSS needs to ramp fuel supply quantities depending on the engine fuel demand. This transient fuel demand can be a challenge, particularly when maintaining fuel supply readiness in times of high demand or zero demand, without causing a shutdown of the FSS. It may also not be part of the engine Original Equipment Manufacturer (OEM) supply, but solely designed to comply with the engine OEM's specifications.

CONCLUSION:

This study evaluates ammonia as a potential marine fuel, focusing on environmental impacts and spill concerns. Ammonia's swift concentration decrease reduces long-term spill worries compared to HFO. Dual fuel engines, especially in LPG carriers, are considered a promising entry point, with expected ammonia engines by 2024. While ammonia is carbon-free, unaddressed combustion emissions pose environmental risks. NOx emissions can be mitigated with exhaust gas treatments like SCR, and future engine tests must minimize ammonia slip. Stringent regulations are crucial for N2O emissions due to their high GWP. Research is needed on emissions from burning ammonia with other fuels, and fuel cells could offer emission-free alternatives, though not yet commercially viable for deep-sea shipping. Ammonia's global production infrastructure supports shipping demand, but green ammonia supply is currently limited, requiring increased production. Synergies with other sectors, like agriculture, also needing green ammonia, exist. Developing robust certification systems for green ammonia is imperative. In conclusion, ammonia, as a carbon-free post-fossil fuel, emerges as a promising marine fuel candidate, potentially cost-effective compared to alternatives, contingent on addressing emissions and scaling up green ammonia production.

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REFERENCES

1. American Bureau of Shipping (ABS) publication[2]- Setting the Course to Low Carbon Shipping: Pathways to Sustainable Future
2. Computational Analysis of the Extended Zeldovich Mechanism[4], November 2014 can be found online at https://www.researchgate.net/publication/278391595_Computational_Analysis_of_the_Extended_Zeldovich_Mechanism
3. Characteristics of an SI Engine[8] Using Direct Ammonia Injection, Department of Mechanical Engineering, Iowa State University, can be found online at https://nh3fuelassociation.org/wp-content/uploads/2013/10/nh3fcx-song-charng-kong.pdf
4. Large Scale Ammonia Storage and Handling[7], D. Webb, pp. 1–37, 2008.
5. The offshore vessel to run on ammonia-powered fuel cell, can be found online at https://www.fch.europa.eu/press-releases/ major-project-convert-offshore-vessel-run-ammonia-powered-fuel-cell
6. Press release article[3], January 11,2022 “What role will Ammonia play in global hydrogen trade”, can be found online at

https://www.hellenicshippingnews.com/what-role-will-ammonia-play-in-global-hydrogen-trade

7. Press Release Article[1], July 14,2021 by Panos Koutsourakis,The Maritime Executive, powerihttps://maritime-executive.com/editorials/powering-a-low-carbon-future-with-methanol-as-a-marine-fuelng a low carbon fuel can be found online at

8. Master's Thesis[6] Emtiaz Ali Brohi, Chalmers University of Technology, "Ammonia as fuel for internal combustion engines?" Applied Mechanics.

Renewable Energy-Driven Liquid Nitrogen Generation for High-Pressure Work Extraction in an Open-Loop System

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ABSTRACT

In today's world and the new marine pollution carbon emission goals (MARPOL 23), achieving net zero carbon emissions is challenging. However, there are numerous ways to achieve it, such as alternate fuels and renewable energies. In the case of vessels, it is quite difficult to propel them with the direct usage of renewable energy electricity. IC Engine has a great power-to-weight ratio, but they are directly not supporting us in reducing carbon emissions [1]. Coping up with the MARPOL laws and the current global warming crisis, this technical paper shows us a system that uses renewable energies to generate liquid nitrogen into an open loop pressure vessel and a turbine cycle. The article goes through a line diagram where liquid nitrogen boils to generate pressure with the help of ambient air and, creating a zero-carbon cycle with a slightly expensive initial setup. Liquid nitrogen can be a energy storage entity except batteries and water head used currently.

Keywords

Renewable, Cryogenic nitrogen generator, Cryogenic boiler, Turbine, Net Zero

1. INTRODUCTION

In a conventional passenger vessel or barge, a single propeller is connected to a propeller shaft, which is connected to a gearbox that takes it to drive from a four-stroke diesel engine, either single or two in number. The fuel used is Diesel oil, Marine Generator oil, or Heavy fuel oil in large vessels transporting goods and cargo. Another way of propelling a ship is using steam. Both systems having a high change in temperature from the ambient room temperature. Heat losses are generally high, reaching the maximum efficiency of 50 percent. Focusing on the near future, carbon emissions must be reduced; an alternative is required to achieve this. The paper takes you through a system of power generation that uses ambient room-temperature air as a fuel to heat liquid nitrogen and pressurize it. The pressurized liquid nitrogen can run a turbine, generating the required power. Liquid nitrogen production is done through renewable energies, either solar panels, wind turbines, or hydroelectricity plants. The paper showcases the usage of LN2 as a medium of power generation and storage. Nitrogen is abundant in nature and does not react with metals at room temperature.

2. NITROGEN SYSTEM LINE DIAGRAM

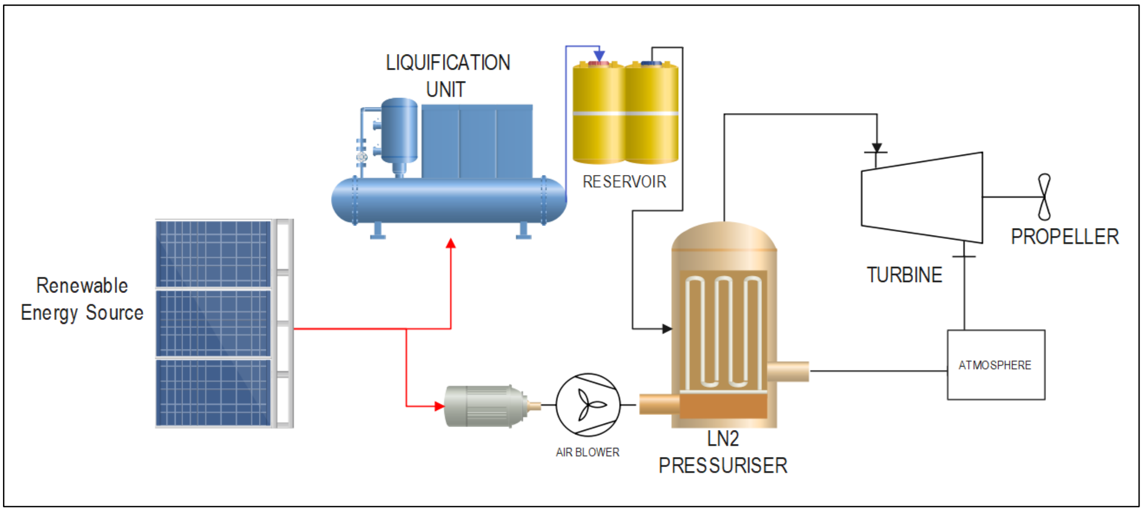

Fig 1: - Production, storage, supply, usage of liquid nitrogen cycle.

A renewable energy source will generate electricity, which will be supplied to a liquefication plant. This plant will generate liquid nitrogen and oxygen and store them in designated cryogenic storage tanks. The liquid nitrogen is transferred to a high-pressure heat exchanger, which uses normal air from the surroundings to heat the nitrogen into a pressurized chamber slowly and gradually. The pressure will rise, the pressurized nitrogen gas will be sent to a turbine, where work is done.

3. LN2 Propulsion on Ship

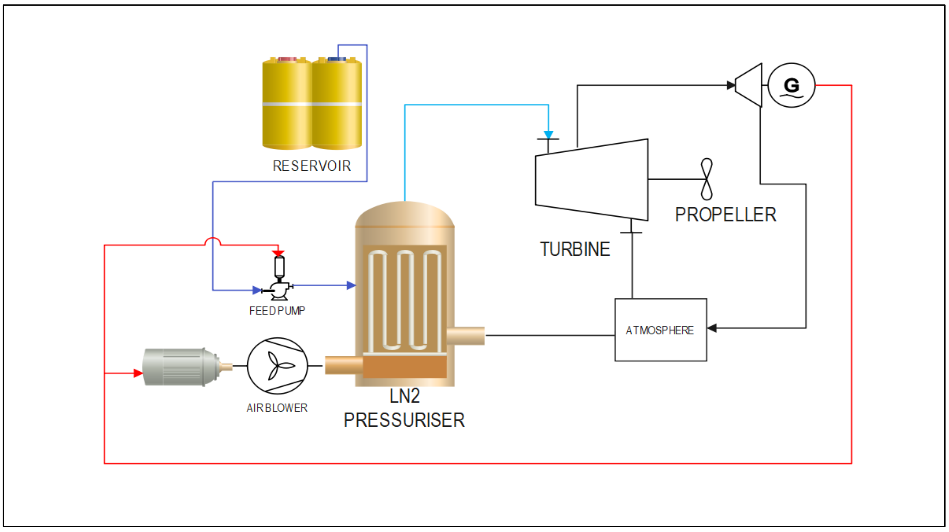

Fig 2: - Usage of pressurised nitrogen gas on board for propulsion and power generation.

In the case of vessels, it is not technically possible to generate electricity using renewable sources such as solar panels and wind turbines, but on the shores, it is quite possible to get a high efficiency of these equipment which can generate electricity[2].
challenges that prevent us from installing solar panels on board ship
Moving platform, Saltwater exposure, Limited surface area

4. Main Components

The main components required to run a nitrogen plant are as follows: the power source and liquefaction plant are present on shore and not on vessels.

4.1 Renewable Energy-Solar Panels, Wind Farm, Hydroelectric Generation plant

Renewable energy sources will be required to run a cryogenic air liquidiser plant, which can be wind turbines installed near shore, solar fields in deserts, Hydroelectricity near water reservoirs, or Biogas recyclers. They need to generate enough liquid nitrogen, which can last enough to propel vessels for daily ferry usage. When the plant is not running, the electricity can be directly supplied to nearby facilities.

4.2 Air Liquification

The air is sucked with the help of a compressor, and then it is cooled, and slowly the gases are separated, and liquid n2 and oxygen are stored in tanks with highly thermal insulating walls. This are generally referred as cryogenic separators.

4.3 Liquid N2 Storage

The liquid N2 is delivered inside the cryogenic container, which is typically made of metals that can sustain -250*Celsius; they are double-walled, and a vacuum is present between them, which makes it nearly hard for the outer heat to enter inside the tank and evaporate the liquid nitrogen the tank is also fitted with a relief valve which will lift when the pressure exceeds a specific limit and keeps the container free from any pressure which can make the container burst. The materials are.

- Aluminium 1100 (UNS A91100)
- Aluminium 3003-F (UNS A93003)

4.4 Liquid N2 Pressure Vessel along with Heat Exchanger

The manufacturing of the pressure vessel, which is a new part of the whole maritime industry, must have the following properties,

the bottom-most part of the pressure vessel must sustain extremely low temperatures and have a heat exchanger that can absorb heat from the surroundings[3].

Therefore, the material should be able to handle high pressures such as 60 bar, and at the same point, it must handle low pressures till- 220* Celsius.

To understand this pressure vessel. We can refer to it as a conventional boiler, which is boiling water to generate steam with the combustion of gases, the differences between this pressure vessel and a steam boiler.

Temperature - the steam boiler can reach up to 300*Celsius. In contrast, a N2 pressure vessel will reach maximum ambient room temperature as we use atmospheric air to boil the liquid nitrogen. Due to high change in temperature.

Heating Medium for LN2 - the tubes carrying nitrogen should have fins on the heating side/Atmospheric air heating side. A drain should be placed below the heating medium fins as it will drip a massive amount of atmospheric moisture, which is converted to liquid water.

Material Selection - Material with high-pressure handling capacity and negative temperature resistance should not react with liquid nitrogen, which is fit for the pressure vessel.

4.5 Nitrogen Gas Driven Turbine

The turbine used here is driven by nitrogen gas, mostly lower than room temperature; it can be either an impulse or a reaction type. This will be precisely calculated according to the flowing medium density and must be designed accordingly, considering that the drive is compressed nitrogen[5].

4.6 Essential Equipments for Running the Plant.

External Forced Draught Fan
Heating Coil at the discharge of FD fan
Feed Pump to Supply LN2
Pressure Control System

5. Calculations for Nitrogen Generation

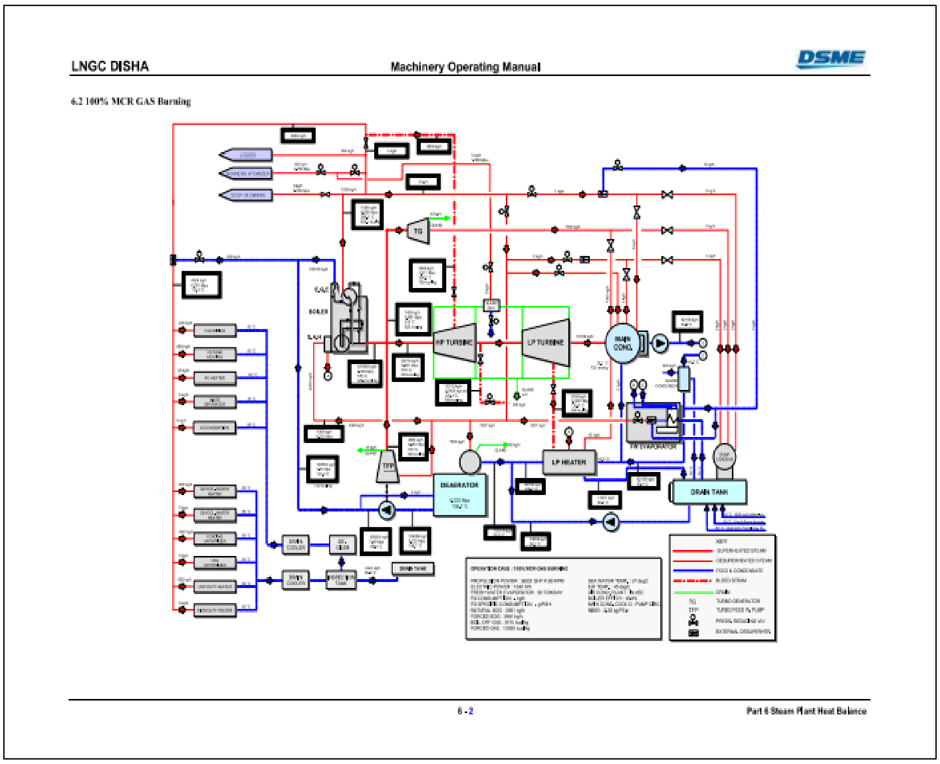

Fig 3: - LNGC Disha 100% MCR (Taken from Disha Operating Manual)[4]

For this steam plant if we compare with LN2 plant we get the following results of LN2 consumption

Power Required = 16 kw for Propelling a passenger ship carrying 100 tourists

$$P = \dot{m}C_v(T_2 - T_1)$$

Initial temperature is 23 degree Celsius and Exhaust temperature we need to find according to inlet conditions.

$$\frac{T_1}{T_2} = \left(\frac{P_1}{p_2}\right)^{\frac{\gamma-1}{\gamma}}$$

From this considering Inlet temperature as 30 degree Celsius and inlet pressure as 18 Bar taking gamma as 1.238 exhaust pressure of 1 bar, we get the exhaust temperature of 174-degree kelvin or – 98 degrees Celsius. Average consumption will be 7.7 L of compressed nitrogen for the same steam plant to run with compressed nitrogen.

6. CHALLENGES OF RUNNING THE LN2 SYSTEM

- Storage

Storing liquid nitrogen in containers is possible, but no material is a pure heat insulator, so some heat enters the liquid nitrogen. It is quite possible that it boils some amount of LN2 and generates gas, which will slowly increase pressure in the container and at negative temperatures, the metals become brittle, which prevents them from handling tension, so a relief valve is fitted on the top to relieve the pressure generated. This gas, which increases the pressure, is called boiloff gas, and the boiloff rate can vary from 0.01 litres per hour to 0.05 litres per hour. This can increase or decrease according to the design of the Cryogenic container.

- Exchanger Design

The part that will be heating the N2 gas will be made in such a way that the FD fan delivering the air for heating, considering the moisture inside the air, will stick to the heating side of the exchanger and convert to solid ice once the ice is coated the heat exchange rate will decrease and more and more ice will be sticking to surface. Preventing measures such as a small vibrating disk must be present on it, which will remove the ice stuck on it, and it can be prevented a suitable arrangement of the drains should be present.

- Very Low Exhaust Temperatures

This is the most challenging part of the system; building a turbine that works at such low temperatures is quite hard to achieve as it is difficult for the turbine to generate high RPM with high centrifu4gal forces and, at the same time, such a low temperature. Solving this problem needs a solution for sustenance at low temperatures, such as -100 degrees Celsius, or a source to heat nitrogen to 100 degrees Celsius to reduce the exhaust temperatures. An alternate can be used by using an IC engine by supplying sea water for heating it, and a Cryogenic temperature coating on the top of the piston can be a solution.

7. ADVANTAGES OF LIQUID NITROGEN GENERATION

- Massive Increase in Energy storage

Current conventional batteries have a limited amount of energy storage capacity. We have two ways to store renewable energy: Batteries and Water Head. Both have limited amount of storage capacities. When we take the case of LN2, you can continuously generate liquid nitrogen and store it. This can hugely increase energy storage.

- Zero Carbon Emissions

This is an entirely Zero Carbon production and propulsion plant. The initial manufacturing of this system will require some energy in the form of Hydrocarbon. The plant is an N2 production unit separating the oxygen and Nitrogen, which will be liquified according to the need. So consistently, this is a zero-carbon production and a Propulsion system.

- No Heat Losses

The usage of liquid nitrogen will be at exceptionally very low temperatures. The external temperature will be very high, so instead of heat loss, it is a heat gain system. IC engines generally have 30 per cent heat losses; if counted to the total losses, they will always have vast amounts of heat losses.

- Least amount of Equipment Needed Compared to Steam Plant

Equipment such as steam trap condensers won't be needed; liquid nitrogen won't be required to be condensed; on the other hand, the FD fan needs to be blown off at a higher rpm for more heat exchange.

8. Conclusion

The system's major components are renewable energy sources to power the cryogenic gas liquefaction plant. This plant produces nitrogen, which is stored in cryogenic container and then transferred to a high-pressure heat exchanger. Here, normal ambient air compresses nitrogen, creating a cycle in which a turbine generates electricity. Challenges such as storage, exchanger design, and minimum extraction temperature were addressed, highlighting the need for specific engineering solutions. Furthermore, the paper identifies the main advantages of this system, including significantly increased energy savings, negligible carbon emissions and minimal heat loss. Ultimately, this innovative approach to using liquid nitrogen for marine resources and energy generation represents an important step toward sustainability goals in the marine industry. Although the initial system may be relatively expensive, the long-term benefits of carbon reduction, increased energy savings and operational efficiency make this system a promising candidate for future shipbuilding technology. They are Combining renewable energy with cryogenic technologies represents a strong synergy with global efforts to combat climate change and reduce carbon footprints. With further research, development and deployment, this system has the potential to change the way ships operate, contributing to a cleaner and more sustainable maritime industry.

9. References

1. https://seniorsbluebook.com/senior-resources/twilight-wish-program-id
2. Ccs in the UK — Fears May Be Liars — Or May Be Not Callum Hughes
3. Daniel Putra Pardamean Mbarep and Herdis Herdiansyah 2020 IOP Conf. Ser.: Mater. Sci. Eng. 725 012026DOI 10.1088/1757-899X/725/1/012026
4. Figure 3: Petronet Machinery Operating Manual LNGC DISHA (H2210)
5. International Adult Literacy Survey (IALS): An analysis of international comparisons of adult literacy Blum, Alain -Goldstein, Harvey Guérin-Pace ,France Doi: 10.1080/09695940123977

10. Acknowledgements

6. Rtd Cdr. Sukanta Binaykumar Dasgupta
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8. Prof Prasad Deshpandey

GAS AND STEAM TURBINE COMBINED PROPULSION PLANT

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ABSTRACT:

The shipping community has realized that LNG enables the implementation of new propulsion concepts, which can increase a vessel's efficiency, and reduce fuel consumption of the vessel. One of the effective ways of achieving this is by using a combined cycle power plant as the propulsion module, which will use LNG as a primary fuel, hence helping in reducing SOx, and NOx emissions and reducing the carbon footprint of the vessel.

Using electric motors for propulsion enables power generation and propulsion which will be powered by the Combined Cycle Power Plant (GT-ST Combination) will be an efficient and modern swift in the industry.

NEED OF COMBINED PROPULSION PLANT (INTRODUCTION)

The global economy heavily relies on the maritime shipping industry to facilitate the cost-effective transport of raw materials and finished products across the world. Modern ships, with their impressive capacity to carry vast quantities of cargo, are arguably one of the most efficient cargo transporters ever created.

However, as the global community becomes increasingly aware of environmental concerns, there is mounting pressure from both the public and regulatory bodies for the shipping industry to reduce emissions to the air and shrink its carbon footprint. This imperative necessitates a fundamental shift in our approach to maritime transportation, particularly in terms of fuel preferences and propulsion concepts. One innovative solution to address these environmental challenges and enhance the sustainability of the shipping industry is the integration of Combined Cycle Power Plants (CCPP) into vessel design. A Combined Cycle Power Plant typically combines the efficiency of a gas turbine and a steam turbine to generate electricity. In the context of maritime transportation, this concept involves using a gas turbine to drive a generator that produces electricity.

This electricity, in turn, powers propulsion motors, propelling the ship efficiently and with a reduced environmental impact. The incorporation of CCPP technology in ships marks a significant departure from traditional propulsion systems, which often rely on fossil fuels with substantial carbon emissions. The implementation of a gas turbine and steam turbine combination offers several advantages. Firstly, it allows for more efficient energy utilization, as both turbines can recover waste heat to produce additional power. This combined cycle approach not only increases the overall efficiency of power generation but also significantly reduces emissions. Moreover, the ability to switch to cleaner and more sustainable fuels, such as natural gas or even hydrogen, in the gas turbine component further aligns with the global push for greener transportation. The result is a more environmentally friendly and economically viable solution for the maritime industry.

Layout Of Plant

This propulsion module is inspired by the Combined Cycle Power Plant, also called CCPP, which is an assembly of Turbines and Boilers.

This propulsion module will have a Gas Turbine, and Steam Turbines, which will be coupled to an alternator, to produce electricity. Both of the Turbines are coupled to the alternators and can be called Turbo Generators. The Electricity produced by the Generators will be supplied to the Electric Propulsion Motors, which will be connected to the Propeller Shaft of the Ship.

In this propulsion module, the Engine Room can be placed on the Fuel Oil Tank Top, which will reduce the size of the Engine Room.

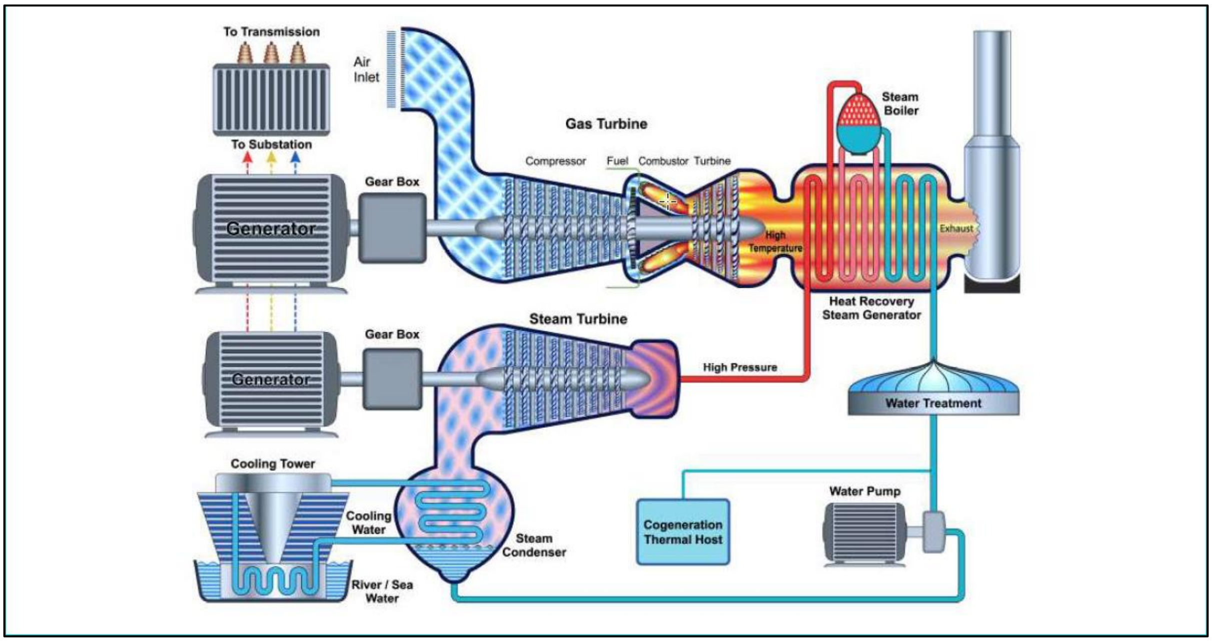

Fig 1.Combined-Cycle Power Plant System using a gas turbine with heat recovery steam generator.

Process Of The Plant

In the beginning, the Gas turbine will compress the Atmospheric Air and will make it hot, and add LNG, in the Combustors. The Fuel is burned and the resultant hot exhaust gases will expand on the turbine blades, making the shaft rotate. As the Gas Turbine is connected to the Alternator, which will convert the kinetic energy to electrical energy.

Now the exhaust gases coming out from the Gas Turbine, which is at high temperature (nearly 1000F) will be sent to the Heat Recovery Steam Generation (HSRG), or exhaust gas boiler, to generate high-pressure and high-temperature steam. Further, it will be expanded in

This system of Combined Cycle Power Plants is certified as the World's most Efficient Power Plant. The efficiency of this power plant is more the 60% (LHV). This plant is also able to produce the electricity more than 100 MW.

The efficiency of this propulsion module is higher than the conventional propulsion module working the Diesel Cycle, Rankine Cycle, and Brayton Cycles.

The conventional power plants the fuel conversion efficiencies are nearly about 33%, but the Combined Cycle power Plants have a Fuel Conversion Efficiency of more than 55%.

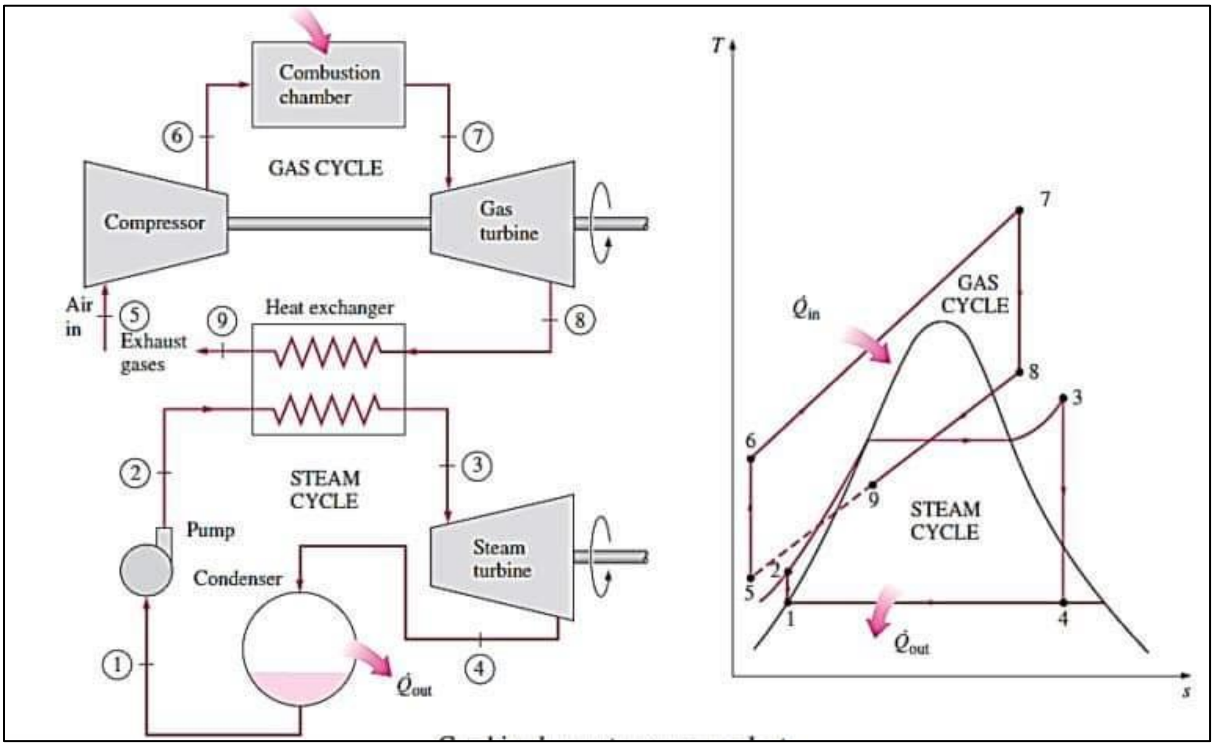

Fig 2 Combined Gas-Steam Power Plant

FUEL OPTIONS

In this present world of growing technology, there has been a path for improvement in the efficiency of propulsion of ships keeping in mind the environmentally friendly aspect. We need to move towards sustainable growth shortly. It all comes down to the fuel used for the propulsion of the ships which plays a key role in maintaining a cleaner environment. Below are a few options for fuel that can meet future needs: -

1. LNG

LNG at present is a widely used fuel among sustainable fuels. Looking ahead, LNG has already overcome the hurdles of international legislation and is among the widely used sustainable fuels in the shipping industry. LNG consists mostly of methane, a potent greenhouse gas (GHG) that traps 86 times more heat in the atmosphere than its carbon dioxide equivalent over 20 years. The technology uses LNG, which has 70% to 82% more greenhouse gas emissions than MGO.

The IMO said it would continue to reduce greenhouse gas emissions in line with its original greenhouse gas strategy and continue to invest in ships and onshore LNG infrastructure, making the transition to zero-emission ships in the future even more difficult.

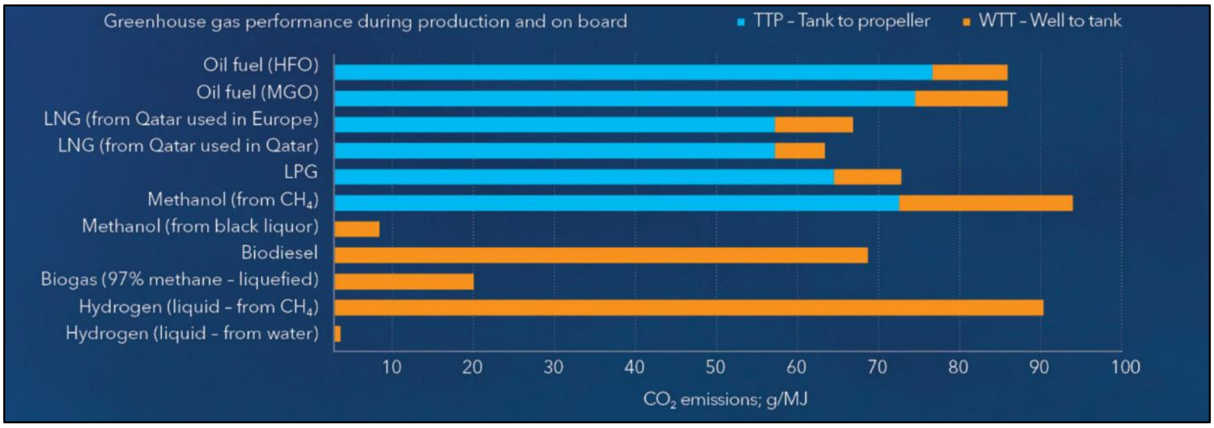

Fig 3 Emissions of fuel alternatives

2. METHANOL

It's the upcoming revolutionary fuel which is a much cleaner and cheaper substitute. Methanol's dominance in the alternative fuel arena has been especially evident in the container shipping segment. According to MAN ES, this agreement includes 45 optional engine retrofit solutions. Each conversion could provide a CO2 reduction of 50.000–70.000 tonnes each year when operating on green methanol.

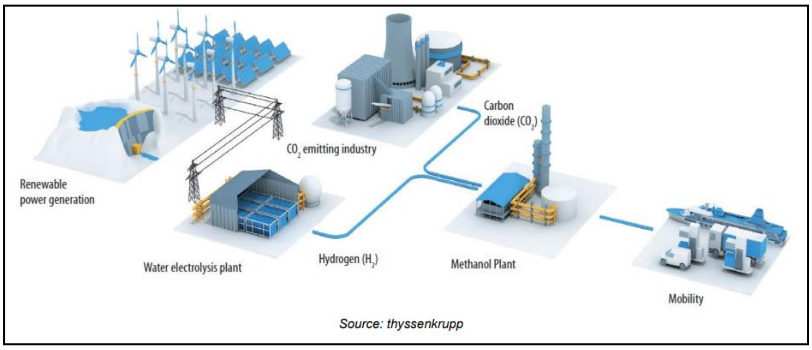

Fig 3Thyssenkrupp's concept of using renewable energy and Waste CO2 to make renewable methanol

3. AMMONIA

In recent years, ammonia gas has become widely accepted as an effective solution to red ucing greenhouse gas emissions. Adapting ammonia as fuel on ships would highly reduce the carbon footprint of international shipping and off-shore transportation. Among the different systems currently being developed for carbon-free energy production in the near term, combined cycle gas turbine systems stand out for their high efficiency and potential to operate on pure ammonia fuel, while maintaining low NOx emission levels.

4. HYDROGEN (FROM CH4)

The cleanest fuel is hydrogen produced using renewable energy. In the future, liquefied hydrogen could be used in transportation. However, due to its low energy, it requires a lot of storage capacity, which may prevent the direct use of hydrogen in international transportation. In an energy-rich world where all energy needs are met by renewable, CO2-free sources, hydrogen, and CO2 will become key ingredients for oil production, most likely in the form of methane or diesel produced from the Sabatier/Fisher. Form of the Oil-Toropsch process.

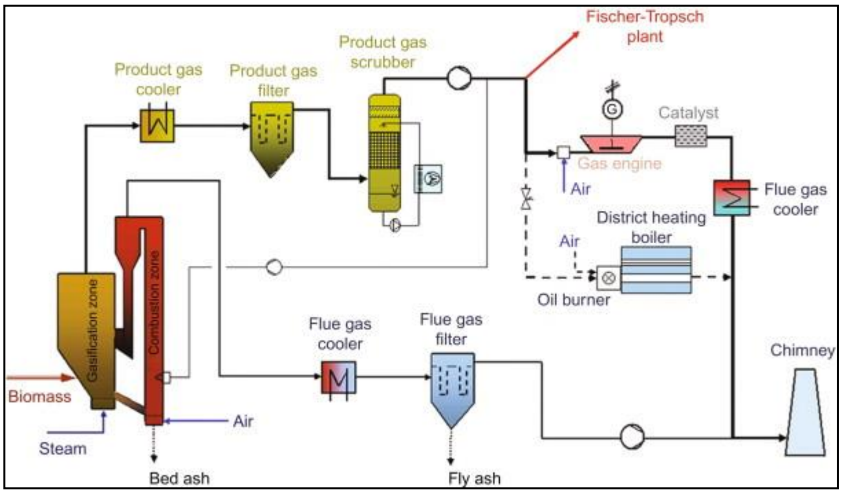

Fig 5 PERFECT SHIP (PISTON ENGINE ROOM FREE EFFICIENT CONTAINERSHIP)

DNV'S PERFECt ship has taken the challenge of making shipping greener and has brought together continents from across the maritime world to see how the industry could preserve its efficiency advantages. World-leading shipping companies such as CMA CGM, GTT, ABB, Solar Turbines, OMT, and DNV-GL have worked together in making this ship. PERFECt uses LNG as its primary fuel resulting in an ultra-low emissions profile, future-proofed against regulations covering NOx Sox particulate. This ship uses a highly efficient combined gas and electric turbine system in combination with an all-electric design.

The modern plant-based COGAS power plant can reach fuel to power efficiency ratio of up to 60% which is much higher than a conventional diesel engine design can reach with high power density. Propelling the ship with electrical motors enables the power generation and propulsion systems to be placed in separate sections of the ship and with the co-gas system providing power for both propulsion and auxiliary systems and engine room is not needed anymore so the powerplant together with the integrated LNG tanks could be moved below the deck house freeing up considerable space for more container slots. The tailored cold shank and new propeller design (addition of contra-rotating accord) have improved the overall efficiency and the propeller design alone has improved the total propulsive efficiency by 5%. A company presentation noted that since more than 90% of the fuel burned is out at sea, part load efficiency is not a significant factor. The presentation highlighted the fast ramp rate of gas turbines and highlighted that a battery system can be offered that would significantly improve performance in ports and during maneuvering. The gas turbine can be enclosed in a package with a noise limit of 85 dB.

ADVANTAGES

A combined cycle power plant on a ship, which utilizes both gas and steam turbines to generate electricity for electric motors, offers several advantages as the main propulsion system:

1. **Fuel Efficiency**: Combined cycle power plants are known for their exceptional fuel efficiency. By using both a gas turbine and a steam turbine, they can harness energy from exhaust gases and waste heat, significantly improving overall thermal efficiency. This results in reduced fuel consumption and increased range for the ship, making it more cost-effective and environmentally friendly.
2. **Power Generation Flexibility**: The combination of gas and steam turbines provides flexibility in power generation. Gas turbines are efficient at high loads, while steam turbines are effective at lower loads. This allows the ship to adapt to various power requirements during its voyage, optimizing energy utilization.
3. **Reduced Emissions**: The efficient utilization of fuel in a combined cycle system leads to lower emissions of greenhouse gases and pollutants. This is crucial for complying with environmental regulations and reducing the ship's carbon footprint.
4. **Compact Design**: Combined cycle power plants tend to have a compact design, making them suitable for ships with limited space. This compactness ensures that the power generation system can be integrated without significantly compromising the ship's overall layout.
5. **Reliability**: Gas and steam turbine systems are known for their reliability and durability. Ships require propulsion systems that can operate continuously under varying conditions, and combined cycle power plants are well-suited for this purpose.
6. **Rapid Response**: Gas turbines are known for their quick start-up and response times. This feature allows the ship to accelerate and decelerate promptly, improving maneuverability and responsiveness to changing operational needs.
7. **Reduced Maintenance**: Combined cycle power plants often have lower maintenance requirements compared to other propulsion systems. The reliability of gas and steam turbines reduces the frequency of maintenance, contributing to lower operational costs.
8. **Redundancy and Safety**: Having two different propulsion methods in a combined cycle system provides redundancy and safety. If one turbine system encounters issues, the ship can still rely on the other for propulsion, reducing the risk of sudden loss of power.

9. **Improved Noise and Vibration Control**: Combined cycle systems tend to produce less noise and vibration, enhancing the comfort and well-being of the crew and passengers on board.

In summary, a combined cycle power plant on a ship, combining gas and steam turbines, offers a range of advantages, including increased fuel efficiency, power generation flexibility, reduced emissions, reliability, compactness, and improved safety and comfort. These benefits make it a compelling choice for main propulsion systems in modern marine vessels.

CONCLUSION

The pivotal question that emerges is whether the industry can successfully embrace and implement this improved propulsion concept on a broader scale. The answer lies in the collective will of stakeholders, including shipbuilders, operators, and regulators, to invest in research, development, and innovation. Additionally, a supportive policy framework and incentives can encourage the adoption of CCPP technology.

While the maritime industry faces formidable challenges in reducing its carbon footprint, the integration of Combined Cycle Power Plants represents a promising step towards a more sustainable and environmentally responsible future for global shipping. By exploring and embracing such innovative solutions, we can navigate the seas of progress towards a cleaner and more efficient maritime transportation sector. Concerns regarding employing gas turbines frequently revolve around efficiency requirements for clean combustion air, fuel suitability, and noise. Since gas turbines are widely employed in other sorts of maritime applications, such as offshore platforms and FPSOs, it is understandable to wonder why they are not used in commercial ships. Today's gas turbines are substantially more efficient than those used 15 or 20 years ago, and they have improved longevity and dependability. They may be installed in either mixed cycle or combined heat and power systems. Because gas turbine exhaust temperatures are greater, combined cycle systems are more efficient and smaller than reciprocating engine systems.

To maximize efficiency, systems should be sized to meet the operating profile. By exploring and embracing such innovative solutions, we can navigate the seas of progress towards a cleaner and more efficient maritime transportation sector.

REFERENCES

[1.] https://www.dnv.com/maritime/insights/topics/lng-as-marine-fuel/technologies.html

[2.] https://www.offshore-energy.biz/producers-vow-to-deliver-11-million-tons-of-hydrogen-derived-marine-fuel-by-2030/

[3.] https://www.methanol.org/

[4.] http://resolver.tudelft.nl/uuid:ed3ce146-fb7b-4ab1-83de-48164e38a853

[5.]https://www.rivieramm.com/news-content-hub/news-content-hub/gas-turbines-ndash-a-viable-alternative-to-piston-engines-58683#:~:text=Gas%20turbines%20offer%20several%20advantages,their%20advantages%20are%20highly%20valued.
[6.]https://www.camfil.com/en/insights/energy-and-power-systems/mythbuster-gas-turbines-in-ships

Nano Carbon Florets Technology On Ship

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ABSTRACT

This project deals with the use of "Nano Carbon Florets in the Marine Field." Merchant ships, consumes approximately 200-400 metric tonnes of fuel daily. Beyond depleting our natural resources it is also a threat to our collective future. Notably, fuel oil consumption stands as a reason for over 25% of the total running cost. Recognizing the urgency of addressing this environmental challenge, the primary focus of this initiative is to optimize fuel consumption in the maritime domain. Embracing eco-friendliness as a priority; the overarching goal is to minimize fuel oil consumption, thereby mitigating the ecological impact and fostering sustainable practices. By investing in innovative technologies, we not only tackle the environmental threats but also aim to revolutionize maritime operations. The proposed solutions not only optimize efficiency but also set the stage for a hybridized approach, combing eco-friendly technologies with existing practices. It is relatively simple to implement this technology on ships. Appropriate design of this will open new opportunities will open new opportunities for large scale acceptance of this technology.

KEYWORDS
Nano Carbon Florets, Eco-friendly, Fuel oil consumption , sustainable practices , revolutionize maritime , innovative operations .

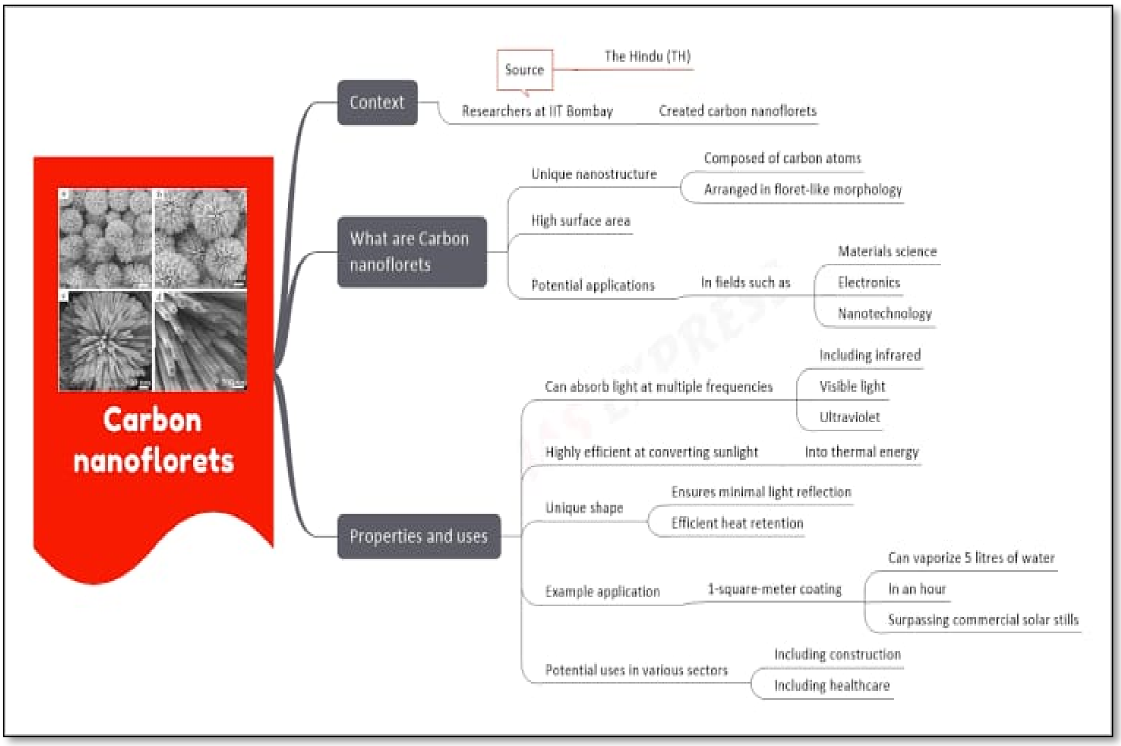


Fig 1 : Properties of carbon nanoflorets

INTRODUCTION

Fuel consumption in the field of merchant Navy always results in a lot of pollution and CO2 emissions. Due to global warming in the rise and new environmental conventions introduced the companies in this field are looking for various new and green solutions to prevent the CO2 emissions or reduce it to a minimum level . Among various new solutions coming in the plan, thermal energy can be one of most effective way to reduce fuel consumptions. Extracting thermal energy from the incident sunlight and then converting it into various forms of energy can reduce the fuel consumption to a minimum level as well as can be cost effective by saving the price for excess bunker. The development of carbon Nano florets (CNF) is ground breaking the most desirable way to exploit sunlight and attain energy without harming the environment .

Solar-thermal conversion (STC) offers an environmentally benign alternative to generate "green" thermal energy for ushering a paradigm shift toward sustainable energy and green shipping.

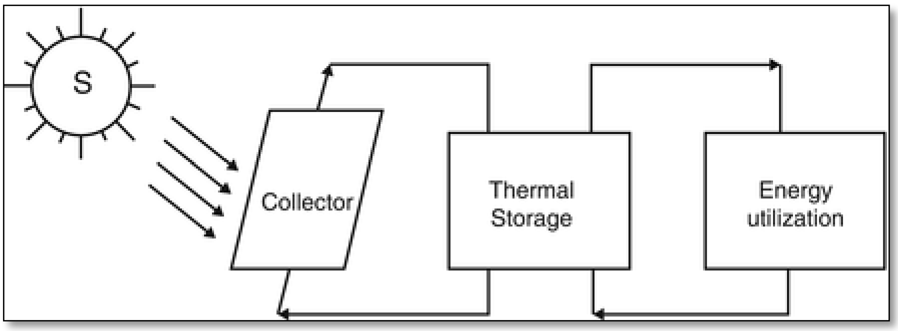


Fig 2: Solar Thermal Conversion Plant

CARBON NANO FLORETS

WORKING PRINCIPLE

They are carbon nano particles that absorb sunlight and convert it into thermal energy. They have an efficiency of 87% as they can absorb sunlight's various frequencies including the infrared, ultra violet and visible frequency. Thus absorbing light across its various spectrums the energy produce is really high. They are produced by heating silicon dust called dendritic fibrous nano-silica in a furnace and then after acetylene gas is introduced to it turning the carbon deposition black , then after the powder is collected and is treated with strong chemicals dissolving DFNS , leaving carbon resulting in spherical beads with cone shaped pits , resembling marigold flowers . This unique structure of CNF minimizes light reflection and ensures maximum internal absorption. This design captures and radiates sunlight converting it into thermal energy, minimizing heat dissipation in environment .

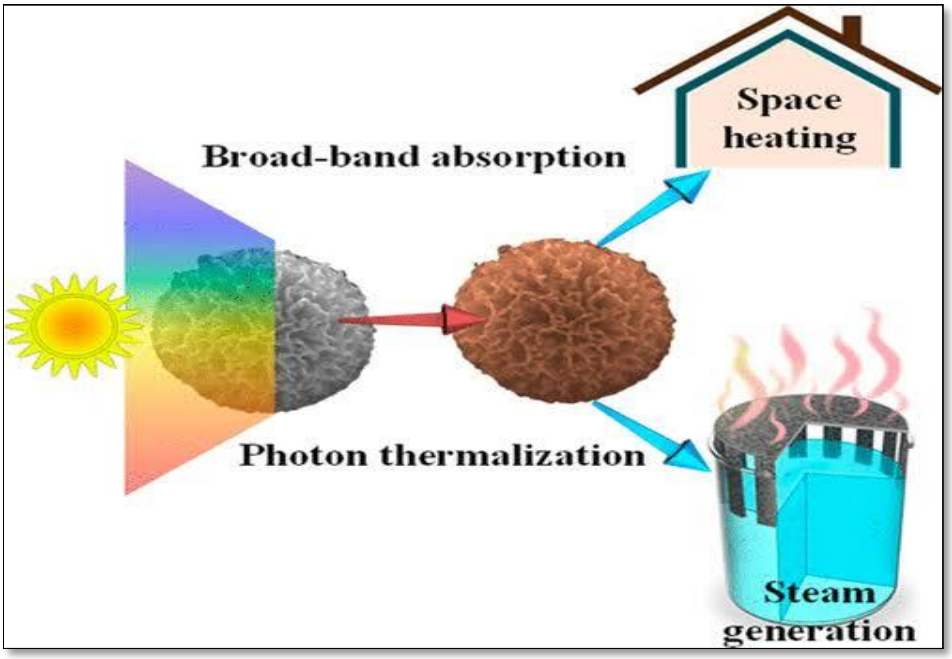


Fig 3: Applications of Carbon Nanoflorets

2. Main Work

2.1.1 Amount of Energy Produced

By taking reference from the paper [1] , it is given that 1m² area of carbon Nano florets can fully vaporize 5l of water in 1 hour , so the energy produced by the florets in 1 hour will be :

Assumptions:
We consider the water to be at 25°C or room temperatures while the temperature of vaporization to be 100°C , and the the weight of 5l of water to be 5 kg ,

Energy produced = mass × (enthalpy of steam – enthalpy of water at room temp)

Therefore, Energy Produced = m × (h2 – h1)

Where h1 = 104.89 Kj / kg

h2 = 2676.1 KJ/Kg

m= 5kg/hr

So, Energy produced = 5 × (2676.1 - 104.89)

= 12756.21 KJ /hr (approx.)

= 3.54 Kw , for 1m² area

Thus if we consider the total favourable area on the ship for the CNF to produce energy be 5000 m² area (assumption) , then the total energy produced on ship be ,

$$3.54 \times 5000 = \mathbf{17700\ KW}$$

2.1.2 ENERGY EXTRACTION THROUGH CNF

Using the thermal energy conversion capabilities of Nano carbon florets can optimize power generation on ships. This technology can potentially be integrated into the ship's structure to harness and convert excess heat into electrical energy.

The thermal energy conversion system could involve technologies like thermoelectric generators (TEGs) or other heat-to-electricity conversion methods. As the temperature difference between the water and the maritime structure exists, the Nano carbon florets help conduct this heat effectively to the thermal conversion system.

Once the thermal energy is captured and converted into electricity, it can be utilized to power various systems on board the ship or offshore platform. This could include electrical systems, sensors, communication devices, or any other equipment, contributing to a more sustainable and self-sufficient operation.

Essentially, the integration of thermal energy conversion in maritime structures harnesses the temperature differentials in the surrounding water to generate electrical power, enhancing the overall energy efficiency and sustainability of the maritime system.

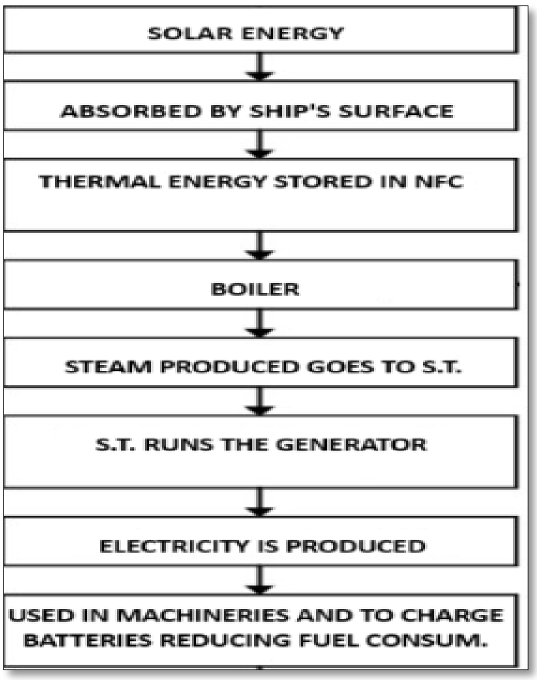


Fig 4 : Flowchart of Energy Extraction

3. MARINE APPLICATIONS

A. BOILER

Boilers are known to consume a significant amount of electricity daily, especially in steam-driven ships. However, envisioning an innovative approach, we propose integrating our Nano carbon florets technology paint. This technology has the capability to convert thermal energy into electrical energy through a solar thermal energy converter. By implementing this hybrid system, we can effectively reduce the overall energy load on the boiler, enhancing its efficiency. It presents a promising avenue for optimizing boiler performance while promoting a greener approach to energy utilization in maritime applications**.**

B. REFRIGERATION

Refrigeration and air conditioning systems typically consume approximately 200 kW of electricity per hour. Our proposed solution involves utilizing our Nano carbon floret paints to completely alleviate this energy load, thereby significantly reducing consumption. This innovative application not only aims to enhance efficiency but also plays a crucial role in mitigating emissions associated with refrigeration systems.

By integrating our nanotechnology-based solution, we can contribute to a substantial reduction in the carbon footprint of refrigeration and air conditioning processes.

we are not only addressing energy efficiency concerns but also aligning with global sustainability initiatives.

C. AUXILIARY MACHINERIES

Auxiliary machinery consumes almost 500 kW of power per hour. By implementing our technology in hybrid mode, we can enhance its reliability and handle increased loads. Utilizing Nano carbon florets in the marine field could lead to a substantial reduction in power consumption. The unique properties of Nano carbon florets, such as enhanced heat dissipation and corrosion resistance, make them a promising solution. This not only contributes to energy efficiency but also extends the lifespan of equipment, reducing maintenance costs. Additionally, the use of such advanced materials aligns with sustainable practices, promoting environmental conservation in the maritime industry.

D. ENVIRONMENTAL IMPACT

By adopting Nano carbon florets, the maritime industry can align with sustainability goals, reducing environmental impact through energy efficiency, reduced fuel consumption, and lower emissions.

Incorporating Nano carbon florets in maritime applications represents a promising avenue for advancing efficiency, sustainability, and performance in this vital industry. The ongoing research and development in this field are paving the way for transformative changes that could redefine the maritime landscape.

3.1.1 HOW TO CONTROL THE THERMAL ENERGY

When employing nanotechnology in paint for thermal-to-electrical conversion, it becomes essential to manage the continuous influx of thermal energy. To address this, we can implement a system where excess thermal energy is directed to boilers. These boilers generate steam, which, in turn, powers turbines. The rotation of these turbines can drive generators, enabling the production of electricity. This electricity can be utilized to charge on-board batteries, offering a sustainable and continuous power source.

a. Energy Storage: The generated electricity can be stored in batteries, allowing for a consistent power supply even during periods of low thermal energy availability. This enhances the reliability and efficiency of the overall energy system

b. Hybrid Power System: Integrating thermal energy conversion with traditional power generation methods creates a hybrid system. This system can provide a more stable and versatile power output, adapting to varying thermal conditions and ensuring continuous operation.

4. ECONOMICAL

4.1.1 COATING APPLICATION

Nano carbon florets can be incorporated into conventional anti-fouling coatings, improving their effectiveness in preventing bio fouling on ship hulls. This helps maintain smooth surfaces and reduces drag during voyages, enhancing fuel efficiency. It is also around 3-4 times the conventional paints applied on the ships so it would be a better option . It is approximately 2-3 times more costlier than the conventional paints use on ship but also provides following characteristics–

A. Durability B. Environmental Impact C. Ease of Application

4.1.2 FUEL CONSUMPTION

The reduction in fuel consumption after implementing Nano carbon florets on a ship can vary based on factors such as ship size, design, operating conditions, and the extent of implementation. Generally, studies and industry reports suggest potential fuel savings ranging from 9% to 15%. It mostly depends upon –

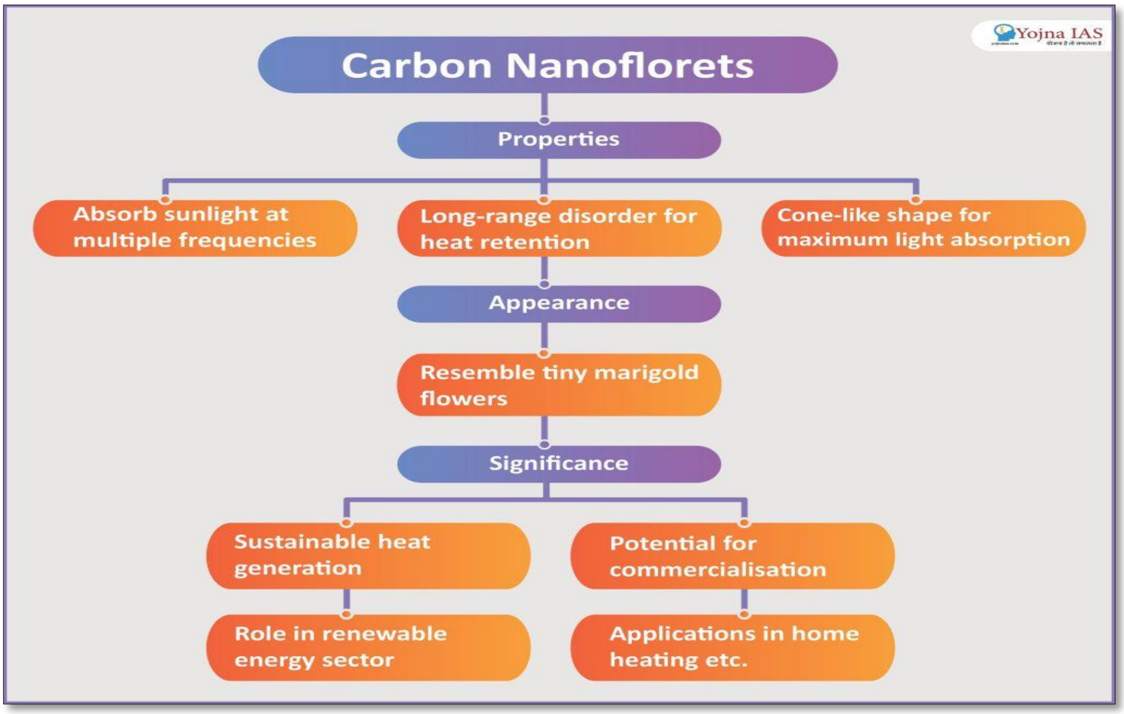
A. Ship size and design B. Operating Conditions C. Maintenance practices D. Speed profiles

4.1.3 RETURN ON INVESTMENT

The time required to achieve a return on investment (ROI) after applying Nano carbon florets and affiliated machineries can vary based on several factors-

A. Fuel Prices B. Initial Investment

As a very rough estimate, the initial investment for a mid-sized vessel could range from several hundred thousand to a few million dollars as it’s installation depends upon coating application , technology integration , material integration . The rough estimated timeframe to achieve a return on investment (ROI) after implementing Nano carbon florets on a ship can vary around 2-3 years after implementation based on fuel savings , operational efficiency and market condition .



Properties of Nano Carbon Florets

5. CONCLUSION

In conclusion, our innovative use of nano carbon florets in ship's coatings represents a transformative step towards reducing fuel consumption, minimizing electrical requirements, and enhancing propulsion efficiency. With this eco-friendly solution, we strive to revolutionize maritime practices and aim for a more sustainable future. The use of nano carbon florets on ships represents a forward-thinking approach to addressing efficiency challenges, reducing environmental impact, and optimizing overall performance. Regular monitoring, maintenance, and adjustments to operational practices are crucial for maximizing the benefits of this innovative technology.

6. ACKNOWLEDGMENT

This paper is result of in-depth analysis of various researches and their drawback. A generous vote of thank to all the faculties and peers for their constant support and guidance

REFERENCES

[1] https://www.iitb.ac.in/en/research-highlight/nanocarbon-florets-to-treat-industrial-effluents

[2] https://www.drishtiias.com/daily-updates/daily-news-analysis/carbon-nanoflorets

[3] https://www.thehindu.com/sci-tech/science/carbon-nanoflorets-iit-bombay-solar-thermal-conversation-high-efficiency/article67472739.ece

[4] https://yojnaias.com/carbon-nano-florets/

[5] https://pubs.acs.org/doi/10.1021/acsami.3c09078

[6] https://www.iasexpress.net/carbon-nanoflorets/

Revolutionizing Shipping: Trends, Technologies, and Sustainable Development

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ABSTRACT

The maritime industry is undergoing a profound shift towards environmental sustainability, epitomized by the concept of green shipping. This abstract explores the pivotal role of marine engineering in advancing sustainable practices within the sector. From innovative propulsion systems to digitalized monitoring solutions, marine engineers are driving the development of technologies aimed at reducing emissions, enhancing energy efficiency, and minimizing the ecological impact of maritime operations. Regulatory frameworks and industry collaboration further underscore the urgency of these efforts. As the industry embraces a greener future, marine engineers play a crucial role in shaping a more sustainable and resilient marine transportation system for the benefit of both the environment and society.

KEYWORDS

Pollution control, Sustainable shipping strategies, International maritime regulations , Methanol engines.

INTRODUCTION

Approximately 11 billion tons of cargo is shipped per year by maritime industry. This digit is said to be tripled by 2050. In recent years, the maritime industry has undergone a transformative shift towards embracing environmental sustainability, driven by increasing awareness of climate change and the urgent need to mitigate its impacts. Central to this evolution is the concept of "green shipping," which encompasses a range of strategies, technologies, and practices aimed at reducing the environmental footprint of marine transportation. As a crucial component of this movement, marine engineering plays a pivotal role in developing innovative solutions to enhance the efficiency and eco-friendliness of vessels and maritime operations.

Green shipping initiatives strive to minimize the adverse effects of shipping activities on marine ecosystems and air quality while also addressing concerns such as greenhouse gas emissions, pollution, and resource depletion. This paradigm shift necessitates a multidisciplinary approach, combining engineering expertise with environmental science, policy frameworks, and industry collaboration.

Within the realm of marine engineering, there is a growing emphasis on designing and retrofitting vessels to be more fuel-efficient, employing alternative propulsion systems such as LNG (liquefied natural gas), hydrogen fuel cells, wind-assisted propulsion, and hybrid technologies. Additionally, advancements in hull design, including the use of specialized coatings and streamlined shapes, contribute to reducing hydrodynamic resistance and improving fuel economy.

Furthermore, the integration of smart technologies and digitalization allows for real-time monitoring and optimization of ship performance, leading to better operational efficiency and reduced environmental impact. From energy management systems to predictive maintenance algorithms, these innovations enable shipowners and operators to make data-driven decisions that prioritize sustainability without compromising safety or profitability.

Fig.1: Container ship

In parallel, regulatory bodies and international organizations have introduced stringent environmental standards and emissions regulations, such as the International Maritime Organization's (IMO) sulfur cap and the upcoming Energy Efficiency Existing Ship Index (EEXI) and Carbon Intensity Indicator (CII). Compliance with these regulations necessitates innovative engineering solutions and operational practices, driving further investments in green shipping technologies and infrastructure.

As the maritime industry navigates towards a more sustainable future, marine engineers are at the forefront of this transformation, tasked with developing and implementing solutions that balance economic viability with environmental stewardship. Collaboration across sectors, proactive research and development, and a commitment to continuous improvement are essential to realizing the vision of green shipping and ensuring the long-term health of our oceans and planet.

ENVIRONMENTAL IMPACTS DUE TO SHIPPING

Shipping industry worldwide contributes significantly in polluting the ecosystem majorly by means of air ,water and noise pollution. It is the sixth largest greenhouse gas emitter worldwide, ranking between Japan and Germany. According to S&P Global Platts Analytics, the shipping industry currently accounts for between 2% and 3% of global Green House Gas (GHG) emissions. Emisson of CO_2 causes changes the oceans' chemistry, causing it to become more acidic, jeopardising the future of shells producing organisms and coral reefs. The ocean becomes warm, thus increasing the intensity of storms, resulting in sea level risings and could be 17% by 2050 if left unregulated. Also, sulphur oxide (SOx), Nitrogen oxide (NOx), Particulate Matter (PM), and black carbon emmison contribute to the premature deaths of more than 60,000 people globally and causes respiratory problems in millions of people, specifically those living close to congested ports.

Fig.2: Pollution caused by merchant ship

A cargo vessel emits around 190 decibels of noise which is louder even than a jet engine at take-off. And noise travels fast in water (four times faster than in air) meaning that noise from a ship can carry exceedingly far, impacting a broad swath of ocean as it travel. Research has shown continuous anthropogenic noise in the ocean was primarily generated by shipping and has caused both short and long-term negative consequences on marine life, especially marine mammals.

Studies show that large accidental oil spills account for about 10–15% of all oil that enters the ocean worldwide every year. A ships' water discharges can also be problematic for marine life and the environment. Cargo ships discharge bilge water, black water, grey water, etc. These discharges can decrease water quality, negatively impact marine environments, and cause health risks to the public. Ballast water is carried in ballast tanks when a ship has delivered cargo to a port and departs with less or no cargo. It is then transported and released at the next port-of-call, where the ship picks up more cargo. The release of ballast water introduces non-native organisms, bio invaders and exotic species into the environment.

WHAT IS GREEN SHIPPING?

Green shipping refers to the practice of conducting maritime transportation in an environmentally sustainable manner, with a focus on minimizing negative impacts on the environment and reducing greenhouse gas emissions, air pollutants, and other forms of pollution associated with shipping activities. This approach involves implementing various strategies, technologies, and practices aimed at improving energy efficiency, reducing fuel consumption, and utilizing cleaner alternative fuels. Green shipping encompasses measures such as the use of alternative fuels (e.g., LNG, biofuels, hydrogen), adoption of energy-efficient technologies and practices, integration of renewable energy sources (e.g., solar, wind), implementation of emission control technologies, efficient routing and speed optimization, and compliance with environmental regulations. The goal of green shipping is to achieve a more sustainable and environmentally friendly maritime transportation sector while meeting global transportation needs and contributing to efforts to combat climate change and protect marine ecosystems.

ROADMAP FOR GREEN SHIPPING

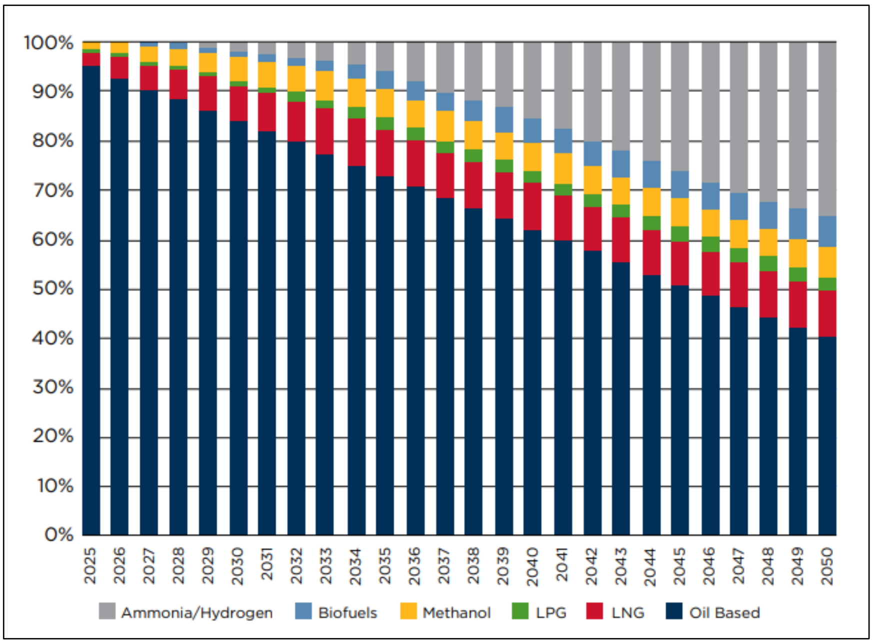

Fig.3: Projected marine fuel use to 2050

Alternative Fuels:

Transitioning from traditional fossil fuels like heavy fuel oil and diesel to cleaner alternative fuels such as liquefied natural gas (LNG), biofuels, methanol, ammonia, or hydrogen. These fuels emit fewer greenhouse gases and pollutants when burned, contributing to cleaner shipping operations.

Renewable Energy:

Integrating renewable energy sources such as solar panels, wind turbines, or sails to supplement or replace traditional propulsion systems. These technologies can help reduce reliance on fossil fuels and decrease emissions during voyages.

Energy Efficiency Measures:

Implementing energy-efficient technologies and practices onboard vessels to optimize fuel consumption and reduce emissions. This may include advanced hull designs, optimized propellers, waste heat recovery systems, and improved operational practices.

Electrification:

Utilizing shore power or onboard batteries to power auxiliary systems while at berth or during port operations, reducing the need for engine idling and emissions in port areas.

Hybrid and Electric Propulsion:

Integrating hybrid or fully electric propulsion systems to reduce emissions and improve efficiency, especially in coastal or short-sea shipping operations where charging infrastructure is available.

Fuel Cells:

Installing hydrogen fuel cells or other fuel cell technologies to generate electricity for propulsion, providing zero-emission power onboard ships.

Efficient Routing and Speed Optimization:

Employing route optimization software and adjusting vessel speeds to minimize fuel consumption and emissions during voyages.

Emission Control Technologies:

Installing exhaust gas cleaning systems (scrubbers) or selective catalytic reduction (SCR) systems to reduce air pollutant emissions from exhaust gases.

Ballast Water Treatment:

Installing advanced ballast water treatment systems to prevent the spread of invasive species and protect marine ecosystems.

Waste Management and Recycling:

Implementing effective waste management practices onboard vessels to minimize pollution and promote recycling of materials.

Regulatory Compliance:

Ensuring compliance with international regulations such as the International Maritime Organization's (IMO) MARPOL convention, which sets standards for air pollution, water pollution, and other environmental aspects of shipping.

INITIATIVES TAKEN WORLDWIDE

Guidelines:

As envisaged in MIV 2030 / Blue Economy 2047 and accordingly, should target more than 50% electrification by the Year 2030 which is to be further increased to more than 90% by the year 2047. Also , share of renewable energy at Ports should exceed 60% by the Year 2030 and 90% by year 2047. Example - Wind Turbine Generator (WTG) can be used in offshore for providing port services. V.O. Chidambaranar Port has been selected for a pilot project on offshore wind farm to be executed by Ministry of Power, Govt. of INDIA.

Ports should also include:

- Environment Management Plan & a dedicated Environment Cell to review and monitor the environment compliance in the Port,
- develop the real time Continuous Ambient Air Quality Monitoring Stations (CAAQMS)
- Continuous Marine Water Quality Monitoring Stations (CMWQMS)
- Online Continuous Effluent Monitoring system (OCEMS)
- use the digital infrastructure i.e. Sagar Setu-NLP-Marine, EBS, RFID etc. to increase the efficiency of Port operation and in turn reduce the carbon footprint as per applicable MoEF&CC/CPCB guidelines.
- also prepare an Emergency Oil Pollution Response Management as per the NOS-DCP (National Oil Spill Disaster Contingency Plan) to combat oil pollution in the event of oil spill within the port limits.

Harit Shrey Scheme:

Mormugao Port launched the “Green Ship Incentive “Harit Shrey” Scheme”. The scheme offers tariff and port due incentives to ships having favourable ESI (Environmental Ship Index) score. The aim of the scheme is to promote de-carbonization and greening initiatives by Shipping lines which would help Indian Maritime sector in achieving the Panchamrit targets and improving sustainability of Port operations. The first ship to receive the Green incentive under the Harit Shrey scheme was M. V August Oldendorff on 31.10.2023.

The "Global Industry Alliance to Support Low Carbon Shipping" (or GIA):

Program launched in 2017 under the auspices of the GloMEEP Project, is identifying and developing solutions that can support overcoming barriers to the uptake of energy efficiency technologies and operational measures in the shipping sector

The global maritime technology network (GMN) project:

Program funded by the European Union, has established a network of five Maritime Technology Cooperation Centres (MTCCs) in Africa, Asia, the Caribbean, Latin America and the Pacific. Through collaboration and outreach activities at regional level, the MTCCs will focus their efforts during 2018 and beyond to help countries develop national maritime energy-efficiency policies and measures, promote the uptake of low-carbon technologies and operations in maritime transport and establish voluntary pilot data-collection and reporting systems.

GreenVoyage-2050 project:

A collaboration between IMO and the Government of Norway. The project, launched in 2019, will initiate and promote global efforts to demonstrate and test technical solutions for reducing such emissions, as well as enhancing knowledge and information sharing to support the IMO GHG reduction strategy.

METHANOL - EMERGING ALTERNATIVE FUEL

Green Methanol (CH_3OH) produced from renewable sources is an attractive marine fuel option due to its low carbon intensity. An engine using green methanol can even provide carbon-neutral propulsion. Methanol inclusion in the IMO's Interim Guidelines for Low Flash Point Fuels was passed in November 2020. It may be used onboard ships as fuel for internal combustion engines or as a fuel source for fuel cell operation.

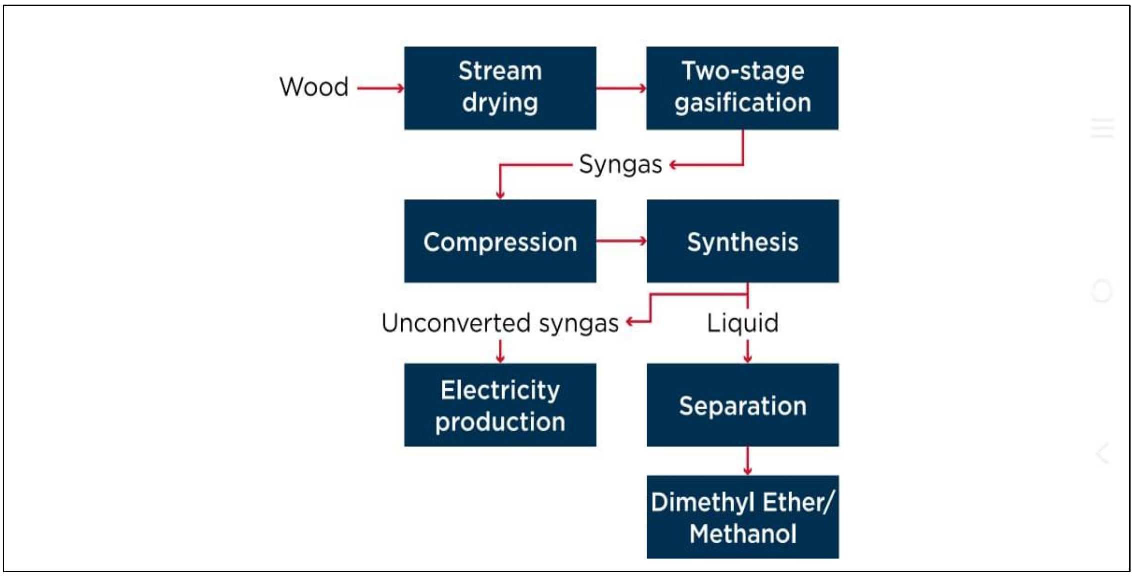

Fig.4: Production of Methanol onboard ship

MAN has developed the 'ME-LGI' concept for high-pressure injection of liquid low flashpoint fuels such as methanol. This involves a relatively low fuel supply pressure, and all high-pressure pumping is done within the injector. Fuel injection is accomplished by a booster fuel injection valve that raises the injection pressure to 550-600 bar. The first application of this concept was in methanol-burning Dual Fuel (DF) engines on several methanol carriers. As methanol is a liquid at ambient temperature, the existing liquid fuel infrastructure may also be leveraged for the supply of methanol with limited conversion. As a liquid fuel, only minor modifications are needed to existing systems/infrastructure used for conventional marine fuels. The modifications are mainly concerning the low flash point of methanol. Hence less funds will be required for the vessel owners to propel the ships using methanol by minor modifications in the existing two stroke IC engine .
Keeping the zero carbon policy into consideration , MAN has developed world's first two-stroke dual-fuel engine named MAN B&W ME-LGIM which can run on both methanol as well as conventional fuels . Specifically designed to meet the needs of the maritime industry, it is a versatile and scalable solution that is suited to a wide range of

vessel types. Simple handling, storage, and bunkering of methanol, combined with relatively simple auxiliary systems and the potential to be carbon-neutral, makes it an attractive option for meeting de-carbonization targets . The engine works with even better efficiency compared to our conventional fuel engines. Switching between methanol and fuel oil is seamless and thereby supports reliable and continuous operation of the engine.

Fig.5: MAN B&W ME-LGIM

Overlooking this transition towards green and environmentally sustainable shipping , the leading maritime trade giant MAERSK has placed and order of 19 vessels propelled by green methanol in pursuit of achieving the zero emission dream of the company .Following this , many other companies are also taking the same path

Large scale production of green methanol is a biggest challenge for which various countries as well as companies are heavily investing in infrastructure for the same. If the production capacity is increased , it will make this green fuel more cost effective . one other drawback that can raise concern is Methanol's specific energy of 19,700 kJ/kg is much lower than that of LNG and conventional liquid fuels. For the same energy content, methanol requires about 2.54 times more storage volume than conventional fuels which needs to be addressed.

KEY CHALLENGES FACED DURING GREEN SHIPPING

Costs and Economics:

This transition led to increase the cost of transportation to 40-60% as per business consultancy firm Mckisey.

Technological Development:

Ensuring the reliability, safety, and scalability of these technologies presents a challenge.

Risk Management:

Introducing new technologies and fuels into maritime operations carries inherent risks, including safety concerns, technical challenges, and potential impacts on vessel performance and reliability.

Education and Training:
Building the necessary skills and expertise among maritime professionals to operate and maintain green shipping technologies requires targeted education and training programs. Addressing these challenges requires collaboration and cooperation among industry stakeholders, governments, regulatory bodies, and research institutions. By working together to overcome these obstacles, the maritime industry can successfully transition to more sustainable and environmentally friendly shipping practices.

CONCLUSION

In conclusion, the project on green shipping and environmental sustainability for marine engineering underscores the imperative for transformative action within the maritime industry. Through the integration of innovative technologies, rigorous regulatory compliance, and collaborative efforts, significant strides have been made towards mitigating the environmental impact of marine transportation. However, the journey towards a truly sustainable maritime sector is ongoing and requires continued dedication from all stakeholders. Marine engineers, as key agents of change, are poised to lead this evolution, leveraging their expertise to drive innovation, optimize operations, and safeguard our oceans for future generations. By embracing the principles of green shipping, we can forge a path towards a cleaner, more resilient maritime future, where economic prosperity aligns harmoniously with environmental stewardship.

REFERENCES:

[1] https://www.man-es.com/marine/products/two-stroke-engines/man-b-w-me-lgim
[2] https://www.imo.org/en/MediaCentre/HotTopics/Pages/Reducing-greenhouse-gbas-emissions-from-ships.aspx
[3] https://www.researchgate.net/publication/336431975_The_Effects_of_Ship_Noise_on_Marine_Mammals-A_Review
[4] https://iopscience.iop.org/article/10.1088/1748-9326/ac146b
[5] *Harit Sagar - Green Port Guidelines .pdf (shipmin.gov.in)
[6] Ministry of Ports,Shipping and Waterways (shipmin.gov.in)
[7] https://www.marineinsight.com/
[8] https://images.google.com/

Pilotage Using AI

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ABSTRACT

This research paper explores the transformative potential of Artificial Intelligence (AI) in optimizing pilotage operations within harbours, focusing on recent updates in Pilotage Regulations and Standards of Training, Certification, and Watchkeeping (STCW) protocols. It delves into AI-driven solutions for route optimization, collision avoidance, decision support, predictive maintenance, data analytics, and communication enhancements. Additionally, it discusses the integration of ADMIRALTY PUBLICATIONS and innovative 3D charting methods, highlighting their role in enhancing AI-driven pilotage. Despite benefits, challenges like technical failures, cybersecurity risks, and data dependence are addressed alongside the need for updated STCW courses to prepare maritime professionals for AI-driven pilotage.

KEYWORDS

Maritime pilotage, Artificial Intelligence (AI), Harbour navigation, Pilotage regulations, Data utilization

1. INTRODUCTION

In the bustling maritime landscape of the 21st century, the effective and secure navigation of ships through intricate harbour channels is paramount. Harbour, a pivotal hub of global trade and commerce, stands at the forefront of maritime activities. As the maritime industry continues to evolve, the integration of cutting-edge technologies becomes imperative to ensure safe and efficient pilotage. This research paper delves into the transformative potential of Artificial Intelligence (AI) in optimizing pilotage operations within Harbour. Furthermore, it explores the recent updates in the Pilotage Regulations and the Standards of Training, Certification, and Watchkeeping (STCW) protocols, with a particular focus on the integration of cyber-security measures to safeguard maritime operations.

Harbour, with its complex waterways and constantly changing conditions, presents a challenging environment for maritime pilots. Traditional pilotage methods have served their purpose, but the advent of AI technologies offers an unprecedented opportunity to enhance navigation precision and safety. This research seeks to investigate the feasibility and efficacy of implementing AI-driven solutions in the day-to-day pilotage operations within Harbour. By leveraging machine learning algorithms, predictive analytics, and real-time data processing, AI has the potential to revolutionize decision-making processes, mitigate risks, and optimize vessel movements within the harbour.

Recent updates in the Pilotage by-laws reflect a proactive approach to adapting to technological advancements. Recognizing the need for a comprehensive framework that incorporates AI applications, the by-laws aim to establish guidelines for the integration and regulation of AI technologies in pilotage practices. This research analyses the implications of these updates, assessing their alignment with the broader goals of enhancing safety, efficiency, and sustainability in maritime transportation.

2. MAIN WORK

2.1 PURPOSE

1. Collision Avoidance, AI-powered collision avoidance systems can continuously monitor vessel positions, predict potential collisions, and provide early warnings to pilots, helping them make timely decisions to avoid accidents.
2. Decision Support Systems, AI can provide pilots with real-time information and decision support, including tide and weather conditions, traffic in the area, and regulatory requirements, enabling them to make informed decisions quickly.
3. Predictive Maintenance, AI algorithms can analyse sensor data from vessels to predict equipment failures before they occur, allowing for proactive maintenance scheduling and minimizing downtime.
4. Data Analytics, AI can analyse vast amounts of data collected from sensors, AIS (Automatic Identification System), radar, and other sources to identify patterns, optimize operations, and improve overall efficiency in maritime pilotage.
5. Communication Enhancements, AI-driven natural language processing (NLP) can facilitate better communication between port authorities, and other vessels, reducing the likelihood of misunderstandings and improving coordination during complex operations.
6. Environmental Impact Reduction, AI can help optimize vessel operations to minimize environmental impact, such as reducing emissions through optimized route planning and fuel-efficient operation strategies.
7. Continuous Learning, AI systems can continuously learn from past operations and adapt their algorithms to improve performance over time, leading to more efficient maritime pilotage operations.
8. Cost Reduction, While AI systems may require initial investment in development and deployment, they can lead to significant cost savings over time by reducing the need for human pilots. This includes savings related to pilot salaries, benefits, training, and insurance.
9. Operational Efficiency, AI-powered systems can optimize vessel routes, improve fuel efficiency, and reduce operational downtime through predictive maintenance, leading to cost savings and increased revenue generation due to more efficient operations.
10. Risk Mitigation, AI-driven collision avoidance systems and decision support tools can help mitigate the risk of accidents and costly incidents, reducing insurance premiums and potential liabilities associated with maritime operations.
11. Increased Throughput, By optimizing vessel operations, AI can help increase the throughput of ports and waterways, enabling more efficient movement of goods and vessels, which can lead to increased revenue for port operators and related businesses.
12. Regulatory Compliance, AI systems can assist in ensuring compliance with regulatory requirements, avoiding penalties and fines associated with non-compliance, which can contribute to cost savings and enhanced reputation.

2.2 WORKING

2.2.1 MASS

The integration of Artificial Intelligence (AI) in the pilotage of vessels within Harbours represents a paradigm shift in maritime navigation. AI technologies offer the potential to redefine and optimize traditional pilotage practices, leading to enhanced safety, efficiency, and adaptability in the dynamic and congested waters of the harbour. One notable application of AI in this context is the concept of Maritime Autonomous Surface Ships (MASS), where vessels gradually transition through four degrees of autonomy. Understanding and applying these degrees in the context of autonomous pilotage can revolutionize the maritime industry.

The first degree of transformation involves the deployment of automatic ships with a crew on the bridge. In this stage, AI technologies assist human operators in navigating vessels through the harbour. The emphasis is on augmenting human decision-making with AI-driven insights, improving the overall safety and precision of navigation. This degree of autonomy serves as a crucial foundation for the subsequent stages in the MASS evolution, ensuring a gradual and controlled integration of AI into existing pilotage practices.

Moving to the second degree, the transition to an unmanned bridge becomes evident. AI systems take on a more active role in vessel navigation, progressively reducing the reliance on human intervention. Advanced sensors, real-time data analysis, and predictive algorithms enable autonomous decision-making, mitigating risks associated with human error. The unmanned bridge concept lays the groundwork for increased operational efficiency and reliability, fostering a transition towards more autonomous pilotage within the harbour.

The third degree of transformation marks a significant step forward with unmanned vessels operating under the supervision of coast operators. AI technologies, combined with remote monitoring and control systems, empower operators situated on the coast to manage and navigate vessels within Harbours. This degree introduces a level of flexibility and scalability, allowing for centralized control of multiple vessels simultaneously. It represents a balanced approach, harnessing the benefits of autonomy while retaining human oversight for critical decision-making.

Finally, the fourth degree of transformation envisions fully unmanned vessels navigating autonomously within Harbours. In this stage, AI takes on the primary responsibility for navigation, collision avoidance, and overall vessel management. The transition to fully unmanned vessels requires robust AI systems, comprehensive sensor networks, and a sophisticated infrastructure to ensure the safety and reliability of autonomous operations. This ultimate degree of autonomy holds the potential to redefine pilotage practices by optimizing routes, minimizing response times, and maximizing resource efficiency.

2.2.2 DATA REQUIREMENTS AND UTILIZATION

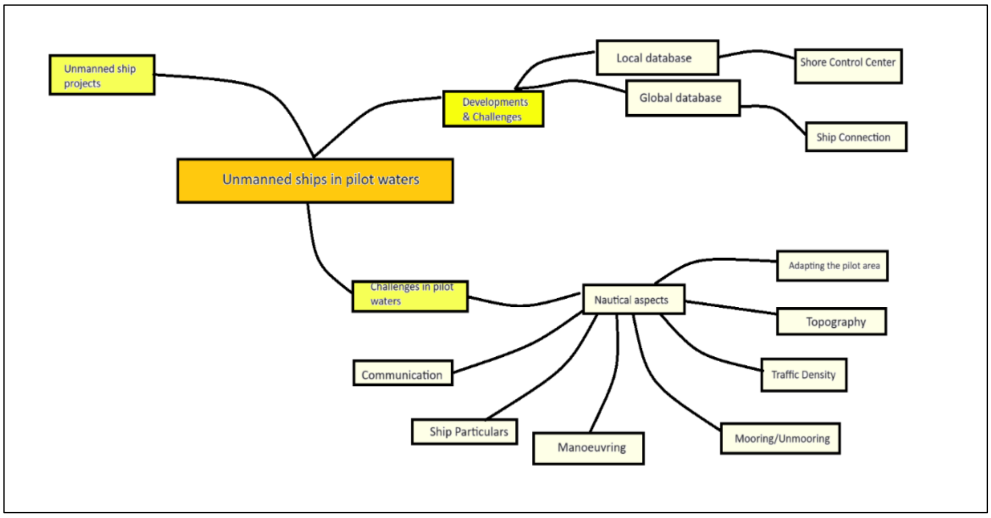

Fig. 1. Classification of unmanned ships in pilot waters

Shore control centre will have the Local databases, these local databases will have the shore data which, the shore AI will feed this data to the ships which are present in the vicinity of the shore and are ready to enter and berth the port. Shore data should include, The current of the water, the tides, depths, widths, any other obstructions or shallow patches in the harbour may need to be manually fed into the system, traffic density of the harbour, port berthing plans of the day.

Global databases will work on cloud databases, data shared by harbours all over the world will be stored on the cloud, available for all the ships to access worldwide. This will be a standardized data for every type of ship depending upon the cargo the vessel is carrying and the draft, the AI will look up the speed for that type of ship at that particular draft of the ship with respect to the shore data, the ship has received.

Route Planning and Optimization, AI algorithms can analyse real-time traffic density data to plan and optimize vessel routes. By considering areas of high traffic density, AI can suggest alternative routes that minimize congestion and reduce the likelihood of delays. Collision Avoidance, AI-powered collision avoidance systems can use traffic density information to predict potential collision risks. By analysing the movement patterns of nearby vessels and assessing traffic density in the vicinity, AI can provide early warnings to ship captains and suggest evasive manoeuvres to avoid collisions.

Dynamic Routing, AI can dynamically adjust vessel routes based on changes in traffic density and real-time conditions. By continuously monitoring traffic density data and adapting routes accordingly, AI can optimize vessel movements to minimize delays and improve overall efficiency. Speed and Course Adjustment, AI algorithms can analyse traffic density information to recommend optimal vessel speeds and course adjustments. By considering traffic patterns and congestion levels, AI can suggest speed reductions or course changes to maintain safe distances from other vessels and avoid potential hazards.

Port Entry and Exit Management, AI-powered systems can use traffic density data to manage vessel entry and exit from ports more efficiently. By analysing traffic density near port entrances and exits, AI can coordinate vessel movements to reduce congestion and streamline port operations. Automated Data Analysis: AI algorithms can analyse vast amounts of data including vessel schedules, port capacities, weather forecasts, and navigational conditions to automatically generate optimized berthing schedules. This eliminates the need for manual data analysis and decision-making, saving time and reducing human error. AI-powered systems can continuously monitor vessel movements, port activities, and environmental conditions in real-time. By integrating data from various sources such as VTS systems, AIS (Automatic Identification System), and weather sensors, AI can provide instant updates and alerts to stakeholders regarding changes in berthing schedules, safety conditions, and operational constraints. By analysing patterns and trends in vessel movements and port operations, AI can anticipate future demand and optimize berthing schedules proactively. AI-driven communication platforms can facilitate automated communication and coordination among stakeholders involved in berthing management schedules. This includes sending notifications, updates, and alerts to harbour pilots, terminal operators, shipping agents, and other relevant parties in real-time. Optimization algorithms can automatically generate optimal berthing schedules by considering various factors such as vessel type, cargo requirements, berth availability, and operational constraints. These algorithms can dynamically adjust schedules to minimize conflicts, optimize port throughput, and reduce congestion. AI can integrate with Internet of Things (IoT) devices installed on vessels, port infrastructure, and environmental sensors to gather real-time data and provide insights for berthing management. This includes monitoring vessel movements, berth occupancy, weather conditions, and other relevant parameters to optimize scheduling decisions.

Ship-shore interactions offers numerous benefits, including enhanced efficiency, safety, and sustainability in maritime operations. AI can optimize various aspects of port operations, such as vessel arrivals, departures, cargo handling, and port congestion, by analysing historical data and predicting vessel arrival times and cargo volumes. This optimization allows port authorities to allocate resources more efficiently, ultimately reducing turnaround times for ships. Additionally, AI-powered systems can provide real-time guidance to ship captains during berthing and mooring operations, minimizing the risk of accidents and damage to both the vessel and shore facilities.

The successful implementation of Artificial Intelligence (AI) in pilotage within Harbour relies heavily on the availability and quality of data. Data is the lifeblood of AI-based systems, providing the necessary input for machine learning algorithms to make informed decisions. In the context of maritime operations, the data collected from various bridge equipment onboard numerous ships plays a pivotal role in optimizing AI-driven pilotage. Instruments such as the Voyage Data Recorder (VDR), course recorder, echo sounder, Navtex, Electronic Chart Display and Information System (ECDIS), and Barograph, among others, contribute valuable real-time information about vessel movements, environmental conditions, and navigation parameters. This wealth of data serves as the foundation for AI algorithms to analyse patterns, predict potential hazards, and optimize navigation routes within Harbour.

Prompt engineering and efficient data processing are essential components in ensuring the seamless operation of AI-based pilotage systems. The integration of AI requires not only advanced algorithms but also a robust engineering infrastructure that can handle and process large volumes of data in real-time. The ability to promptly address any technical issues or anomalies ensures the reliability and safety of AI-driven pilotage operations. A responsive engineering approach is crucial in maintaining the resilience of the system, allowing for continuous improvement and adaptation to evolving conditions within the harbour.

Experience garnered from veteran pilots, particularly in challenging weather conditions and extreme circumstances, is invaluable in shaping the capabilities of AI-driven pilotage systems. The nuanced decision-making, intuition, and situational awareness developed over years of navigating through rough seas or handling exceptional conditions contribute to the training data that feeds into machine learning algorithms. By exposing AI systems to a diverse range of scenarios, including adverse weather conditions, the software learns to adapt and make informed decisions that mimic the expertise of seasoned pilots. This symbiotic relationship between human experience and machine learning facilitates the development of AI systems with enhanced pilotage skills, particularly in situations where quick, precise decisions are imperative.

2.2.3 ESSENTIAL UPDATES IN PUBLICATIONS AND ENC'S

(AND USAGE OF INNOVATIVE 3-D CHARTS)

The integration of Artificial Intelligence (AI) in pilotage within Harbour relies not only on real-time data but also on comprehensive navigational information provided by ADMIRALTY PUBLICATIONS. These publications, including ADMIRALTY TOTAL TIDE and ADMIRALTY SAILING DIRECTIONS, serve as invaluable resources for the AI system. ADMIRALTY TOTAL TIDE, with its extensive tidal predictions, aids in optimizing routes and ensuring vessels navigate through Harbour with precision. The inclusion of tidal data allows AI algorithms to predict tidal influences, enabling proactive decision-making in response to changing water levels.

ADMIRALTY SAILING DIRECTIONS, on the other hand, provides crucial insights into the navigational challenges within the harbour, including recommended routes, anchorage areas, and potential hazards. By incorporating this wealth of information into the AI system, it gains a comprehensive understanding of the harbour's intricacies, allowing for the prediction of various situations and optimal courses of action. The reliance on ADMIRALTY PUBLICATIONS enhances the AI system's ability to adapt to dynamic conditions and make informed decisions, ultimately contributing to safer and more efficient pilotage in Harbour. In essence, the synergy between AI technology and ADMIRALTY PUBLICATIONS empowers the system to navigate the complex maritime landscape with a level of precision and foresight that is essential for the bustling harbour environment.

Artificial Intelligence (AI) is reshaping the landscape of pilotage in Harbour, leveraging cutting-edge technologies and updated maritime publications to enhance safety and efficiency. The incorporation of ADMIRALTY PUBLICATIONS, including ADMIRALTY TOTAL TIDE and ADMIRALTY SAILING DIRECTIONS, is instrumental in providing crucial data for AI-based systems. To keep pace with the evolving maritime environment, updates in these publications are essential. For instance, ADMIRALTY TOTAL TIDE offers tidal predictions, allowing AI algorithms to anticipate and adapt to dynamic tidal conditions within Harbour. Frequent updates in ADMIRALTY SAILING DIRECTIONS provide real-time insights into navigational challenges, helping AI systems make informed decisions based on the latest information. Furthermore, Electronic Navigational Charts (ENCs) play a pivotal role in AI-driven pilotage. Instantaneous updates in ENCs ensure that the AI system has access to the most current and accurate navigational data. This dynamic information is vital for route optimization, hazard avoidance, and overall decision-making within Harbour. The real-time nature of ENC updates enhances the adaptability of AI systems, enabling them to respond promptly to changing conditions and ensuring the safety of vessels navigating through the harbour.

In the quest for innovation, the utilization of 3D charts has gained prominence in enhancing the visualization and understanding of maritime environments. CAMBRIDGE's research paper titled 'Generating 3D Depiction for a Future ECDIS Based on Digital Earth' in 'The Journal of Navigation' presents innovative methods for creating 3D charts. This approach holds significant promise for AI-based pilotage in Harbour. The integration of 3D charts allows AI systems to have a more holistic and immersive understanding of the harbour's topography, enabling better-informed decision-making. The visual representation of the maritime environment in three

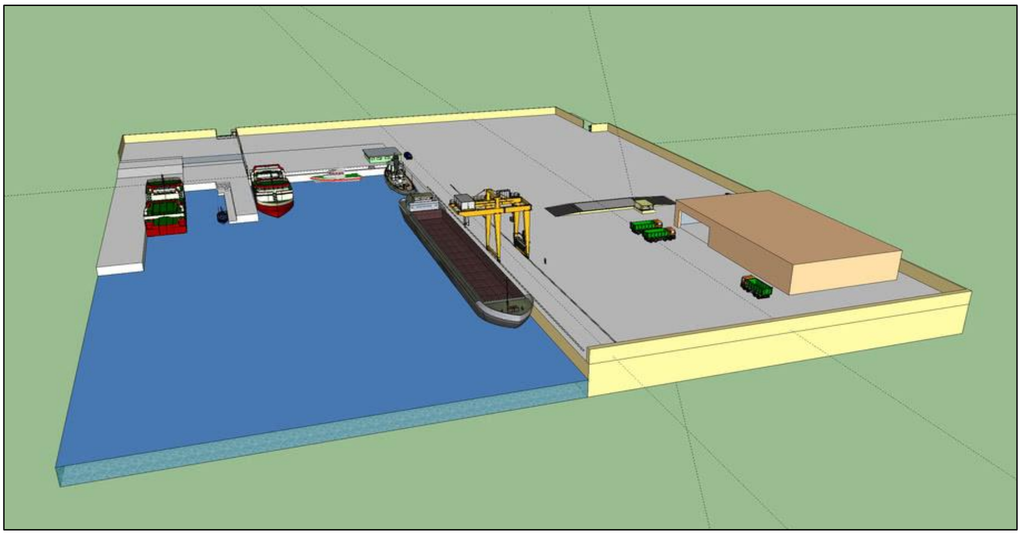

Figure 2. Example of a 3D map

dimensions enhances situational awareness and aids in navigating through complex waterways, contributing to the overall safety and efficiency of pilotage operations.

2.2.4 DRAWBACKS/DISADVANTAGES

Technical Failures and Malfunctions, AI systems are not infallible and can experience technical failures or malfunctions, which could lead to erroneous recommendations or critical system failures during manoeuvring. If AI is working with supercomputers, supercomputers provide high performance speed and can work with very large amount of data and can auto-repair the damages to the system.

Cybersecurity Risks, AI systems used in pilotage are vulnerable to cybersecurity threats such as hacking, malware, or data breaches. An attack on the AI system could compromise critical ship data or control systems, endangering the safety of the ship.

Data Dependence: AI systems rely heavily on accurate and up-to-date data for navigation and decision-making. Inaccurate or incomplete data could compromise the effectiveness of AI algorithms, leading to navigation errors or safety hazards

Complexity and Understanding: AI systems used in maritime pilotage can be complex, requiring extensive training and expertise to understand their functionalities, limitations, and proper usage. Maritime pilots may struggle to grasp the underlying algorithms and mechanisms, leading to potential errors in interpretation or operation.

2.2.5 New STCW requirements

The dynamic landscape of maritime operations in Harbour demands continuous evolution in training methodologies to ensure the competency of maritime professionals. Recent updates in the Standards of Training, Certification, and Watchkeeping (STCW) courses reflect a proactive response to the integration of Artificial Intelligence (AI) and the increasing importance of cyber security in the maritime domain. In recognition of the evolving technological landscape, a pertinent addition to the STCW courses is the inclusion of a dedicated cyber security course. This course equips seafarers with the knowledge and skills needed to safeguard vessels from cyber threats, ensuring the resilience of critical navigation and communication systems.

In parallel, the integration of AI familiarization courses is pivotal in preparing maritime professionals for the adoption of AI technologies in pilotage within Harbour. These courses provide a foundational understanding of AI principles, machine learning algorithms, and their application in navigation systems. By imparting knowledge about AI, seafarers can better comprehend and harness the capabilities of AI-driven pilotage, fostering a harmonious collaboration between human expertise and technological advancements.

While incorporating these AI-focused courses, it is imperative to maintain the relevance of existing mandatory courses. Basic Safety Training (BST) and Ship Security Training for Seafarers with Designated Security Duties (STSDSD) remain integral components of maritime education, ensuring that seafarers possess the essential skills for emergency response and security measures. The synergistic integration of AI-focused courses with the established mandatory courses establishes a comprehensive training framework that addresses both traditional and emerging challenges in maritime operations.

2.3 Results and discussions

1. Feasibility and Efficacy of AI-driven Solutions:

- Evaluate the effectiveness of AI algorithms in optimizing vessel routes, minimizing fuel consumption, and enhancing safety.
- Discuss the impact of AI-powered collision avoidance systems on reducing accidents and improving decision-making for pilots.
- Assess the success of predictive maintenance in minimizing equipment failures and downtime.

2. Implications of Pilotage Regulations and STCW Protocols:

- Analyse the alignment of recent updates in Pilotage by-laws with broader goals of safety, efficiency, and sustainability.
- Evaluate the role of cyber-security measures in safeguarding maritime operations and compliance with STCW protocols.

3. Implementation of AI Technologies in Mass Degrees:

- Discuss the progression and challenges in implementing Maritime Autonomous Surface Ships (MASS) with degrees of autonomy.
- Evaluate the impact of each degree on safety, operational efficiency, and adaptability within harbours.

4. Data Requirements and Utilization:

- Assess the importance of local and global databases in providing essential data for AI-driven pilotage.
- Discuss the role of shore control centers in managing traffic density, tides, and other harbours-related data.

5. Essential Updates in Publications and ENC's:

- Evaluate the contribution of ADMIRALTY PUBLICATIONS in optimizing routes, navigating tidal conditions, and providing insights into navigational challenges.
- Discuss the significance of real-time updates in Electronic Navigational Charts (ENCs) for AI-driven decision-making.
- Explore the benefits of innovative 3D charts in enhancing the visualization and understanding of maritime environments.

6. Drawbacks and Disadvantages of AI-driven Pilotage:

- Discuss potential technical failures, malfunctions, and the role of supercomputers in ensuring system reliability.
- Address cybersecurity risks and the need for robust measures to protect AI systems.
- Explore the challenges associated with data dependence and the complexity of understanding AI systems in maritime pilotage.

7. New STCW Requirements:

- Evaluate the effectiveness of new STCW requirements in preparing seafarers for the integration of AI and cybersecurity measures.
- Discuss the importance of maintaining relevance in existing mandatory courses while incorporating AI-focused training.

The results and discussions should provide a comprehensive analysis of the research findings, including the benefits, challenges, and future implications of integrating AI into pilotage operations within harbours.

CONCLUSIONS

In conclusion, the integration of Artificial Intelligence (AI) in Harbour pilotage represents a transformative shift, promising enhanced safety, efficiency, and adaptability. The research emphasizes the significance of recent updates in Pilotage Regulations and Standards of Training, Certification, and Watchkeeping (STCW) protocols, particularly in addressing cybersecurity and AI integration. The main work outlines the multifaceted purposes and applications of AI in collision avoidance, decision support, predictive maintenance, data analytics, communication enhancements, environmental impact reduction, continuous learning, cost reduction, operational efficiency, risk mitigation, increased throughput, and regulatory compliance. The exploration of Maritime Autonomous Surface Ships (MASS) and the four degrees of autonomy illustrates a progressive transition towards unmanned vessels. The data requirements and utilization section emphasizes the importance of real-time and comprehensive data for effective AI-driven pilotage. Essential updates in publications, including ADMIRALTY PUBLICATIONS and Electronic Navigational Charts (ENCs), are highlighted, along with the role of innovative 3D charts. However, potential drawbacks, such as technical failures, cybersecurity risks, data dependence, and the complexity of AI systems, are acknowledged. The discussion on new STCW requirements underscores the need for continuous training evolution, incorporating AI and cybersecurity courses to prepare seafarers for the evolving maritime landscape. In essence, the comprehensive approach to AI integration, coupled with ongoing training advancements, ensures a harmonious collaboration between human expertise and technological progress, fostering a future of maritime excellence in Harbour pilotage operations.

3.1 Acknowledgement

We extend our heartfelt gratitude to all those who contributed to the completion of this research paper on the transformative potential of Artificial Intelligence (AI) in optimizing pilotage operations within harbours.

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References

[1] www.wikipedia.com/autonomousships
[2] https://www.imo.org/en/MediaCentre/HotTopics/Pages/Autonomous-ships
[3] www.google.com/autonomusships
[4] www.Marineinsight.com
[5] For Video: Shutter stock
[6] https://www.researchgate.net/profile/Gregory-Pretorius/publication/351492188_Remotely_Controlled_AutonomousUnmanned_Ships_in_Rotterdam_Pilot_Waters_Man_or_Machine/links/609a95a4299bf1ad8d937028/Remotely-Controlled-Autonomous-Unmanned-Ships-in-Rotterdam-Pilot-Waters-Man-or-Machine.pdf, 2017
[7] https://www.researchgate.net/profile/Tuisku-Salonen/publication/339875331_Designing_a_remote-pilotage_system_work_styles_to_be_considered/links/5e69f58992851c20f3220df9/Designing-a-remote-pilotage-system-work-styles-to-be-considered.pdf, 2020

HYBRID BOILER SUIT

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ABSTRACT

Global concerns of man overboard incidents and the lack of comprehensive seafarer body condition monitoring, our solution comes in the form of the hybrid boiler suit. Utilizing advanced sensor technology, this unique garment detects potential man overboard situations by identifying erratic movements and physiological anomalies in the wearer. Upon detection, the suit autonomously deploys a small life jacket, offering immediate buoyancy and potentially saving lives. This innovation signifies a significant leap in water safety technology, providing a proactive approach to drowning prevention. Additionally, the suit integrates sensors for real-time monitoring of body temperature, blood pressure, and heart rate, addressing health conditions and enhancing overall safety for individuals at sea.

KEYWORDS

HBS: Hybrid boiler suit, OCMS: onboard crew monitoring system

INTRODUCTION

The Hybrid Boiler Suit stands out for its unique ability to detect drowning scenarios swiftly and respond with an immediate life-saving measure. Equipped with advanced sensors, this safety gear maintains constant vigilance over the wearer. These sensors not only monitor movements but also track vital signs, creating an additional layer of safety. In the unfortunate event of someone falling overboard and facing the risk of drowning, the suit springs into action. It triggers the automatic inflation of a compact life jacket, providing crucial buoyancy and increasing the chances of saving lives in critical situations.

Beyond Emergency Response: Real-time Health Monitoring
This Hybrid Boiler Suit is not limited to reacting to emergencies; it goes above and beyond by actively monitoring the wearer's health in real-time. The incorporation of advanced sensors allows for the continuous tracking of vital health indicators. This feature addresses common issues faced by crew members, such as fatigue, stress, and general health concerns. By keeping a constant eye on the well-being of the crew, the suit becomes a proactive tool that contributes to a safer and more efficient maritime work environment.

A Game-Changer in Maritime Safety
In summary, the Hybrid Boiler Suit represents a paradigm shift in maritime safety, utilizing smart technology to address the critical issue of man overboard incidents. Its proactive approach to drowning prevention, combined with real-time health monitoring, positions it as a vital tool for modern maritime safety protocols.

OBJECTIVE

The main objective of this HBS is to ensure the safety of the crew by providing automatic inflatable suits and also ensures the mental and physical being of the crew through an onboard crew monitoring system [OCMS]

Drowning Detection: Advanced sensors continuously monitor wearer movements and vital signs, enabling swift detection of potential man overboard situations.

Automatic Life Jacket Deployment: In response to a man overboard incident, the suit autonomously triggers the inflation of a compact life jacket, providing immediate buoyancy.

Real-time Health Monitoring: Sensors keep track of the wearer's health, offering insights into fatigue, stress, and overall well-being for enhanced crew safety.

Efficiency in Emergency Response: The Hybrid Boiler Suit not only reacts to emergencies but actively contributes to the prevention of incidents, making it a game-changer in modern maritime safety.

As technology continues to shape the maritime industry, the Hybrid Boiler Suit emerges as a testament to our commitment to advancing safety protocols, embracing innovation, and safeguarding the lives of those who navigate the challenging waters of contemporary maritime operations.

WORKING

HBS is a newly fabricated boiler suit of withs sensor setup and an inflatable specially arranged life jacket material which placed accordingly to blow up on sensing drowning and the sensor setup crew monitoring would help the company and ensuring authorities to verify the physical and mental conditions
We are using This is a newly fabricated boiler which consists of a list of microprocessors and microcontrollers. the main idea of this is to help the victims who are overboard and also to address the issue to ship have the proper surveillance.
If those who are wearing this hybrid boiler suit fall to sea or over boarded suddenly the life jacket folded according to the inflating order will inflate using the air which is given by a chemical process The signal given for reaction is given by the automatic detection of the crew monitoring system or the panic detection system integrated into the suit and we are also providing an emergency switch, which also makes the chemical process happen and after this, an alert will give to the concerned vessel and according the GPS coordinates the other crew onboard can rescue their crew mate.

The sensors that we are using in the suit are:
ESP-8266
HEART RATE SENSOR
THERMOCOUPLE SENSOR
GPS
MAX30102

BATTERY (rechargeable)
PULSE OXIMETER
SPLASH SENSOR
These are the sensor that is integrated in the suit the ESP8266, THERMO COUPLE, HEART RATE SENSOR, MAX30102, AND PULSE OXIMETER helps the system to recognize the person's body conditions and detect drowning since the data show that if a person is drowning his heart rate, body temperature will vary from the normal and it will show varying values and from these data, we could understand the person's physical condition. This will give a signal to the controller to activate the chemical reaction and inflate the life jacket. The splash sensor will detect the sudden splashing of water and give signals to the controller to activate the chemical reaction. We will be also arranging an emergency distress button to physically inflate the jacket if the system fails. These signals will alert the controller to generate electric pulse to act in the cartridge for filling air. Chemical called sodium aside, NaN3. When this substance is ignited by a spark it releases nitrogen gas which can instantly inflate an airbag. The problem, however, is that the reaction also forms sodium metal which reacts with moisture to generate sodium hydroxide, a highly corrosive substance. A burst airbag could wreak havoc. Chemical ingenuity, however, came to the fore. If potassium nitrate and silicon dioxide were also included with the sodium aside, the only products that would form in addition to nitrogen would be potassium silicate and sodium silicate. Both of these are inert, harmless substances.

In the meantime, there will be a distress message and the GPS coordinates of the person will be sent to their concerned vessel for help

SOLUTION

1. There few Men overboard cases and crew monitoring issues mentioned which have helped and HBS and OCMS are standing as a possibility for these concerns
2. UK MAIB has issued an update on fatal man overboard from fishing vessel name LAURA JANE, where a crewman was dragged overboard after his leg became entangled in fishing gear
3. Crew Member falling from cruise ship AIDA Perla
4. Grappling with shortage of seafarers, report from sea trade maritime news

CONCLUSION

In conclusion, the development of the hybrid boiler suit (HBS) presents a groundbreaking solution to address the global concerns surrounding man overboard incidents and the lack of
comprehensive seafarer body condition monitoring. This innovative garment, equipped with advanced sensor technology, not only detects potential man overboard situations but also proactively responds to them by autonomously deploying a small life jacket, providing immediate buoyancy and potentially saving lives.

The primary focus of this solution is to enhance water safety and prevent drowning incidents at sea. The HBS distinguishes itself by identifying erratic movements and physiological anomalies in the wearer, signaling a potential man overboard situation. The integration of sensors for real-time monitoring of body temperature, blood pressure, and heart rate further adds a layer of comprehensive health condition monitoring, addressing the broader spectrum of safety concerns for individuals at sea.

One of the key advantages of the HBS is its ability to offer immediate assistance in critical situations. By deploying a small life jacket autonomously, the suit ensures that individuals in distress have a timely and effective means of staying afloat while awaiting rescue. This proactive approach to drowning prevention is a significant leap in water safety technology, potentially reducing the tragic consequences of man overboard incidents.

The detailed paper explores various scenarios and incidents where the implementation of the HBS could have made a substantial difference. Case studies highlight situations in which the HBS could have detected early signs of distress, enabled a swift response, and prevented accidents. These examples underscore the real-world applicability and life-saving potential of the hybrid boiler suit in maritime environments.

Beyond its life-saving capabilities, the HBS contributes to the overall well-being of seafarers by providing continuous monitoring of vital signs. The integration of sensors for tracking body temperature, blood pressure, and heart rate ensures that health conditions are promptly identified, allowing for early intervention and medical assistance if needed. This comprehensive approach to body condition monitoring addresses a critical aspect of seafarer safety that has been previously overlooked.

In the broader context of maritime safety, the HBS represents a paradigm shift towards proactive risk mitigation. Traditional safety measures often focus on reactive responses to emergencies, but the HBS takes a proactive stance by identifying and addressing potential dangers before they escalate. This shift not only enhances individual safety but also contributes to the overall safety culture within the maritime industry.

In conclusion, the HBS is not just a piece of protective gear; it is a holistic safety solution that addresses multiple facets of seafarer well-being. From preventing man overboard incidents to monitoring vital signs, this innovative garment represents a significant advancement in water safety technology. The detailed paper provides a robust foundation for the adoption and implementation of the HBS, showcasing its potential to revolutionize maritime safety practices and save countless lives at sea.

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REFERENCE

[1] Hamish Mureddu- Reid (2023), News report on man overboard BBC

[2] Ismail Cicek Ph.D. (2019), a report on Maritime Investigation Reports Involving Man overboard (MOB) causalities: A METHODOLOGY FOR EVALUATION PROCESS 2019

[3] Paying, L.M. King, S. S. Dol, 2015, “A Review on Marine Search and Rescue Operations Using Unmanned Aerial Vehicles” International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering Vol: 9, No: 2, 2015

[4] Salem tubas, 2014“Motion Detector Alarm Project” https://twinschip.com/index.php?route=pavblog/blog&id=41.,Accessed at (14 June 2017)

[5] Kaseko Yun, and Sang-Shin Lee, 2014, “Human Movement Detection and Identification Using Pyroelectric Infrared Sensors”, 2014,

[6] Henry C Bowman (2009), Sunderland news report

APPLICATIONS OF QUANTUM SENSORS IN SHIPPING

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ABSTRACT:

Merchant ships when sailing in water tend to use GPS which is also called as Global Positioning System so as to navigate from one location where the cargo is picked to other location where the cargo is supposed to be discharged, but this GPS system fails in many ways as it has many drawbacks that are like if there is even 1ms of error then it might cause an error of 300kms in terms of distance also there are many jammers being installed that tend to cause disruption in the GPS connectivity and ultimately it hinders the navigational performance of the ships and because of these errors there are many accidents happening now and then due to issues of the GPS like the collision of 2014 between MV FRANCISCA and MV RMS BREMEN. So, we tend to replace these GPS practices onboard and develop a Quantum sensor which basically works upon the principles of quantum mechanics like the quantum entanglement, the Schrödinger wave equations, quantum tunnelling and quantum superposition principle. So, by using these principles we tend to develop a Quantum Accelerometer which can detect the position, speed and time taken by the vessel to reach from one location to another.

KEYWORDS:

Global Positing System, Trilateration principle, Quantum superposition theorem, Quantum Entanglement, Schrödinger wave equations, Quantum tunnelling, Interferometer and Quantum state of caesium particles

INTRODUCTION:

QUANTUMN MECHANICS is mainly a branch of science that deals with the mathematical description of the motion and interaction of subatomic particles, incorporating the concepts of quantization of energy, wave–particle duality, the uncertainty principle, and the correspondence principle, so quantum mechanics finally came into existence when the scientists discovered that light is neither a particle nor a wave and it exhibits two natures as a single state which ultimately came out to be known as the quantum state.

The Navigation in the shipping industry mainly depends upon the GPS (Global Positioning system) that works upon the trilateration method in which to determine exact the position of the vessel we require the distance of that vessel from at least 3 known points so that's why we have 3 satellites that 3 known points that measures the distance of the vessel and each satellite draws a concentric sphere and the intersectional point of these 3 spheres from there a straight line is drawn and that line wherever it reaches it determines the position of the object.

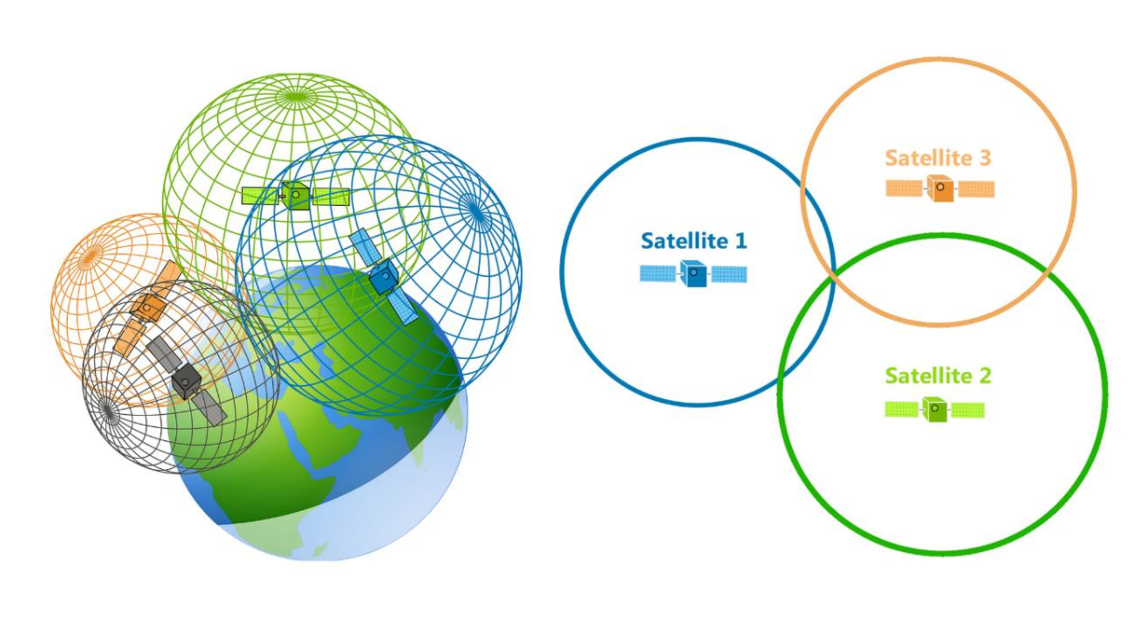

Figure 1. Trilateration Principle on which Navigational GPS works.

These GPS systems although are very efficient and complex systems but yet posses a lot of disadvantages such as:

1. Calibration Error-_If there is even 1ms of error in the calibration of GPS it can cause a difference of up to 300kms in terms of distance.
2. Poor signal quality in some areas which tends to cause a lot of accidents.
3. GPS locations can be easily tracked if jammers are installed within the system, so it can also lead to terror attacks and hijacking of the ships.
4. GPS systems also tends to have a long learning curve.
5. GPS also acquires high cost of usage.

All these disadvantages ultimately hinder the safety of the seafarers, so that is why we replace this complex GPS systems and by using the principles of quantum mechanics we tend to develop a quantum accelerometer which is a type of quantum sensor that measures the speed, time and distance travelled by the object. This quantum accelerometer is 1000 times more accurate, precise, and sensitive then classical sensors.

According to classical mechanics to determine the state and dimension of the object we require the (x, y, z) coordinates of the object as well as all the 3 types of rotations an object could adhere in its position.

So, in this quantum sensor we mainly use caesium particles as they have high excitation state, high electron gain enthalpy and this particle is also capable of being stable when brought under 0Kelvin temperature where it will exhibit its quantum state and when brought under quantum state the caesium particles will exhibit wave-particle dualism and it will tend to interact with the outside particles that are present outside the sensor periphery. This particle interaction is detected by an optical ruler which further leads to the plotting of Speed-Time graph and from this graph we tend to determine the position of an object.

PRINCIPLES OF QUANTUM MECHANICS THAT GOVERNS THE SENSOR:

1.Quantum Entanglement- This principle of quantum mechanics came into existence in the year 1900s and was discovered by Max Born and further researched by Neils Bohr. So, it was this time that Einstein and Thomas Young had already discovered that light is neither a particle nor a wave and light also tend to not follow the laws of classical mechanics mainly invented by Newton.

But this quantum entanglement theory opened new areas and conspiracies of the microscopic world and it became a breakthrough in the department of Modern Physics.

The quantum entanglement principle mainly states that when 2 or more particles come closer to each other then there is a thin thread like structure between them through which they tend to share their individual state information and then they become entangled to each (the properties of the particles are identical to each other) which means that if you take one of the entangled particles anywhere in the universe and then destroy that particle then the other particle also gets destroyed faster than the speed of light. This phenomenon when it was observed and proved mathematically lead Einstein to question about his Theory of Relativity.

As Einstein's Theory of relativity states that nothing can travel faster than the speed of light as light is massless in nature and if any particle having mass 'm' travels with the speed of light then the mass of that particle will tend to infinity and that particle could potentially no longer exist.

This led to an argument between Einstein and Neils Bohr as Neils Bohr stated that as information that is being exchanged between the two particles is also massless so it can travel faster than the speed of light. So, ultimately this theory of quantum mechanics was quoted as 'SPOOKY' by Einstein as he said that there could be the possibility of hidden variables or operators that could potentially explain this phenomenon.

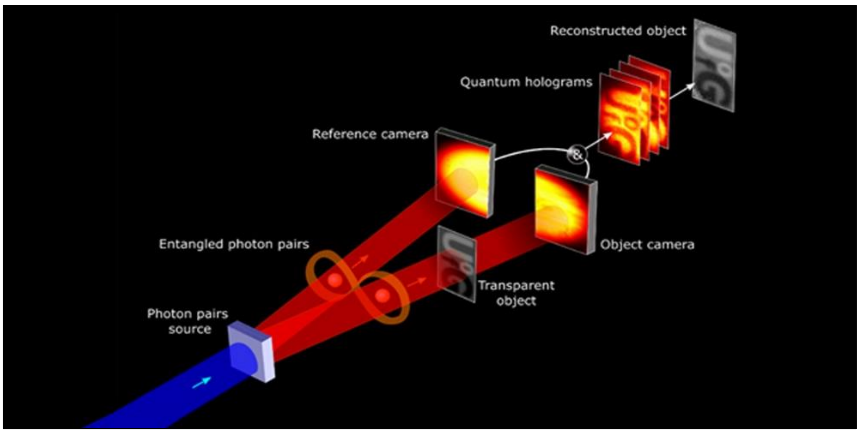

Figure 2. Entangled Photons that are further used in reconstruction of an object.

2.Schrodinger Wave Equation- The Schrodinger wave Equation was invented by SIR Erwin Schrodinger in the year 1926. This equation describes the behaviour, position, and state of the particle in time dependent and time independent environment.

Heisenberg's Uncertainty principle states that it is very difficult to determine the position and momentum of an electron at a same time, if we find the position of an electron then it is impossible to find its momentum and if we find the momentum of an electron then it is impossible to find its position.

$$\Delta x.\Delta p \geq nh/2\pi \qquad [1]$$

Where,

- X= Position
- P= Momentum
- H= Planck constant
- n= No of shells

So, Sir Erwin Schrodinger came up with his wave equation that describes about the presence probability of an electron in a particular dimension. This equation comprises of complex conjugate and mathematical operator such as the Hamiltonian operator(H) and PSI operator(ψ). Both operators mainly define the kinetic energy, spin orbitals and momentum of an electron in free space (time independent) and we mainly use these operators as a function of time (t) in case of time dependent space.

The derivation of this equation comes by determining the definite momentum, Angular Momentum, Characteristics of a particle in a line segment and circle, Harmonic oscillator, and Electron in a magnetic field.

Electron Momentum Equation:

We shall obtain solution of Schrödinger equation for a particle with a definite momentum in space without any constraints.

$$\Delta^{2\psi(r)} + \frac{2mE}{h^{2\psi(r)}} = 0 \qquad [2]$$

This equation mainly describes the momentum of an electron in any space for time independent frame.

Where,

$\Delta^{2\psi(r)}$= Momentum Operator with respect to the eigen values of r and ψ.

$\frac{2mE}{h^{2\psi(r)}}$= Hamiltonian operator with respect to the energy (E) of the electron in free space.

So, by partial differentiation and integrating this above equation 1 with respect to r$\psi(\vec{R} \rightarrow 0)$ we will get the Schrodinger's wave equation as:

$$H\psi = E\psi \qquad [A]$$

Where,

- H= Hamiltonian operator
- E= Energy operator
- Ψ= PSI (It will operate both E and H with respect to the state of the particle in terms of spin, momentum, and position)

3.Quantum state of a particle- According to the classical physics theory a body with a definite mass m can exist in only one state, but as the wave particle dualism nature of the light was discovered it became very much essential for the scientists to determine the state of particles in the microscopic world.

Any particle when brought to the 0kelvin temperature scale tends to exhibit its quantum nature which mainly means that the particle unless and until observed can exist in its particle state as well as wave state. This is also called as 'Cold Atom Interferometry.'

Sir Erwin Schrodinger conducted a hypothetical experiment in which he placed a cat inside a box and that box also consists of a flask filled with a radioactive element and on top of this flask there was a hammer which was connected to a controller, as we give input to the controller it activates the hammer which then breaks the flask and the radioactive element gets spilled in the box where the cat is present, all this was conducted when the box was closed now from this experiment there are a total of three possibilities and they are that the cat is dead or is it alive or it can also be that the cat is living in both the states either dead state or alive state. So, he inferred from the experiment that unless and until the box is not open the cat can be assumed to be in a quantum state which means that it can be dead or alive unless and until not disclosed. This behaviour of particle came to be known as quantum state of the particle.

4.Quantum Superposition of a particle- It is defined as the ability of the particle to be present in different states until measured. If we consider a qubit particle that can exist in states (0) and (1) and let's assume we have 'n' number of states present and each state is represented by (ψ1, ψ2, ψ3,….,ψn) so from this we can say that a state when not under observation according to the Schrodinger's equation can be written as:

$$\sum_{i=1}^{n} |Ci|^2 = 1 \quad [3]$$

Where the (ψ) state can be represented as a complex conjugate form as

$$\langle \psi \rangle = C_i < O| + C_2 < 1| \quad [4]$$

The equation 4 mainly represents the (0) and (1) of the qubit state present at a same time with respect to the PSI operator.

So, from both these equations above we can say that a particle tends to coexist in both the states unless and until they are not observed as we keep the value of n=1 we tend to get the operator as ψ1 whose value is 1 and if we keep the value of n=I then we get the value as 0 as it exist in the imaginary axis, but if the value of n is not known then the qubit could lie in between 0 and 1 or it could exist in 0 as well as 1, this is called as the Quantum state of Superposition.

5.Quantum Tunnelling- It is a quantum mechanical phenomenon when a particle can penetrate through a potential energy barrier that is higher in energy than the particle's kinetic energy. This phenomenon when was observed became another breakthrough in the field of modern physics as this phenomenon can be latterly used in tunnelling microscopes as well as for studying radioactive decay and thermal effects also.

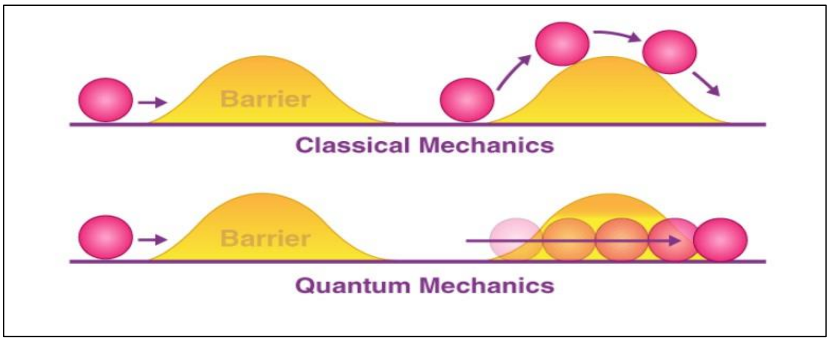

Fig. 3. Tunnelling concept in terms of Classical mechanics an Quantum mechanics.

6.Quantum Lasers or Atomic Lasers-The word laser is defined as 'Light Emission Through Stimulated Emission and 'Radiation'. Lasers are not considered as Light Amplifiers but they are called as Light Emitters, now as they are called as light emitters they don't tend to emit light like traditional light emitting sources as laser is a more akin to radio and microwave transmitters and produces a highly directional coherent monochromatic light beam. These lasers are made to generate or emit a light of certain spectrum to excite the particle in its quantum state. Based upon its construction and the type of light being emitted by the laser there are different types of lasers available to use but the laser which we are going to use to excite and re-excite the caesium particles in our quantum sensor is called as 'Photonic Laser'. The radiation incident on a material I viewed as a stream of photons, where each photon carries a energy E and after when the interaction with other atom takes place there is a difference in the energy levels which is denoted as (E2-E1)=hv where (E=hv) and here (h=Planck's Constant) and (v=Electromagnetic Radiation Frequency). When the photons of the photonic laser travel through the medium to excite the caesium particle they tend to go through different processes like Absorption, Spontaneous Emission and Stimulated Emission.

We would tend to go through each of these processes in detail so as to understand the behaviour of photonic laser when interacting with other particles.

<u>ABSORBTION-</u> Suppose an atom is in the lower energy level E1. If the photon of energy (E2-E1) =hv is incident on the atom, then it imparts its energy and disappears. Then we say that an atom has absorbed an incident photon and as a result that atom which has absorbed the incident photon rises to a higher energy level which ultimately leads to more particle interaction in the particular dimension (x, y, z). This is called as absorption transition.

$$A + hv = A^* \quad [5]$$

Where A is an atom in the lower state and A^* is an atom in the excited state.

<u>Spontaneous Emission-</u> An atom cannot stay in the excited state for a long period of time it can only stay in its excited state for about 10^-8s, as after that the atom reverts to its old energy by releasing hv amount of energy. SO, emission of a photon by an atom without any external impetus is called as spontaneous emission. We can write this process as

$$A^* \rightarrow A + hv \quad [6]$$

<u>Stimulated Emission-</u> According to Albert_Einstein he stated that 'If a photon can stimulate an atom to move from lower energy level (E1) to a higher energy level (E2) by the means of absorption transition then it can also be able to stimulate same upper energy level atom (E2) to lower energy level (E1). This property of Photonic Laser is called as Stimulated Emission.

WORKING OF QUANTUM SENSOR BASED ON THE PRINCIPLES GOVERNING IT:

A sensor is basically a device which senses the changes in the physical quantities and generates an electrical signal out of it which is being sent to the controller so that necessary actions can be taken to eliminate the errors being generated.

A quantum accelerometer is a type of sensor that mainly measures on how fast an object travels with respect to time.

So, our quantum sensor mainly works upon the cold atom interferometry where we mainly take caesium atoms from a hot caesium oven as caesium is considered to have lowest boiling point, lowest melting point, High density, and it has also stable state at zero or ground potential.

So, we use caesium particles and then we tend to it bring at 0 kelvin temperature scale where these caesium atoms tend to exhibit its quantum nature (as discussed above). This process of bringing the caesium particles at 0 kelvin temperature is called as Cold Atom Interferometry.

The cold atom interferometry is a method in which we use an atomic laser which is a analogous of photonic lasers as photonic lasers tend to generate a coherent of electromagnetic waves, these atomic lasers tends to generate Matter Waves and matter waves are defined as the waves which works upon the principle of De-Broglie Hypothesis and it tends to describe the relationship between momentum and wavelength, So we use these atomic lasers so as to cool the caesium particles that are being generated from the hot caesium oven.

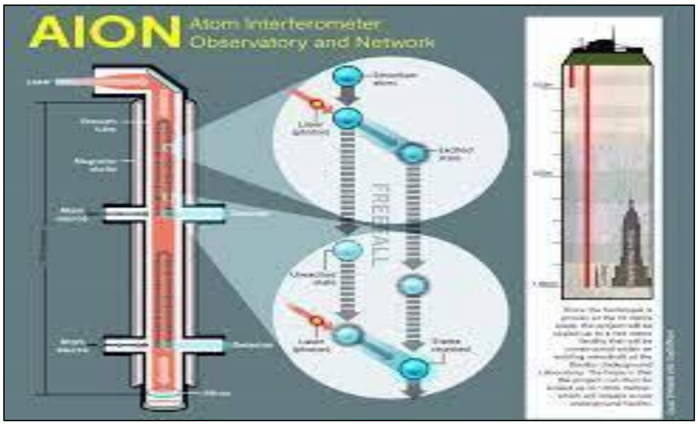

Figure 4. Atomic Interferometer

The cold caesium particles will start to exhibit its quantum state and then we will excite the caesium particles using the Photonic Laser and because of the Absorption Transition phenomenon the caesium particles will get divided into two states and they are 1) High Excited caesium particles and 2) Low Excited caesium particles. The more the excitation the more the particles will tend to interact and exchange their energy with other particles present in the surroundings, to increase this excitation we again Re-Excite the low excited caesium particles using the photonic laser. So, this increase in the excitation levels will tend to increase more particle interaction and energy exchange between them, each caesium particle in its quantum state will deliver its excitation energy and it will become de-excited and will return to its lower energy levels.

So, these particle interactions are being detected by the Optical Ruler and then this ruler sends the results to the controller which then generates the Speed-Time graph based on the inputs provided and then from this graph it is easy to find the position of the object. So, in this way we are able to generate the position of the object in all the 3 axes of rotations and dimensions respectively.

ADVANTAGES OF QUANTUM SENSORS

1. High Precision, Accuracy and Sensitivity- These quantum sensors are 1000 times more accurate than the global positioning systems.

2. No chances of jammers Installation- As the quantum sensors are housed in the vessel itself and it tends to interact with particles present in the surroundings to determine the position of the object, so it is nearly impossible to install jammers in these sensors.

3. Increased safety standards of the crew- These quantum sensors are so advanced that it can detect and warn even a minute change in whether as well as any potential obstacle or barrier in the passage plan, and this could significantly decrease the rate of accidents of ships and ultimately increase the safety standards on-board.

4. Low Maintenance- This sensor requires very low maintenance which mainly involves cleaning of the equipment and changing over of atomic laser and Photonic lasers once in every 1 and 3 years, respectively.

5. Higher analysed data- This mainly means that quantum sensor is capable of even detecting the minute changes in the electric and magnetic fields so, the data generated by this sensor very accurate and perfect for the determination of the position of the object.

6. Calibration is Not required- As it measures physical quantities against atomic properties. Hence, there is no drift and moreover it not required to be calibrated.

In summary we can say that the quantum sensors can do far more than classical sensors could ever do. This level of data acquisition, precision, ability to interact and detect changes at the microscopic levels and also decide the probability of threat so that necessary actions could be taken in advance.

CONCLUSION:

This paper presented the state-of-the art in quantum technology with a focus on the ones that could have applications for maritime navigation. Inertial sensors or Quantum accelerometers that are starting to become of a size compatible with the dimensions of today's marine autonomous vehicles. For this technology, the paper discussed their maturity levels and their main advantages and limitations with respect to classical methods. Quantum technologies might hold the key to solve several existing challenges in robotic navigation, potentially in the submarines so as to reduce DVL (Doppler Velocity Lag) and the paper includes indications, based on the authors' findings, on what might be promising technologies that could have an important impact for maritime autonomous navigation**.**

REFERENCES:

[1] N. Subrahmanyam, Brij Lal, M.N. Avadhanulu "A Textbook of Optics" Pg 573 - 580

[2] Trilochan Pradhan "Quantum Mechanics" Pg 8 - 60

[3] Prof K Venkatesan "A Textbook of Quantum Mechanics" Pg 234-256

[4] Olga Sambataro, Riccardo Costanzi, Joao Alves, Andrea Caiti, Pietro Paglierani, Roberto Petroccia, Andrea Munaf` o∗ Senior Member, IEEE, "Current Trends and Advances in Quantum Navigation for Maritime Applications: A Comprehensive Review".

Supply Chain Resilience and Global Trade

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ABSTRACT
Global trade heavily relies on the resilience of supply chains, with the maritime industry playing a pivotal role in ensuring smooth and efficient transportation of goods. This paper explores the challenges and opportunities for enhancing supply chain resilience in the context of the maritime industry. Factors such as geopolitical tensions, natural disasters, and the ongoing digital transformation are examined for their impact on global trade dynamics. The study emphasizes the need for proactive measures, technological innovations, and international collaboration to build resilient supply chains in the face of uncertainties. Insights from this research contribute to a better understanding of the interconnectedness of global trade through the maritime sector.

KEYWORDS
Supply Chain, Resilience, Global Trade, Multimodal Integration, Regulatory Compliances.

1. INTRODUCTION

Supply chain resilience is of utmost importance in the context of global trade and the shipping industry. The interconnectedness of supply chains across borders and the reliance on efficient transportation and logistics make resilience crucial for ensuring the continuous flow of goods. Organizations involved in global trade must prioritize resilience to navigate the complexities and uncertainties inherent in the international supply chain landscape.
The importance of shipping in global trade lies in its ability to provide a reliable, cost-effective, and scalable means of transporting goods across the globe. It is the backbone of the international supply chain, fostering economic development, supporting businesses, and improving the quality of life for people around the world.

2. RELATIONSHIP BETWEEN SUPPLY CHAIN AND GLOBAL TRADE

The relationship between the supply chain and global trade in the shipping industry is highly interdependent. The efficiency and effectiveness of the supply chain are directly influenced by the capabilities and performance of the shipping sector, and, conversely, global trade heavily relies on the smooth functioning of supply chain logistics.
The relationship between the supply chain and global trade in the shipping industry is also symbiotic. Shipping is the enabler of global trade, providing the physical means for goods to move across borders, while the supply chain relies on efficient shipping operations to ensure a seamless and cost-effective flow of products from manufacturers to end consumers. Successful coordination and collaboration between shipping and supply chain management are essential for optimizing the overall performance of international trade networks.
Shipping facilitates the integration of international supply chains. Companies source raw materials, components, and finished products from different countries, and shipping is the mode of transportation that connects these disparate elements of the supply chain. It

enables an uninterrupted flow of goods across borders, contributing to the globalized nature of supply chains.

The efficiency of the shipping industry directly impacts the timeliness and reliability of the supply chain. Delays, disruptions, or inefficiencies in shipping can lead to bottlenecks in the supply chain, affecting production schedules, inventory levels, and ultimately, the ability to meet customer demand.

2.1 Disruptions and the importance of resilience

In a world where disruptions, be they natural disasters or geopolitical tensions, have become the norm rather than the exception, understanding how organizations can fortify their supply chains becomes paramount. The ripple effects of disruptions can reverberate globally, impacting economies, industries, and the livelihoods of countless individuals. The relationship between supply chain resilience and global trade

2.2 Globalization and Interconnected Supply Chains

Global trade involves the movement of goods across international borders, and supply chains are often spread across various countries. A disruption in one part of the world can have a cascading effect on the entire supply chain. Resilient supply chains are better equipped to absorb and recover from such disruptions.

2.3 Dependency on Efficient Shipping

The shipping industry is a backbone of global trade, responsible for transporting the majority of goods between countries. Disruptions in shipping, such as port closures, transportation bottlenecks, or delays, can have a significant impact on the timely delivery of goods. A resilient shipping industry is essential for maintaining the integrity of global supply chains.

2.4 Just-In-Time Inventory Practices

Many industries, particularly those engaged in global trade, follow just-in-time inventory practices to minimize holding costs. This makes them vulnerable to disruptions because there is little buffer stock available. Supply chain resilience becomes crucial to adapting to unexpected delays or shortages.

2.5 Geopolitical and Economic Uncertainties

Global trade is influenced by geopolitical events, trade policies, and economic fluctuations. Resilient supply chains can adapt to changes in regulations, tariffs, or political environments, minimizing the impact of uncertainties on the movement of goods.

2.6 Natural Disasters and Climate Change

The shipping industry and global trade are susceptible to natural disasters and the impacts of climate change. Resilient supply chains incorporate strategies to cope with disruptions caused by events such as hurricanes, earthquakes, or rising sea levels.

2.7 Technological Advancements and Digitalization

The integration of technology and digitalization in the shipping industry enhances supply chain visibility, traceability, and responsiveness. Resilient supply chains leverage these technologies to monitor and manage the movement of goods efficiently.

2.8 Trade Route Diversification

Relying on a single trade route or transportation mode increases vulnerability to disruptions. Resilient supply chains diversify trade routes, utilizing multiple modes of transportation (such as sea, air, and land) to ensure flexibility and continuity in the movement of goods.

2.9 Global Supply Chain Collaboration
Collaboration among countries, companies, and stakeholders in the supply chain is essential for building resilience. International cooperation facilitates information sharing, coordinated responses to disruptions, and the development of best practices for global trade resilience.
2.10 Regulatory Compliance and Trade Agreements- Resilient supply chains stay abreast of changing regulations and trade agreements, ensuring compliance and adapting strategies accordingly. Understanding and navigating the regulatory landscape is crucial for the smooth operation of global trade.

3. IMPACT OF MAJOR ACCIDENTS ON GLOBAL TRADE-
3.1 Evergreen ship stuck in Suez Canal
On 23rd of March 2021, the ship got stuck in the canal and it took roughly 150 hours (which is 6 days) to salvage the ship. Normally 50-70 ships everyday carrying 12-13% of world trade. Because of this blockage 370 vessels were stuck on both sides over the course and hence the stake holders faced a loss of $57 billion. The Suez Canal Authority also faced a heavy loss and in compensation the authority demanded more than 900 million USD from the company which was settled at 550 million USD according to court's judgement.
The stuck ships took a whole week to clear the traffic.

3.2 Russia-Ukraine War
The Russian Federation's (hereafter "Russia") war of aggression against Ukraine has had both a significant direct impact on the maritime sector notably by disrupting maritime activities in the area. The war is likely to have further structural impacts on maritime trade routes and maritime decarbonisation.
The war has directly affected maritime transport in the Black and Azov seas, including a halt of the activities in Ukrainian ports and the export of agricultural products through the Black Sea.
Longer-term impacts can be expected, such as changes in trading routes, a consequence from the war and of its sanctions, and changes in energy demand and costs. For instance, the war has contributed to longer shipping routes and, an increasing demand for LNG-carriers, due to the interruption of gas supply via pipelines from Russia to Europe, while significantly increasing the operating cost of LNG-fuelled vessels following the increase in gas prices in 2022. This may also impact the further decarbonisation of the maritime sector. Finally, the war contributed to an increase in the number of ships that operate as a "dark fleet," vessels with unclear ownership, no insurance and with maintenance which is below standards.
3.3 Houthi Attack
The Houthis portray their attacks on ships in the Red Sea as an act of solidarity with Palestinians. They hope that the costs of the trade disruptions will encourage Western governments to pressure Israel into accepting a ceasefire in Gaza.
The significantly heightened risk of attack has caused shipping companies to reconsider transiting the Suez Canal via the Red Sea. Between December 15 and 19, 13 shipping operators announced suspensions of their trips to and from Israel or their voyages transiting the Red Sea.

Analysts tracking cargo insurance have seen a sharp increase in insurance rates for Red Sea and Bab al-Mandab voyages. These rates, which are typically 0.6 percent of the value of the cargo on a ship, are now up to 2 percent

For Europe-Asia voyages, a diversion to the Cape of Good Hope increases shipping time by 30 to 50 percent. According to International Monetary Fund data as of January 22, 2024, the seven-day rolling average of Bab al-Mandab passages has dropped to 46 percent compared to the same period last year. Suez Canal passages are at 63 percent compared to the previous year.

Egypt's Suez Canal revenues have taken a hit due to ship diversions. As of January 12, 2024, revenues are down 40 percent in comparison to 2023 levels.

Drewry's World Container Index—which tracks the average price of transporting a 40-foot (ft) container on a cargo ship— jumped from $1,521/40 ft on December 14, 2023, to $3,777/40 ft as of January 18, 2024.

Shanghai to Los Angeles cargo rates jumped from $1,985/40 ft to $3,860/40 ft between December 14, 2023, and January 18, 2024.

While these numbers suggest immediate increases in prices, other economic elements will factor into the cost of shipping in the long run. According to the Financial Times, carrier companies have ramped up their purchasing of vessels. Between 2022 and 2025, the global capacity of container shipping is expected to increase by around 25 percent, helping to control prices.

3.4 Panama Canal

Around 1,000 ships pass through the Panama Canal each month carrying a total of over 40 million tons of goods—about 5 percent of global maritime trade volumes. But water levels in this vital link between the Atlantic and Pacific oceans have fallen to critical lows because of the worst drought in the canal's 143-year history. Drought restrictions imposed amid insufficient rainfall at the Gatun Lake, which feeds the canal, have reduced throughput by some 15 million tons so far this year. Ships have faced an additional six days in transit. The authorities are exploring strategic options to boost the water supply in the canal.

Ports in Panama, Nicaragua, Ecuador, Peru, El Salvador, and Jamaica are suffering most from these delays, with 10 percent to 25 percent of their total maritime trade flows affected. But the drought's effects are felt as far away as Asia, Europe, and North America. The drought will hamper trade for months to come, with canal passages set to halve to 18 ships per day by February, down from 36 in ordinary times. Economies reliant on the canal for trade should prepare for more disruption and delay.

4. MULTIMODAL INTEGRATION AND SUPPLY CHAIN CONNECTIVITY

Multimodal transportation, also known as intermodal transportation, refers to the movement of goods using multiple modes of transportation, such as rail, road, water, and air, in a coordinated and an integrated manner. It involves the seamless transfer of packages between different transportation modes to optimize efficiency, cost-effectiveness, and sustainability.

4.1 How multimodal transportation benefit supply chain and logistics business

Multimodal transportation is a game-changer for supply chain and logistics businesses, offering a range of benefits that streamline operations, reduce costs, and enhance customer satisfaction. One of the key advantages is enhanced efficiency. By integrating multiple modes of transport such as rail, road, water, and air, companies can leverage the strengths of each mode to optimize the movement of goods.

- Increased Flexibility: Multimodal transportation provides supply chain businesses with greater flexibility in managing their logistics operations. By utilizing multiple modes of transportation, companies can adapt to changing circumstances, such as fluctuations in demand, disruptions in certain transportation routes, or specific requirements of different markets. This flexibility enables businesses to optimize their transportation routes, reduce lead times, and meet customer demands more effectively.
- Improved Reliability: Reliability is a crucial aspect of supply chain management. Multimodal transportation offers an opportunity to mitigate risks associated with relying solely on a single mode of transport. For example, if a trucking route experiences unexpected delays or closures, the ability to switch to rail or water transport ensures a continuous flow of goods and minimizes disruptions. By diversifying transportation modes, supply chain businesses can enhance the reliability and resilience of their operations.
- Cost Optimization: Multimodal transportation allows supply chain businesses to optimize their transportation costs. By selecting the most cost-effective mode of transport for each leg of the journey, companies can reduce overall transportation expenses. For instance, using rail or water transport for long-haul segments can be more economical than relying solely on trucks. Additionally, the consolidation of goods at intermodal terminals and the use of standardized containers contribute to economies of scale and reduce handling costs. By minimizing transportation costs, businesses can improve their profitability and remain competitive in the market.
- Enhanced Efficiency: Multimodal transportation improves overall supply chain efficiency. By leveraging the strengths of different transportation modes, businesses can achieve faster transit times and better utilize transportation infrastructure. For example, using air transport for time-sensitive goods and combining it with other modes for the rest of the journey allows for quick and efficient delivery. Furthermore, intermodal terminals play a vital role in optimizing efficiency by facilitating smooth transfers between modes, reducing waiting times, and improving the coordination of transportation activities.
- Reduced Environmental Impact: Sustainability is a growing concern for businesses and consumers alike. Multimodal transportation helps supply chain businesses reduce their environmental impact. By shifting some of their transportation activities from road to rail or water, companies can significantly decrease carbon emissions and fuel consumption. This contributes to their environmental sustainability goals and can also help them comply with regulatory requirements related to emissions and environmental stewardship.
- Improved Customer Satisfaction: Multimodal transportation can positively impact customer satisfaction. With faster transit times, improved reliability, and more efficient logistics operations, businesses can enhance their service levels and meet customer expectations. The ability to offer flexible delivery options, such as expedited air transport or cost-effective rail transport, allows businesses to cater to diverse customer needs. Moreover, by minimizing delays and disruptions, multimodal transportation helps businesses deliver products on time, thereby building trust and loyalty with customers.
- Global Reach: Multimodal transportation enables supply chain businesses to expand their reach and tap into global markets more effectively. By seamlessly combining different modes of transport, companies can navigate complex international supply chains and overcome geographic barriers. For instance, combining ocean freight with trucking or rail

transport allows goods to be efficiently transported from seaports to inland destinations. This global reach opens up opportunities for businesses to access new markets, source materials or products from diverse locations, and expand their customer base.

- Improved Inventory Management: Multimodal transportation can contribute to better inventory management practices. With faster transit times and reliable transportation options, businesses can reduce inventory holding costs and improve inventory turnover. The ability to optimize transportation routes and choose the most efficient modes also allows for better coordination between supply chain partners, leading to improved visibility and accuracy in tracking and managing inventory.

4.2 Multimodal transportation disadvantages

Despite its numerous benefits, adopting multimodal transportation can come with its own challenges that businesses must navigate. Awareness of these challenges enables companies to devise strategies to mitigate them effectively.

- More Paperwork: With multiple modes and carriers involved, administrative tasks are often increased. The paperwork can pile up from different billing documents to various insurance requirements.
  However, digitalizing operations and using integrated logistics platforms can streamline these processes, reducing the administrative burden.
- Inability or Poor ability to track shipments: Switching between various modes might lead to blind spots in shipment tracking. This can create uncertainty about the cargo's exact location. Implementing advanced tracking systems and ensuring communication between different carriers can provide real-time updates, improving transparency.
- Supply chain Disruptions: The involvement of different modes means there's potential for disruptions, especially if one mode faces delays. This can have a ripple effect on subsequent modes. To counteract this, businesses can establish contingency plans and maintain open lines of communication with all involved parties to adapt swiftly to unforeseen changes.
-

5. REGULATORY COMPLIANCE AND INTERNATIONAL STANDARDS

Trade compliance means complying with international export, trade, and financial laws.

International trade compliance regulations and best practices compliance remain challenging. Regulations vary depending on the country and type of goods. Some countries have import controls. Other countries have stringent customs regulations. Trade agreements and international regulations may change rapidly with little warning, owing to a volatile international trade environment.

Every global business has a global supply chain — as such, they must deal with multiple government agencies when trading in the same country. Other times they must abide by sanctions in line with their countries' foreign affairs policies.

Standards are the distilled wisdom of people with expertise in their subject matter and who know the needs of the organizations they represent – people such as manufacturers, sellers, buyers, customers, trade associations, users, or regulators.

For instance,

5.1 Quality management standards to help work more efficiently and reduce product failures.

5.2 Environmental management standards to help reduce environmental impacts, reduce waste and be more sustainable.

5.3 Health and safety standards to help reduce accidents in the workplace.

5.4 Energy management standards to help cut energy consumption.

5.5 Food safety standards to help prevent food from being contaminated.
5.6 IT security standards to help keep sensitive information secure.

6. CONCLUSIONS

In recent years the introduction of new environmental and security regulations has influenced the way supply chains are operated globally. Maritime operators have been in search of optimal strategies to improve performance while complying with regulatory requirements in an increasingly complex regulatory framework. This research establishes a link between environmental and network resilience performance for maritime supply chains and provides a methodological framework to analyze the impact on global trade.

7. ACKNOWLEDGMENT

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8. References

[1] https://www.cnbc.com/2021/03/25/suez-canal-cargo-ship-blockage-could-cause-problems-for-the-globe.html

[2] https://www.imf.org/en/Blogs/Articles/2023/11/15/climate-change-is-disrupting-global-trade

[3] https://www.cnbc.com/2021/03/25/suez-canal-cargo-ship-blockage-could-cause-problems-for-the-globe.html

[4] https://www.inboundlogistics.com/articles/multimodal-transportation/

[5] https://www.iso.org/standards.html

[6] https://youtu.be/VzxDpIl8uAk?si=zxibnbQJ3PJoSHgK

Human Factors and Crew Welfare

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ABSTRACT

This research delves into the intricate dynamics of human factors and crew welfare, recognizing their pivotal role in complex operational environments. Focusing on domain like maritime sector the study investigates the multifaceted influence of human factors on overall performance, safety, and mental health within crewed settings. By analysing specific stressors and ergonomic considerations, the aim is to develop targeted interventions and strategies that can optimize crew welfare, thereby enhancing operational effectiveness and the overall quality of work life for individuals in these demanding contexts.

KEYWORDS

1) Safety of crew
2) Implications of crew welfare
3) Criminalization of the seafarers

MAIN TEXT

- **Ship's Crew**

The definition of crew can be seen in Article 1 paragraph (42) of Law No. 17 of 2008 which states that, "crew members are crew members other than the skipper". The crew certainly has a strict selection through certain qualifications so that the ship can sail well and minimize all potential problems at sea.

Clauses on the minimum requirements that crew members must meet to work on ships, as set out in the provisions of the MLC (Maritime Labour Convention) 2006 held in Geneva, Switzerland, covering minimum age limits, health certificates, training and qualifications, and recruitment and placement systems on ships. This is reaffirmed in Article 17 of PP No. 7/2000 on Maritime Affairs, which explains that, to be able to work on a ship as a crew member, you must meet requirements such as a seafarer skill certificate and / or seafarer skill certificate; be at least 18 years old; be physically and mentally healthy based on the results of a medical examination specifically conducted for that purpose; and be licensed.

Qualifications for crew members are certainly needed to overcome any problems that may occur while the ship is sailing at sea

- **Living Conditions**

Cabin space should meet international standards for size and amenities, ensuring seafarers have a comfortable and private space. Adequate ventilation and temperature control are crucial for creating a healthy living environment. Regular maintenance and cleanliness of living areas contribute to the overall well-being of the crew.

- **Healthcare**

Vessels should be equipped with medical facilities and trained medical personnel. Regular health check-ups, especially before and after long voyages, help identify and address potential health issues. Access to essential medications and medical resources is vital to handle common illnesses and emergencies.

- **Training and Development**
  Ongoing training programs should cover safety procedures, emergency response, and the use of new technologies. Opportunities for career development and skill enhancement contribute to job satisfaction and professional growth.
- **Mental Health Support**
  Counselling services should be available to address the mental health challenges faced by seafarers. Education and awareness programs can help reduce the stigma associated with seeking mental health support. Providing recreational activities, hobbies, and entertainment options on board helps alleviate stress and monotony.
- **Communication Facilities**
  Reliable internet access allows seafarers to stay connected with their families, reducing feelings of isolation. Communication tools should include satellite phones and email services, ensuring continuous contact even in remote areas.
- **Fair Employment Practices**
  Ensuring fair wages and timely payment is crucial for the financial well-being of the crew. Implementing reasonable working hours and adequate rest periods prevents fatigue and enhances overall job satisfaction.

Fig.1: Day to day activities on-board

- **Factors Undermining Seafarers' Mental Health**

There are many factors that may be considered to undermine seafarers' mental health and wellbeing. Some of these can be seen as factors that are generic across the occupation and others relate more to some shipboard positions than others. Generic predisposing factors that may be regarded as inherent to the seafaring profession overall include isolation and loneliness, lack of shore leave, bullying, fear of criminalisation and separation from family.

There is little consensus over which roles on board carry higher challenges for mental health. However, there is agreement that risk exposure in terms of mental ill health does vary with rank and role on board. Officers are generally regarded as having more psychiatric problems than ratings However, both engineers and engine crew have also been identified in the literature as more prone to mental health problems than other seafarer's other factors have also been linked to differences in mental health outcomes among seafarers. Shift work has been identified as a risk factor by Jepsen et al and

Filipinos have been identified as less likely to present with psychiatric disorders on because of both pre-employment medical screening and under-reporting

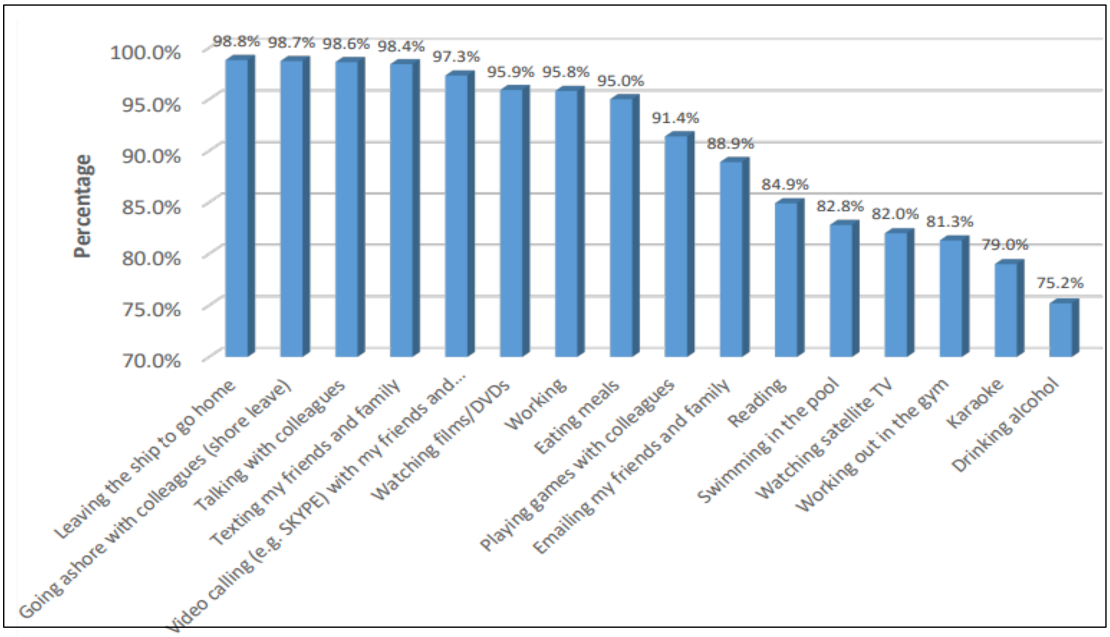

Fig.2: Things that made seafarers happy/very happy on-board ship

- **Implications for crew welfare**

In the Appendix to the Regulation of the Minister of Transportation of the Republic of Indonesia Number PM 10 of 2021, it explains the costs and salaries of crew members as operational costs in the cost and revenue components calculated in the implementation of public service obligations in the field of sea transportation. The cost and salary components of crew members in this regulation are as follows:

1. Basic Salary

Costs incurred as a reward given to the Skipper and crew according to the rank and class of employees whose amount is determined by the National Sea Transportation Executive in accordance with the provisions of the Laws and Regulations.

2. Fixed Allowance

The allowance given to the Skipper and crew every month by considering the class of position and is not influenced by attendance (sailing) and work performance.

3. Command Allowance

An allowance given to skippers and crew members with certain positions, including skipper, chief, chief mate 1 and machinist 1, which is given every month, the amount of which is determined by the National Sea Transportation Executive.

4. Professional Allowance

Special allowances given to doctors and nurses assigned to ships whose amount is determined by the National Sea Transportation Executive.

5. Leave Allowance

Allowance given to the skipper and crew for annual leave given at the end of the year proportionally

6. Income Tax Allowance

Allowance given to skipper and crew for payment of PPH (gross up method) amounting to the amount of income tax payable each month.

7. Operational Allowance for Labaran

Allowances to Shipmasters and crew who provide services to passengers to support Labaran, Christmas and New Year transportation.

8. Education Allowance

An allowance given to the skipper and crew which is at least one time the total salary (Take Home Pay) of the last month given in the middle of the year during the new school year proportionally.

9. Work Performance Incentive Allowance

A fixed allowance given to Ship's Captains and crew members, which is calculated based on the class of position and the level of employee attendance. The amount of Work Achievement Incentive Allowance is determined by the national sea transportation implementer after being reported to the Director General of Sea Transportation no later than 5 (five) working days before it is determined.

10. Telecommunication Allowance

An allowance given to Captains and crew members of vessels.

- **Criminalization of the seafarers**

  In past many years it has been seen that crew, master, or any maritime professional faces criminal charges due to an unfortunate accident. This accident may involve vessel, which caused damage to the port or territorial waters of a country, environment or damage to person or property. This is calling the criminalization of the seafarers. Most of the time when a charge is brought against the captain of the ship which caused the damage, there is a wrong belief that it had an intention on the part of him to commit the offence. Mostly such criminal charges are brought against the seafarers with a wrong belief that it had a malefice intention to commit the offence. However, it is obvious to know that unpredicted incidents may not always need malefice intention behind their commission. Generally, due to lack of knowledge on the part of the authorities, the seafarers being nearest to the site of the accident are prosecuted by the local laws of the country, where such incident took place, even though they may be sailing on a different nationality flag or themselves being from some other country.

Fig.3: Pirate attack on ship and crew

- **Some Surveys Indicates that:**

- ✓ Nearly 24% of Masters have faced criminal charges
- ✓ With 50,000 ships trading internationally, and about 65,000 Masters, that is 15,600 Masters.
- ✓ In addition, the survey states that 8% of seafarers have faced criminal charges.
- ✓ Estimations indicate that there are about 1,187,000 serving seafarers, so at 8%, that is 94,960 serving seafarers that have faced criminal charges, or put another way, two crewmembers for every vessel at sea

- **Work-Family Conflict and Work Alienation Among Seafarers**

Ships, which deliver more than 80 % of international trade, are one of the main drivers of globalization The seafarers who operate these ships are the unsung heroes who ensure the transportation of vital cargoes such as food, medical supplies, fuel, and clothing in times of global crises. Seamanship differs from onshore occupations with its working conditions and is among the most challenging professions in the world.

Seafarers working on shipping routes are away from family and social life for months due to the nature of the job. Being on board for long voyages or short voyages with frequent ports of call can create stress. This includes living, working, resting, and having a limited social life in the same environment, not being able to leave the ship at the end of the shift or duty, insomnia, insufficient social opportunities and communication, noisy and closed working spaces, the possibility of marine accidents and living alone. Seamanship is associated with stressors that can cause mental disorders, and two of the important factors that trigger this association are loneliness and family. In seamanship, which is a profession where work–family conflict is experienced the most, seafarers who try to balance the requirements of work and family roles find themselves in intense conflict when they fail. Long-term absences from family life form the basis of this conflict and affects the attitudes of family members because each time seafarers board a ship during their profession, the time they spend with their families decreases. Work-family conflict and emotional exhaustion are closely associated because stressors that can cause trauma on the ship can turn into burnout over time.

Seafarers who see their partners as a source of emotional strength may experience emotional exhaustion on ships where they are exposed to prolonged loneliness. This is an issue that needs to be paid attention. A study conducted by Thomas indicated that emotional health problems caused by communication difficulties are severe enough for seafarers to consider suicide on board.

Factors affecting seafarers' performance is the conflict between work and family life. Seafarers experiencing this conflict and longing for their families may not be able to fully perform their duties on board. A study conducted by Mansyur at all. revealed that tugboat crew members who experienced work–family conflict suffered approximately three times more fatigue.

CONCLUSION

The present study found that work-family conflict positively predicted work alienation among seafarers, and this association was partially mediated by emotional exhaustion. In recent years, many maritime companies have checked the mental health of seafarers using psychotechnical tests when recruiting them. When seafarers fail these tests, they cannot join the ship and they are likely to be unemployed. Based on this rationale, seafarers may conceal their emotional burnout during the medical. Sea Labor Agreement is an agreement that must be recognized by a government official appointed by the Minister. The crew as human resources in the field of transportation also have the right to obtain work protection in the form of welfare, occupational safety, and occupational health which must be provided by the employer in accordance with the provisions of laws and regulations and work agreements.

REFERENCES

[1.] www.researchgate.net
[2.] http://piracy-studies.org/managing-security-risks-at-sea-a-challenge-for-the-shipping-industry/
[3.] https://clydetravel.com/the-challenges-with-crew-changes-in-maritime
[4.] https://iosh.com/media/6306/seafarers-mental-health-wellbeing-full-report.pdf

Prioritizing Crew Welfare for sustainable development of the maritime industry

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ABSTRACT:

In today's work environment, the wellbeing of the crew plays an important role in maintaining the sanity and commitment of the workforce. When an organization gives importance to the physical and psychological wellbeing of the crew members, it builds a culture of responsibility and concern towards the organization. The sense of accountability is cultivated which becomes a driving force for the development of the organization along with the industry. The recognition of the crew welfare needs by the organization and industry will bring about the sustainable growth of the maritime industry.

KEYWORDS:
Crew welfare, physical health, psychological health, sense of accountability, sustainable development

INTRODUCTION:

Creating a positive onboard environment enhances communication and nurtures a collaborative spirit among seafarers. This approach is not merely a good business practice; it is a fundamental aspect of ensuring the well-being of seafarers, rather than providing financial aid alone.
The term "welfare" is clarified to emphasize that it goes beyond financial assistance and encompasses the overall wellness of seafarers. While safety awareness and practical knowledge are consistently promoted, the welfare of seafarers is deemed essential for safe ship operations, acknowledging that a ship cannot be operated safely if the crew is burdened by welfare issues.
A moment of quiet reflection is suggested to bring awareness to the challenges faced by seafarers signing on or off, recognizing their exposure to natural elements and the pressures encountered during ship-to-shore interactions in ports.
We need to acknowledge the evolving nature of seafarers' welfare support and underscore the historical enactment of regulations to protect seafarers. Today we need to stress upon the aspect that seafarer's welfare is not only a matter of compliance but is intrinsic to ensuring safety for those working at sea. Overall, we need to advocate for a comprehensive approach to seafarer welfare, considering both physical and mental well-being, to foster a safer and more supportive maritime industry.

BACKGROUND

The maritime industry stands as a key trunk of worldwide commerce, facilitating the movement of goods and capital across the world's oceans. As the industry progresses, it's clear that attaining viable evolutionary demands with thorough advancement towards amalgamating social, ethical, and economic factor. Despite being crucial to the maritime workforce, the wellbeing of seafarers is frequently disregarded or given less importance. Seafarers, encountering extended periods away from home, tackle distinctive dares that bump their physical and mental wellbeing. The onerous nature of seafaring characterized by separation, meticulous schedules, and subjection to brutal ecological conditions, frequently leads to intensifying tensity levels and mental health issues among seafarers. Moreover, giving importance to the safety and security of seafarers throughout their journeys is decisive. Over the course of its evolution, the Maritime sector has witnessed significant changes, adjusting to shifts in economic conditions and technological improvements.

Nevertheless, the attention to crew welfare hasn't kept pace with other advancements. The human aspect of shipping is frequently underestimated or regarded as a passing matter, resulting in substantial repercussions for seafarers and, consequently, the industry at large. This paper aims to bridge this notable gap by investigating the hardships encountered by seafarers and advocating for the prioritization of crew welfare as a fundamental pillar of sustainable development within the maritime sector. Through an analysis of the interdependence among economic, environmental, and social factors, this paper aims to underscore the significance of cohesive policies and initiatives that advance the welfare of maritime professionals. Through this endeavor, it aims to enrich the wider conversation on building a sustainable and empathetic future for the maritime industry.

OBJECTIVE

The aim of this paper is

-To investigate and analyze the current challenges faced by seafarers in the maritime industry

- To focus on the need for crew welfare and its outcome on the sustainable growth of the maritime industry

- To give some recommendations for crew welfare and sustainable development of the maritime industry

CHALLENGES FACED BY SEAFARERS:

Seafarers face many challenges in their profession. The *Isolation and Mental Health Issues* are prominent due to extended periods at Sea. Seafarers often spend long durations away from their families and friends. This isolation can lead to feelings of loneliness, depression, and anxiety.

Along with that *limited connectivity* at sea exacerbate feelings of isolation, making it challenging for seafarers to stay connected with their support networks.

The working Conditions and Safety Concerns along with *Psychological Safety* is another major condition. The workload, long hours, and the nature of their job involves dealing with complex machinery and equipment, leading to high levels of stress and fatigue. The aspect of 'Psychological Safety' i.e. the importance of mental well-being is sometimes overlooked, leading to an environment where seafarers may be hesitant to report psychological concerns due to fear of being humiliated, stigma or career repercussions.

As outlined in Maritime Admiralty Law article, navigating *onboard politics and conflicts* aboard vessels poses a significant challenge for seafarers. The continuous interaction with individuals of diverse generations and varying mindsets blurs the lines between personal and professional spheres, given the 24/7 nature of their work. Despite a commitment to avoiding involvement in onboard politics, the inability to do so becomes a compelling reason for some maritime workers to depart from their vessels. Additionally, limited crew members on board can lead to fatigue and burnout.

The implications of *extended periods at sea* on physical and psychological health is serious. The limited accessibility onboard can result in delayed treatment for illnesses or injuries. The family separation, health of loved ones, relationship strain makes the work-life balance difficult.

The concern of *Harassment and Bullying* is prominent these days. At times, the hostile work environment may be experienced by the seafarers from colleagues, superiors, or even passengers, contributing to a stressful and unhealthy work environment. No provision or lack of awareness on reporting mechanisms of such incident may make seafarers more stressful to manage onboard.

SUSTAINABLE DEVELOPMENT AND CREW WELFARE IN THE MARITIME INDUSTRY:

The UN 2030 Agenda for Sustainable Development, established by all UN Member States in 2015, outlines 17 Sustainable Development Goals (SDGs). These goals focus on global cooperation to handle poverty issues, improve health and education, minimize inequality, promote economic growth, address issues of climate change, and preserve oceans and forests for a sustainable future.

Sustainable development in the maritime industry and ensuring the welfare of the crew are interconnected goals. A holistic approach involves addressing environmental, economic, and social aspects. Here are considerations for achieving sustainable development while prioritizing crew welfare and Wellbeing-

-Fair Wages and Conditions: Ensure that seafarers receive fair wages and establish reasonable working hours and conditions to promote their physical and mental well-being.

-Healthcare Access: Provide access to quality healthcare services for seafarers, both during their time at sea and while in port.

-Mental Health Support: Address the mental health challenges faced by seafarers by offering counseling services, creating awareness programs, and fostering a supportive work environment.

- Training and Skill Development: Continuous Learning and providing opportunities for ongoing training and skill development to enhance the capabilities of seafarers, preparing them for evolving technologies and industry requirements are the needs. Prioritizing safety training to mitigate the risks associated with the maritime profession, and reducing accidents and injuries are of utmost importance.
- Ethical Labor Practices such as Anti-Harassment and anti-bullying policies need to be implemented and enforced in order to create a safe and respectful workplace for seafarers. Additionally, promoting fair and ethical recruitment practices to prevent exploitation and human rights abuses in the hiring process is a must.

- Community Engagement: The local community support to ensure that maritime activities benefit the areas in which they operate, providing employment opportunities and supporting local economies.

- Digitalization for Efficiency such as Smart Shipping which embrace digital technologies for optimized route planning, predictive maintenance, and efficient logistics to improve overall operational efficiency, reduce fuel consumption, and enhance crew well-being.

International Collaboration based on Global Standards with international organizations, governments, and industry stakeholders to establish and adhere to global standards for sustainable maritime practices and crew welfare can be done.

The integration of sustainable practices into the maritime industry should be accompanied by a commitment to the well-being of the crew, creating a balanced and responsible approach to the sector's development. By addressing the above considerations rigorously in the industry can contribute to a more sustainable and humane maritime future.

POLICIES AND INITIATIVES:

There are policies and initiatives carried out my International Maritime Organization (IMO), Industry best practices, Case studies of successful welfare programs.

International Maritime Organization (IMO):

- Maritime Labour Convention (MLC, 2006): It mentions minimum working and living conditions for seafarers, emphasizing health, safety, and welfare.
- International Safety Management (ISM) Code: It ensures the safety of ship operations and the wellbeing of the crew through managing the risks and focusing on continuous improvement.

Flag States:

- National legislation: Regulations are enforced by every country to safeguard seafarers' welfare, concentrating on aspects such as working hours, rest periods, and medical care.
- Flag State inspections: They adhere to international standards and national regulations, including provisions for seafarers' welfare.

Port States:

- Port State Control (PSC): Inspections are performed by port authorities to confirm compliance with international conventions, including seafarers' welfare requirements.
- Port welfare committees: Concentrated on shared initiatives for enhancing the welfare of seafarers during their stays in ports.

Shipping Companies:

- Company policies: Guidelines have been made by shipping companies to ensure the welfare of seafarers, covering areas like working conditions, medical care.
- Crew welfare officers: Designated welfare officers are nominated to address concerns and provide necessary support.

Seafarers' Welfare Organizations:

- International Seafarers' Welfare and Assistance Network (ISWAN): Offers guidance and supports the welfare initiatives through various programs, including helplines, training, and port welfare services.
- Mission to Seafarers: Provides support services, including welfare centers, counseling, and emergency assistance, to seafarers globally.

TECHNOLOGY AND INNOVATION:

The Safetytech Accelerator, as highlighted by Lloyd Register, is exploring various initiatives to enhance the well-being of seafarers through technology. Among these initiatives is a mobile application utilizing visual and audio analytics to provide regular updates on the emotional well-being of seafarers.

These technologies engage artificial intelligence to analyze speech and behavioral patterns, suggesting insights into whether a crew member is experiencing fatigue, distress, lethargy, or other indicators of potential mental well-being issues.

Captain Faouzi Fradi, the Group Director for Crewing and Training at Columbia Ship Management, has revealed that the company is actively collaborating with multiple vendors and partners to implement technological solutions intended at enhancing the wellbeing of its seafarers.

As part of the comprehensive welfare package, the company is incorporating telemedicine services along with features such as nutrition planning, hygiene management, and onboard education. Captain Fradi emphasized the company's approach of consolidating these services into a unified package managed cohesively, aiming for sustainable solutions to address the varied needs of seafarers.

Improved connectivity at sea enhances crew welfare and reduces isolation during long voyages. It enables online training, continuous learning, and skill development. Reliable bandwidth also allows for telehealth services, ensuring that crew members can access medical care remotely. These developments contribute to a more sustainable working environment for those at sea.

RECOMMENDATIONS:

1. Develop Crew Welfare Standards: Strengthening the implementation and enforcement of crew welfare standards across the maritime industry. Regular review and updating of these standards will ensure alignment of these standards as the needs and challenges are the ongoing process faced by seafarers.

2. Advancement in Research and Development: Allocating the resources to support research and development initiatives with the focus on improving working conditions of the seafarers. Encouraging innovation in areas such as health and safety, living conditions, and mental wellbeing to enhance overall job satisfaction and performance.

3. Raise Industry Responsibility: Encourage a culture of responsibility and care within the maritime industry. This includes emphasizing the wellbeing of crew members as a priority, encouraging ethical practices, and holding industry stakeholders accountable for maintaining high standards of safety and welfare.

4. Establish Alliance: Building collaboration among shipping companies, maritime organizations, maritime training institutes, and relevant stakeholders will help in mindful detection of the issues. Establishing platforms for sharing best practices, insights, and innovations that contribute to the overall improvement of working conditions and crew welfare will be a major positive change.

5. Provide Training and Education: Implementing training programs to raise awareness about the importance of crew welfare and the implementation of related standards is necessary. Ensuring that all personnel, from ship management to crew members, are well-informed and equipped to contribute to a positive and supportive working environment.

6. Standard Industry Assessments: Conducting regular assessments of industry practices and compliance with crew welfare standards can help in building some uniformity. The survey and findings at regular standards will help to identify areas for improvement, address emerging challenges, and adapt regulations as needed to meet the evolving needs of seafarers.

7. Seafarer Welfare Organizations: Collaborating with and taking support from seafarers' welfare organizations will provide assistance, resources, and support to crew members. Encouraging the partnerships between industry stakeholders and these organizations to enhance the overall welfare ecosystem.

8. Mental Health Support: Prioritizing the mental health support for seafarers by implementing programs that for the concerns such as stress, isolation, psychological safety, anti-harassment and anti-bullying, and other mental health challenges faced during extended periods at sea need to address. In-house psychologists need to be appointed by maritime organizations, maritime training institutes to ensure the mental wellbeing of the cadets and seafarers during and after the training will remove the stigma and crew will feel comfortable to seek assistance when in distress.

9. Technology for Welfare: Using technological solutions to improve communication, access to information, and overall wellbeing for seafarers can be helpful. Utilizing digital platforms to enhance connectivity with loved ones, provide access to educational resources, and offer entertainment during voyages can keep the happiness index high on prolong level.

10. Recognize and Reward Best Practices: Recognizing and rewarding shipping companies and maritime organizations that prove exemplary commitment to crew welfare will create positive competition and incentivize the adoption of best practices across the industry.

11. Continuous monitoring: Continuous monitoring of traditional and conservative mindsets is necessary to avoid the conflicts/politics/harassment onboard. Helping seafarers through training and counseling to modify will help in positive work environment onboard.

CONCLUSION:

Prioritizing crew welfare is essential for the sustainable development of the maritime industry may occur by adopting a focused approach. This involves understanding and acknowledging the challenges faced by seafarers, technological advancement and required training. Recognizing the concerns at the root level is crucial, efforts should concentrate on foundational issues to drive advancements. Ensuring the right attitude across maritime organizations, training institutes, and government entities is pivotal. By collectively fostering a culture that values and supports seafarers, the industry can contribute to sustainable development and a healthier working environment.

REFERENCES:

[1] Crew Welfare: The challenges of seafarers' life onboard. The Editorial Team August 8, 2023

[2] How can the maritime industry meet Sustainable Development Goals? An analysis of sustainability reports from the social entrepreneurship perspective

[3] J. Mar. Sci. Eng. 2021, 9(1), 74; https://doi.org/10.3390/jmse9010074 Innovation in the Maritime Industry

[4] Mental health challenges facing seafarers, Julian Longson 25 June 2021

[5] Oleksiy Melnyk, April 2023, "FOCUSED RESEARCH ON TECHNOLOGICAL INNOVATIONS IN SHIPPING INDUSTRY: REVIEW AND PROSPECTS"

[6] Osman Arslan [a], Tuba Kececi [b], Murat Selcuk Solmaz [c], Hasan Bora Usluer, August 2023, Science Direct, "A social sustainability model for maritime labour force based on card sorting, fuzzy AHP & QFD method"

[7] Maritime Admiralty Law article, https://maintenanceandcure.com/maritime-log/why-do-seafarers-quit-their-jobs-at-sea/Why Do Some Seafarers Quit Their Jobs at Sea?

[8] Maritime Policy & Management-The flagship journal of international shipping and port research Volume 47, 2020 POMS 22nd Annual Conference Reno, Nevada, U.S.A. April 29 to May 2, 2011

[9] Maritime must tackle seafarer crew challenges with greater transparency.

[10] Development of sustainbale practices for maritime industry.K.G. Kaveesha Methmini

[11] Xueqin Wang a b, Kum Fai Yuen b, Yiik Diew Wong b, Kevin X. Li a, January 2020

[12] https://www.lr.org/en/knowledge/industry-news/2022/role-of-technology-in-improving-seafarer-safety-and-wellbeing/

[13] 10 Problems Affecting Seafarers Today https://www.marineinsight.com/life-at-sea/5-problems-affecting-seafarers-today/MARPRO October 9, 2023

[14] https://technode.global/2021/09/15/the-importance-of-technology-in-improving-seafarer-welfare/

[15] https://sdgs.un.org/goals

[16] https://doi.org/10.1016/j.trd.2019.11.002Get rights and content

[17] https://www.pomsmeetings.org/confpapers/020/020-0355.pdf

[18] https://safety4sea.com

[19] https://www.tradewindsnews.com/opinion/maritime-must-tackle-seafarer-crew-challenges-with-greater-transparency/2-1-1029697
[20] https://ciltinternational.org/education-development/publications-articles/publication/development-of-sustainable-practices-for-maritime-industry/

A Proposal for Alternate Berthing of Ships

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ABSTRACT

Berthing a ship is a highly complex process which has seen high accident rates, especially while handling hazardous cargo it becomes more dangerous. Currently available alternate berthing techniques include vacuum and magnetic berthing which demand additional technical expertise as well as upkeep. To mitigate the existing accident rate, a mechanical berthing approach-MECHBER is proposed that will necessitate minimum human intervention. This system is based on extended mechanical arms which are fastened to a ship in addition to rubberized supporting structures which incorporate movements of ships degrees of freedom towards a safe and effective berthing of ships.

KEYWORDS

Mechanical Berthing, Accidents, Human Safety, Autonomous ships.

INTRODUCTION

The Marine Industry is heading towards a face change by adopting Autonomous technology and is aiming towards Unattended Machinery ships, the industry is focusing on alternate fuels and dual fuels also. But still, we must bring in an effective and economic development in berthing methods. We are still sticking with the conventional berthing methods in most of the ports. The process of berthing a ship is a multifaceted one that involves the cargo ship, tugboat, mooring lines, and other environmental, topographical, and human elements. The safety of the berthing system on hazardous cargo ships must be guaranteed by using highly efficient boats, ships, and equipment, as well as by the exercise of extraordinary caution and attention to detail.

According to navigation experience, ship berthing is the dynamic process of manoeuvring a ship to berth, which is a challenging task even for seasoned shipmasters and pilots. It is also easy to fall into an emergency or even cause accidents while encountering unexpected events (such as a gale, strong current, misjudgement, or underestimation). Currently, the process of berthing is a crucial part of maritime transportation, and numerous studies have examined it from various angles. From the standpoint of risk analysis or assessment, it is vital to determine the influencing elements of ship berthing operations to prevent berthing mishaps (such as collisions, fires, oil spills, and groundings) in harbours or ports. Achieving autonomous berthing, which is one of the clever tactics used by marine ships, has received increased attention with the swift

development of Maritime Autonomous Surface Ships (MASS). The under actuated properties of berthing ships become the key problem for automatic berthing control because low-velocity motion impairs the ability of ships to move. To counter these challenges, studies are going on, and the implementation of Magnetic berthing and vacuum berthing are results of the same.
Therefore, the motivation behind this paper is to propose a new method of berthing other than the prevailing ones. We tend to make this method more economical, effective and easy to operate. Instead of making this whole berthing complicated by adding in new technologies, we can utilize the MASS and berth the ships using mechanical arrangements by adapting the design and working existing cranes in the ports.

METHODOLOGY

The structure of this paper is further divided into 2 stages.

In Stage 1, we will be studying the background and relevance for comparing the existing berthing techniques such as conventional berthing, Magnetic berthing, and Vacuum berthing and the disadvantages or improvements to be made to them through the papers available and various analyses made on similar topics

In Stage 2, will consist of a rough sketch with a brief ideation of how this new mechanical berthing will be better and more effective than the ones mentioned above and how it will help to reduce accidents without investing too much technologically and financially, which in turn will benefit both the seafarers and the shipping companies at the same time.

STAGE I BACKGROUND & RELEVANCE

Comparison of Existing Berthing methods.

a) Conventional Berthing

Windlass and mooring ropes are used in a traditional mooring system. To hold the vessel in place, the mooring lines must be kept taut. Windlasses, which may have electric or hydraulic driving motors, enable tension. When moored alongside, mooring lines secure the vessel. The rope tension is affected by ship movements, loading and unloading procedures, and environmental factors such as wind, tide, and current. For the vessel to be held properly, the ropes should be at their ideal tension. Increased tension could lead to rope breakage, which could result in major losses or injuries. Reduced tension could lead to the vessel giving away from the quay. Because of this, maintaining a constant eye on things and adjusting the rope tension in response to shifting circumstances is essential when working alongside. Four linemen are needed on shore to handle ropes, while about six crew members are needed on board when using a traditional mooring method. Depending on the size of the vessel, the crew for a mooring operation may vary. Before the mooring operation, the mooring crew predisposes themselves. For mooring operations, they arrange and plan their ropes and places. Planned ropes are sent out to the linesmen when the vessel approaches the quay so they can use bollards on land to make fast. All ropes are sent out and the mooring procedure is finished after the vessel is in the required position at the dock.

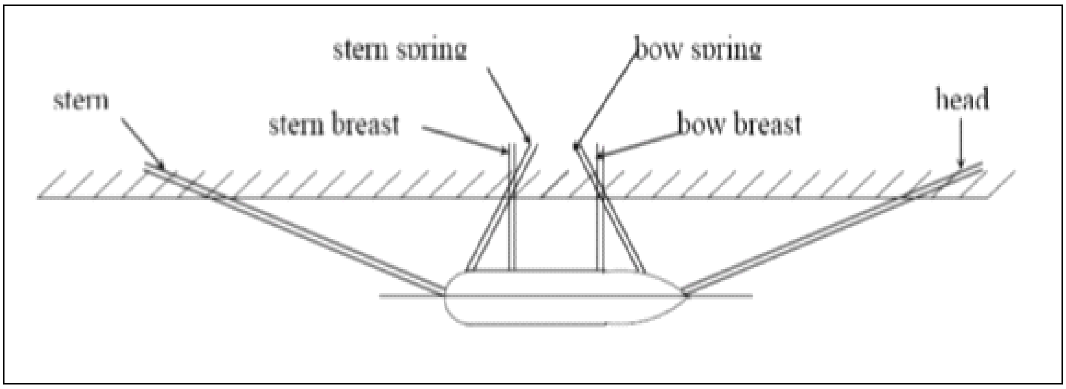

Fig.1.1: Conventional Mooring Arrangement

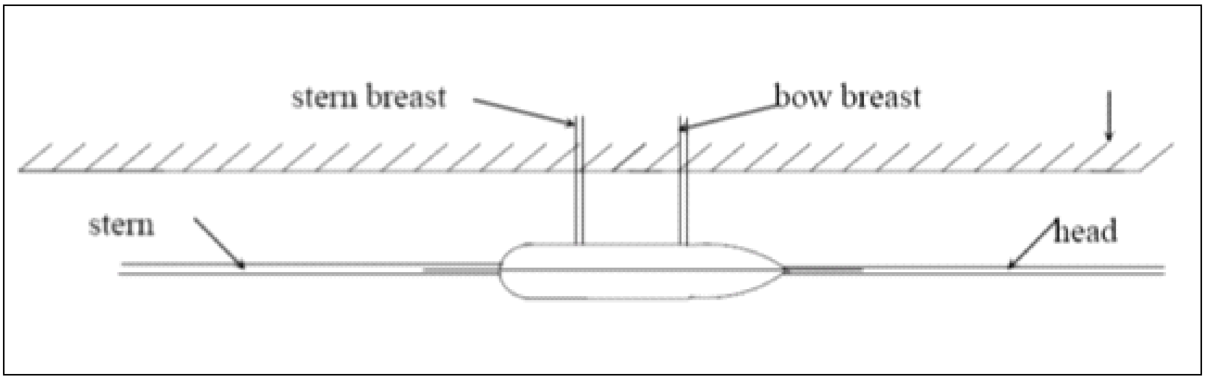

Fig.1.2: Idealized Mooring Arrangement

b) Vacuum Berthing

Vacuum pads are utilized in place of ropes in the more intricate and inventive vacuum mooring technique. Safe connections between the ship and the shore are made possible by the measurable working load of vacuum pads. When paired with the inventive, three-dimensional supporting system, the mooring units mimic the flexibility, durability, and range of motion of a line mooring. The ship is suctioned to the quay by the vacuum pads once the vacuum pump is activated, a few meters from the quay. Two hours are allowed in the event of a system failure for the system to maintain its vacuum, giving workers adequate time to repair any leaks or restore power. The device will alert the crew to the need for rapid repairs if the vacuum pad leak reaches 60%. This will prevent the vessel from losing its vacuum. An additional option for preventing an electrical blackout is a power generator. To operate the entire system, the vacuum system uses a vacuum pump, a hydraulic system, steel, monitors, and a power source. The system is equipped with sensors and monitors that show ship movements, vacuum force, and alerts. In certain ports, mooring has been accomplished via the automated ship-to-shore interface technology.

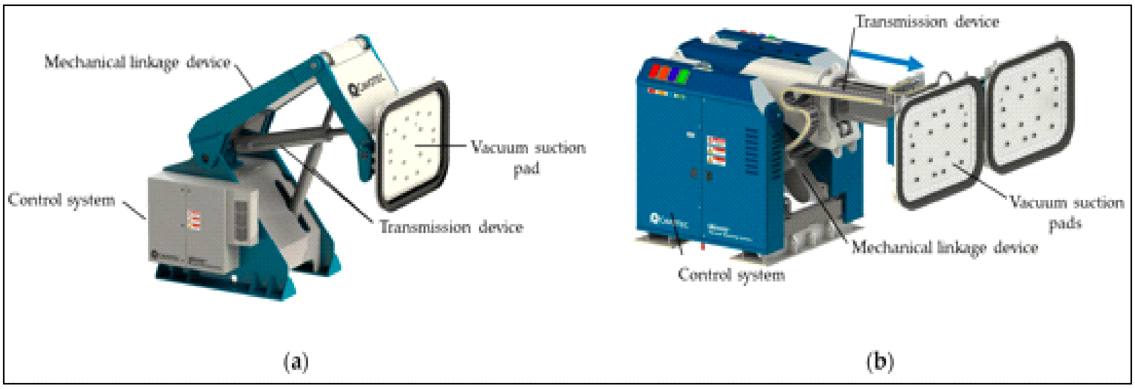

Fig.1.3: Vacuum Berthing Apparatus

c) Magnetic Berthing

The magnetic berthing system works based on electromagnetic principles. An electromagnet is a kind of magnet in which an electric current generates a magnetic field. Electromagnets, which are transient magnets based on the magnetic effect of electric current, are created using electric current. An electromagnet is made up of a soft iron core and a solenoid. When the electric current is switched off, an electromagnet's magnetism should be removed using a soft iron. Depending on the intended function, electromagnets can be produced in a variety of sizes and shapes. The magnetic mooring system has electrical cables, fenders to protect the quay and vessel, magnetic pads connected to the hydraulic arms and the power supply that provides magnetism. Electrical power produces electromagnetic fields that turn on the magnets and electromagnetic fields are used for mooring the ship. The magnetic ship automatic lockage device is designed to improve the existing problem of conventional mooring systems.

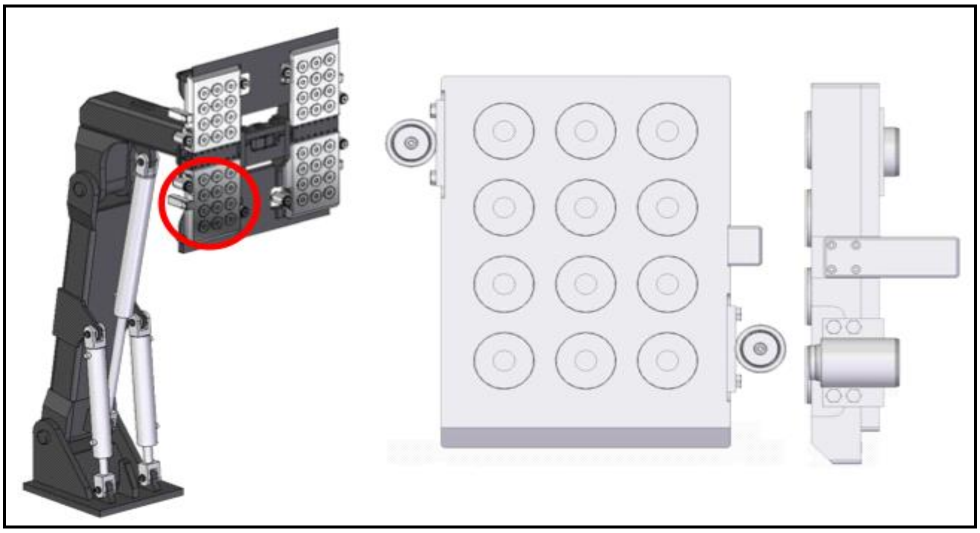

Fig.1.4: Magnetic module

COMPARISON OF BERTHING METHODS

When comparing vacuum, magnetic, and traditional anchoring systems, each one has unique benefits and drawbacks. Analytical comparative results, however, indicate that the vacuum mooring system is superior to the other mooring techniques. The marine sector often uses conventional mooring systems, which have a large global market, suppliers, and technical support departments due to their long history of use. When the system requires equipment or technical help, it is simple to locate them. A vacuum mooring system requires a far larger initial investment than a traditional mooring system. Nonetheless, the vacuum mooring technique has lower maintenance and operational costs. Regarding safety, a vacuum mooring system, which only requires one person to operate and monitor, can reduce the risk of injuries to ship crew members and linesmen from mooring ropes. In contrast to vacuum mooring systems, which allow for quick attachment and speedy release, traditional mooring systems require a greater number of individuals, putting them at risk both during the mooring operation and for a longer period. In the case of a tanker terminal emergency-such as a fire or explosion-vessels may need to evacuate the quay right away.

Vacuum mooring systems provide for faster and easier emergency shore escape than traditional mooring methods. When considering fast mooring from an environmental perspective, it also allows for less operation of the ship's propulsion, tugs, and line boats, which reduces emissions into the port. Consequently, the vacuum mooring technique offers a great deal more benefits. This study has shown that vacuum mooring systems are superior to conventional and magnetic mooring systems in terms of safety, speed, and environmental friendliness. This justifies expanding the usage of the vacuum mooring system and developing the technology. But if we need to anchor a ship to the dock, the thickness of the hull can be an issue. When the thickness of the hull is less than 9.8 mm, the hull can be bent by the automated vacuum mooring system. Pads are not allowed to suck into the glass. The total force of the automated vacuum mooring system needs to be lower than the maximum force acting on the fenders. If the total force of the automated vacuum mooring system is greater, the fenders may be damaged or even broken. Each automated vacuum mooring system can only move 0.5 m in the horizontal direction. The automated vacuum mooring system can't move vertically. To obtain an 80% vacuum, a vacuum pad must have at least 2.5 m^2 of adsorption area. The vacuum pad must be attached to the flat hull, or the vacuum will be lost. Thus, we are carrying out a study to gauge the possibility of proposing a simple mechanical type Berthing system.

In such berthing techniques, we also must consider several loads acting on the ships once it is moored, few of them are:

- **<u>Environmental Loads</u>**

Environmental site conditions such as bottom soil characteristics, water depth, water levels, winds, currents and waves are important to mooring design. Design criteria for water level, wind, current, and wave characteristics should be selected using probabilistic methods for safe/economical mooring design.

- **Wind load**

For almost all mooring installations, wind is a necessary design condition. under many design applications, wind loads are idealized as static; yet, under certain situations, wind can impart significant dynamic loading. Local wind conditions, ideally from long-term wind data, must be taken into consideration when determining design wind speeds. To accurately reflect conditions at the mooring location, recorded wind data usually needs to be corrected for height, duration, and overland/over-water effects.

Typically, design winds are adjusted to a conventional wind duration and elevation of 10 meters. Duration determines wind speed; the longest gust corresponds to the shortest duration. Based on statistics and experience, the right wind speed duration has been chosen over time. A wind field is characterized. by a range of wind velocities. Depending on whether the frequency of the gusts aligns with the natural period of the moored vessel system, a vessel may or may not react to individual wind gusts.

- **Current Load**

It is therefore particularly desirable to align a mooring with prevailing currents, as currents of any significant magnitude have the power to dominate mooring design. Moreover, the current may control how you steer into a mooring. Estuaries and harbors frequently experience tidal currents, which are best calculated via direct measurements. In situations when measurements are unavailable, current speeds can be approximated using mathematical or physical models. Throughout the tidal cycle, current direction and speed fluctuate. In most cases, maximum tidal currents are used in design.

- **Wave Loads**

Designing a mooring can be influenced by wave loads, particularly in open waters. Even in a protected harbor, a mooring could be exposed to the sea and swell. The most accurate way to estimate design wave conditions is through long-term data made at the mooring site. However, these measurements are rarely available, and analytical wave hind-cast studies are frequently required. Storm-generated waves have durations ranging from six to twenty seconds. Long waves can last anywhere from 20 seconds to many minutes, and their duration may have a role in mooring design.

- **Loads due to passing by vessel**

Hydrodynamic loads are imposed on a moored ship when a moving ship passes close by. These loads, which include time-varying yaw moments and surge and sway forces, must be borne by the mooring system.

STAGE II – MECHBER

Apart from existing methods, we are suggesting the Mechanical Method of berthing. Our design will incorporate a hydraulic arm, holding gears, ball and socket joints, and rubber padding.

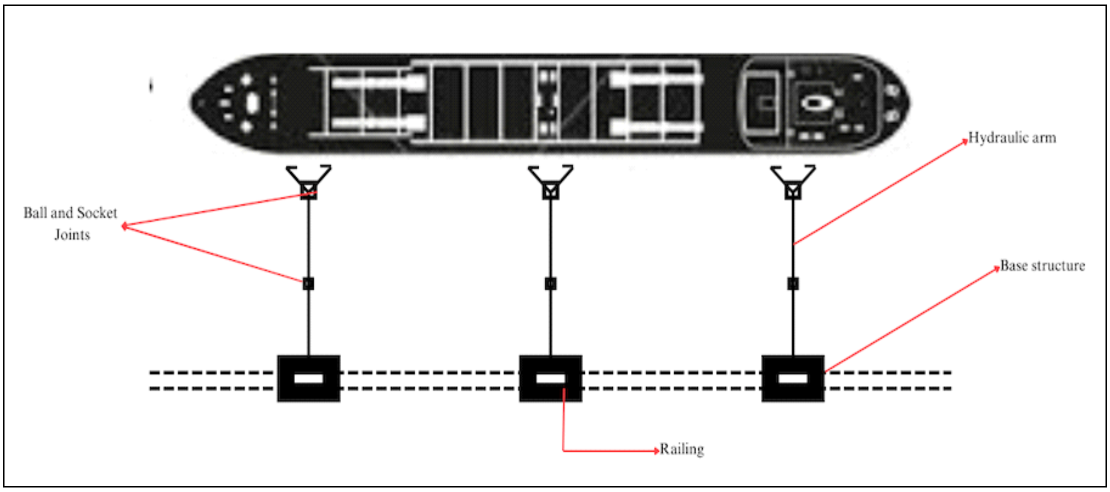

Fig.1.5: Top view of MECHBER apparatus

As per fig 1.5 we will be providing hydraulic arms to pull the ship towards the port for berthing, to hold the hydraulic arm we will be providing holding gears on the ships. To accommodate ships of any size we have railing on the port where we can move the hydraulic arms to adjust.

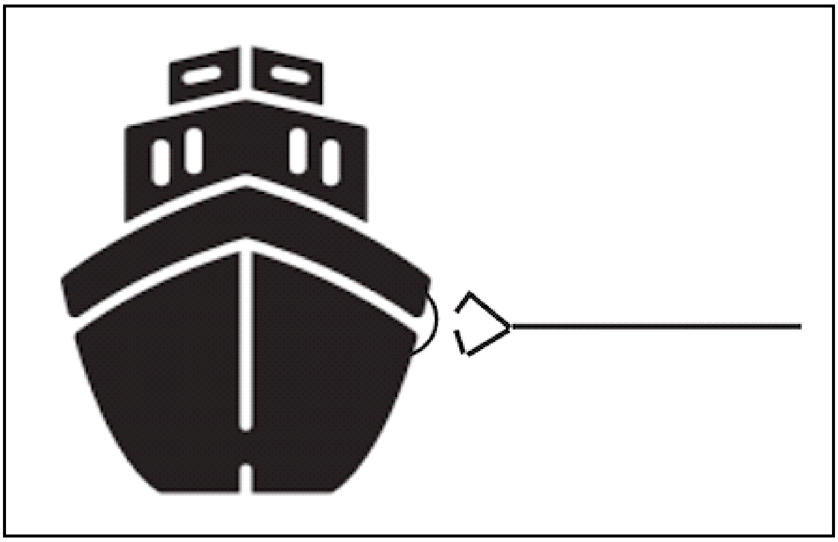

Fig.1.6: Side view of MECHBER Apparatus

In fig 1.6 we can see the holding gear which is attached to the ships to pull using the hydraulic arms.

These two figures clearly depict the berthing technique which will eliminate the sway motion of the ship and will help the ship to remain in a stable condition

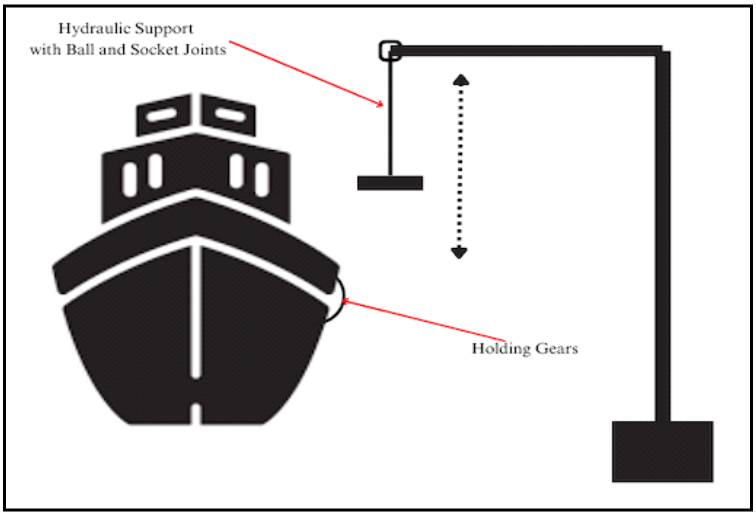

Fig.1.7: The front view of restricting heaving motion.

In fig 1.7 we have given hydraulic arm support from the top at both the aft and forward end of the ships which will help to minimize the heaving motion of the ship while loading and unloading cargo and while tide varies.

COMPONENTS USED IN MECHBER

- Hydraulic motors – They will be the power source of the whole MECHBER which will be actuating the hydraulic arms.
- Hydraulic arms – This will be the vital part of the system which will be holding the ships, these arms will be self-adjusting to a certain extent to avoid major deviation and stress on the ships.
- Ball and socket arrangement – for providing freeness to the attachment.
- Rubber paddings – We are also providing rubber paddings at the contact points of the ships so that no damage will be caused to the ship structure due to load or any other factor.
- Railing – It will help to move the hydraulic arms to and fro to accommodate ships of any size.

CONCLUSION

The shipping industry needs a unique berthing method which will be safe for the seafarer and will reduce berthing time. These changes will make the whole process economical by eliminating tugboat hiring cost and will reduce human intervention. There are several methods already implemented for the same, but all of them have their drawbacks, such as lack of technological knowledge to operate the same, high initial investment, high maintenance cost, adaptation of new technologies, need for training etc. It is also found that these methods damage the ships structure by peeling of paint, forming dents. To avoid these, we decided to introduce a mechanical berthing method which will be using present technology and maintenance methods to berth a ship. Only by using a simple hydraulic system, we are proposing to berth the ship to the port, which will be comparatively easy and less expensive method. We are utilizing a normal hydraulic arm set up to pull the ship and hold it to the port by making sure that we arrest all the possible motions of the ships. By adapting to this method, we can also reduce the accidents associated with berthing.

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REFERENCE

[1] A novel system-theoretic approach for human-system collaboration safety:

Case studies on two degrees of autonomy for autonomous ships

[2] Analytic comparison of different mooring systems

[3] Automatic ship berthing using artificial neural network trained by consistent teaching data using nonlinear programming method

[4] A performance-based approach for the design of coupled dolphin-fender berthing structures

[5] Review of Progress and Applications of Automated Vacuum Mooring Systems

[6] Comparison of automated mooring systems against existing mooring systems by using the IF-TOPSIS method

[7] Estimation of berthing state of maritime autonomous surface ships based on 3D LiDAR

[8] Mapping the landscape of ship berthing research: A bibliometric analysis and literature review over two decades

[9] Offshore safety case approach and formal safety assessment of ships

[10] Prediction of Dynamic Response of a Multi-Point Moored Vessel Exposed to Loads Induced by Wave Current, Wind and Passing by Vessel

Optimizing Port Terminal Stowage: A Hybrid Approach Utilizing K-Means Algorithm and Rule-Based Heuristics

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ABSTRACT

One of the most pressing issues in the maritime sector revolves around the efficient relocation of containerized cargo within seaport terminals. Even minor adjustments in cargo processing procedures can yield remarkable outcomes, including substantial cost savings and a noteworthy reduction in the carbon emissions. The paper delves into crafting a more efficient stowage plan for the port terminal. It suggests forming clusters considering factors such as destination port, container size, weight, and type. The study extensively explores a rule-based heuristic approach, evaluating its effectiveness and investigating its potential for optimizing the storage plan.

KEYWORDS

Heuristic algorithm, Machine Learning, POD, Carbon Footprint

INTRODUCTION

Containers revolutionized the international sea freight market nearly fifty years ago, introducing a unit-load concept that has since gained widespread acceptance. These standardized, uniform boxes have become the cornerstone of efficient cargo handling, eliminating the need for unpacking at each transfer point. The containerization trend has only grown stronger due to its numerous advantages, such as protection against weather and theft, simplified scheduling, and improved cargo control. When discussing containers, a common reference is the standard container, measuring twenty feet (20’) in length. Other containers are often measured in twenty feet equivalent units (TEU), with properties like weight, special handling requirements (e.g., for reefer or oversized containers) [1]. The positive forecast for container freight transportation suggests a continued upward trajectory in the future. This surge in container shipments places higher demands on seaport container terminals, logistics, management, and technical equipment. The resulting increased competition among seaports emphasizes the importance of success factors such as trans-shipment time, loading and discharging rates, and overall operational efficiency. The rapid turnover of containers becomes a crucial competitive advantage, minimizing the time ships spend at berths, hence, reducing trans-shipment costs. The containerization trend has transformed the landscape of international sea freight, emphasizing efficiency, standardization, and rapid cargo turnoveras key drivers in the highly competitive market of container seaports. Container turnover at major seaport terminals has experienced substantial growth, as demonstrated by Figure 1, depicting the container turnover for the ten largest terminals from 2017 to 2021.

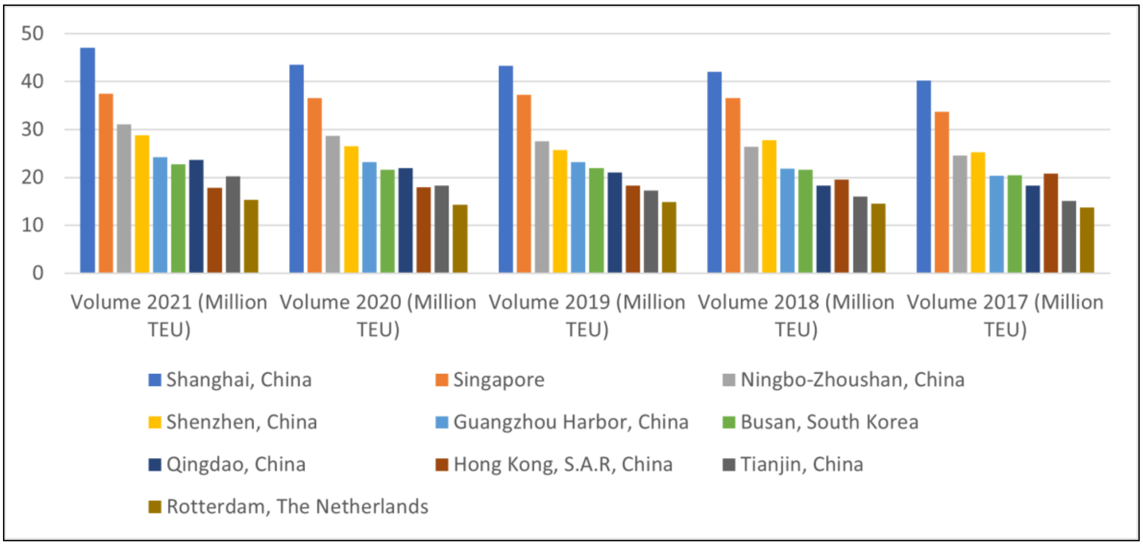

Fig.1: Trend of container operations from 2017 to 2021

Container terminals commonly utilize various types of handling equipment, including Quay Cranes (QC), Yard Cranes like rubber-tired gantry cranes (RTG), rail-mounted gantry cranes (RMG), and various configurations of RMGs such as double, twin, or triple. Additionally, internal vehicles like yard trucks, straddle carriers, chassis, automated guided vehicles (AGV), and land cranes are employed for tasks such as loading trains. External transportation modes such as trucks or trains are also integral to the operation.

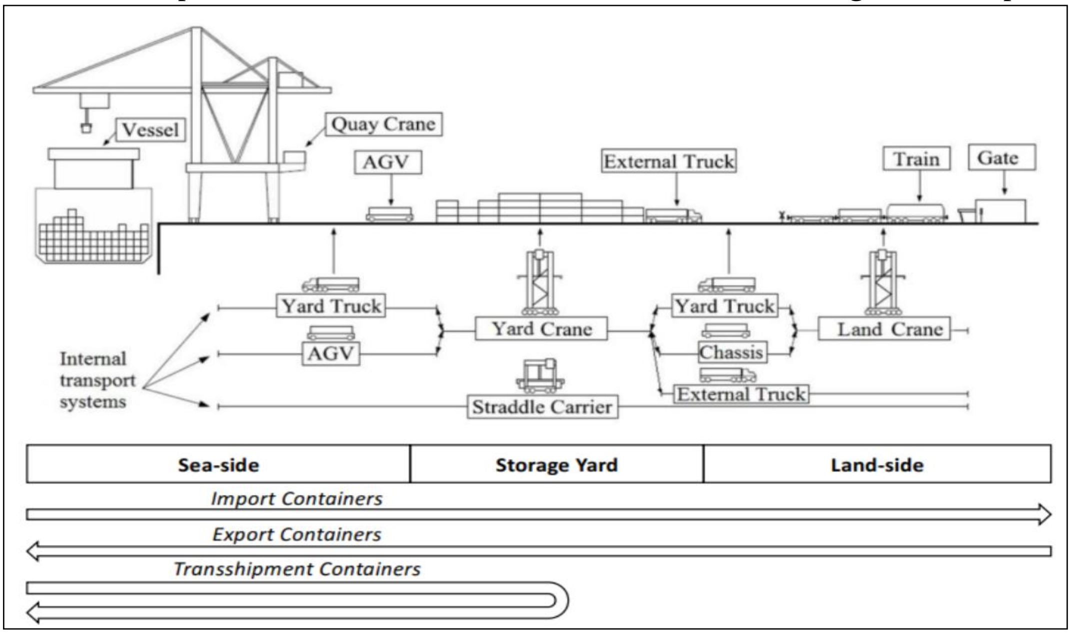

Fig.2: Basic outline of port terminals [6].

Figure 2. illustrates a typical layout of a container terminal, depicting three primary sections: the Sea-side comprising the Vessel, the Quay, and the Internal transport areas; the Storage Yard; and the Land-side encompassing external transport areas and the gate.

Each piece of equipment is designated to operate within specific sections of the container terminal, as delineated in Figure 2.

The **Container Relocation Problem** involves managing a set of uniform containers stored in two-dimensional last-in-first-out (LIFO) stacks. The primary objective is to efficiently retrieve containers from these stacks while minimizing the need for relocation maneuvers. Relocations happen when accessing containers not situated at the stack's top, which are deemed unproductive moves. The quantity of relocations significantly impacts operational efficiency within container terminals, closely tied to the loading sequence and rehandling strategies. Hence, this study aims to showcase the efficacy of employing both k-means and rule-based heuristics to tackle the container stowage challenge. The ultimate objective is to devise an optimized stowage plan utilizing Python code that integrates the aforementioned algorithms.

1. Literature Review

Containerized cargo was introduced in 1956 through the vessel “Ideal X”. Over time, it developed into a sophisticated business model, eliminating the need for unpacking at transfer points. These containers were designed for efficient freight handling. There have been several methods applied to optimize the container stowage problem.

Some of the approaches have been illustrated in the chronological order of the time of their publication.

The method of Kozan;

Kozan discusses the most important factors of transmission effectiveness of multimodal vessel outstations. The image shows a network model describing the logistics structure of the terminal and the progress of holders. Its purpose is minimization of the total prosecution time as the sum of vessel running and transport times [2].

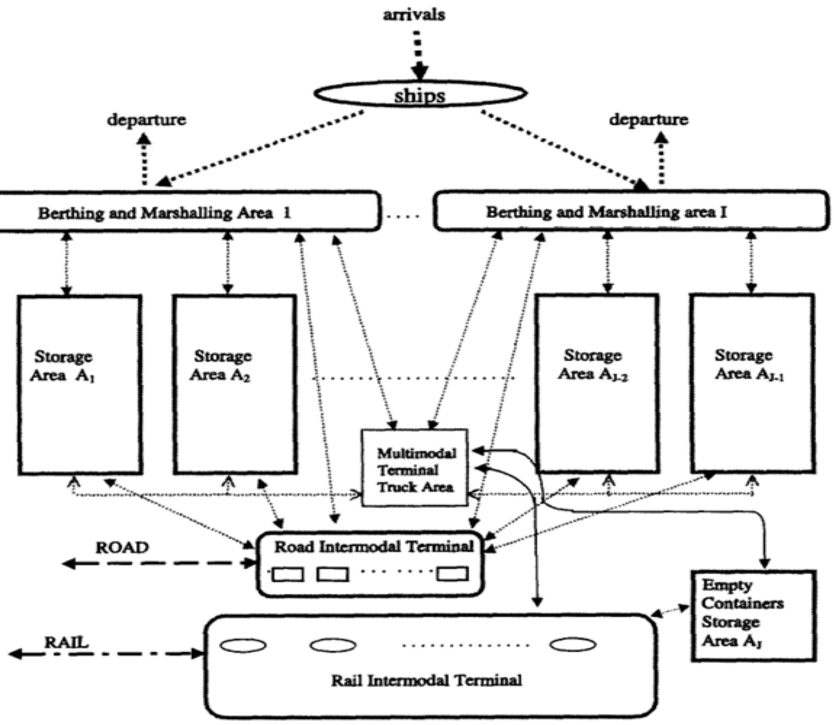

Fig.3: Flowchart of port operations [7].

The Method of Lim;

Lim reformulates the problem as a defined form of a two- dimensional quilting problem and studies a graph-theoretic representation. In this reformulation, this particular pier design problem is shown to be NP-complete [3].

The Method of Wilson and Roach;

The stowage problem was decomposed into two sub problems: Master Bay Planning Problem, Slot Planning Problem. MBPP involved distributing containers into ship bay sections, while SPP used the master bay plan to allocate slots for stowage. Additional studies focused on sub-problems, with various heuristic and mathematical models presented [4].

Limitations and shortcomings: These approaches, how- ever, often overlooked stowage planning for full container liner shipping routes, leading to potential re-handling issues. Shortcomings includes potential difficulties in accurately estimating container sizes, challenges in handling irregularly shaped items, and limitations in addressing dynamic changes in cargo dimensions or weight during the planning process. Additionally, it may not consider certain practical constraints in container loading, leading to suboptimal results in real-world scenarios.

The Method of Kim and Hong;

They adopted a branch and bound method to address the container relocation problem. In this approach they divided the containerisation problem into a numbers of sub problems and chose the one which was least expensive [5].

Limitations and shortcomings: It turned out to be time- consuming and computationally expensive for large and complex systems. The number of sub problems grew exponentially with the size of the problem and the bounds were not tight enough to eliminate many sub problems. This resulted in requirement of more iterations, memory space and computing time.

In summary, different types of optimization algorithms including the exact and heuristic bones were proposed in the literature to address the CRP, and several types of machine literacy ways similar as the decision tree, the neural network and so on were espoused to parameter estimation and system optimization in a wide range of operation. In the CRP, however, the algorithms that combines the optimization styles and the machine literacy ways are veritably spare. Inspired by the fact that further precious information regarding the structure of the optimal result can be uprooted and facilitates the result for large scale cases, we're motivated to make such an attempt in this regard.

2. Problem Description

Given a layout of container stacks within the terminal, the objective is to minimize the number of relocations required to access specific containers, thereby enhancing operational efficiency and reducing resource wastage. The Container Relocation Challenge pertains to the efficient management of containers stored in two-dimensional stacks within a terminal environment. This problem arises due to the need to retrieve containers from these stacks while minimizing the number of relocations required.[9]

The challenge can be described formally as follows:

Let $S = \{S_1, S_2, ..., S_n\}$ represent a set of two-dimensional stacks, where each stack S_i contains a variable number of containers stacked in a last-in-first-out (LIFO) manner. The objective is to devise an optimal strategy for retrieving target containers from the stacks, minimizing the number of relocations required.

- Stack Configuration: Each stack S_i can be represented as a two-dimensional array or matrix, denoting the arrangement of containers within the stack.

- Target Container Identification: Given a target container to retrieve, denoted as C_t, the algorithm must determine its current location within the stacks.

- Relocation strategy: To retrieve C_t efficiently, the algorithm needs to identify the minimum number of relocation maneuvers required to access C_t without disturbing other containers unnecessarily.

- Objective Function: The primary objective is to minimize the total number of relocations needed to retrieve all target containers within a given time frame.

- Decision Variables:

$x_{ij} = \begin{cases} 1, & if\ container\ C_i\ is\ relocated\ to\ the\ top\ of\ stack\ s_j \\ 0, & otherwise \end{cases}$ ………………………………. (1)

- Objective Function:

Minimize $\sum_{i=1}^{n} \sum_{j=1}^{n} x_{ij}$, representing the total number of relocations…………………… (2)

- Constraints:

$\sum_{j=1}^{n} x_{ij} = 1$, *ensuring each container is relocated to only one stack.*………………... (3)
$\sum_{i=1}^{n} x_{ij} \leq 1$, *ensuring each stack receives at most one container.* ……………………. (4)

Additional constraints may be added to account for stack capacity limitations and operational constraints.

The Container Relocation Challenge shares similarities with various optimization problems, including the Traveling Salesman Problem (TSP) and the Vehicle Routing Problem (VRP). These problems involve finding optimal routes or sequences to minimize travel distances or costs, akin to minimizing relocations in the Container Relocation Challenge [8].

The Key shortcomings in the conventional method include:

1. Movement of Internal Transfer Vehicles (ITVs): Placement of containers in clusters governs the movement of ITVs on the terminal. Improper planning can result in haphazard movement of the ITVs, clashing of routes and traffic, resulting in delay.

2. Idle time of Rubber Tyre Gantry cranes (RTGs): These cranes need adequate space to operate. When due to improper cluster formation, the operation of all the RTGs is concentrated on one portion of the stack, some RTGs stand idle while others compensate for the idle ones, causing wastage of resources.

3. Overload of Quay Cranes (QCs): Often times it is observed that the containers handled per hour for every QC is different, causing some QCs to be overloaded while the others standing idle. These inefficiencies result in increase of cost per container handled, and also increases the carbon footprint generated. Following is a detailed demonstration of how the formation of cluster affects the overall moves and time required for handling the containers.

3. Solution

We have addressed the underlying issue with the help of a program with rule based heuristic algorithm and machine learning as its core principles as follows:

3.1 Stage 1:

Segregation of Data. The program begins by taking an Excel file (‘shipdataset E XPORT.xlsx’) containing data on multiple ships and their respective container details. It reads this data and creates separate Excel sheets for each vessel, segregating the data based on the ‘VESSEL’ column.

3.2 Stage 2:

Clustering of POD (Port of Discharge). It takes the segregated Excel file (‘split d ata.xlsx’) created in *Stage 1* and reads each sheet (ship data). Utilizes TF-IDF vectorization on the ‘POD’ (Port of Discharge) data and performs Kmeans clustering on it. Adds a ‘Cluster’ column to each ship’s data based on the clustering results and saves this updated information into a new Excel File.

3.3 Stage 3:

In Stage 3, the process involves reading the clustered output file ('clusteredoutputfilefinal.xlsx') from Stage 2 and employing a rule-based heuristic approach for sorting and classification. The heuristic approach for sorting and classification. The heuristic rules, based on ‘TEU’ and ‘WEIGHT’ columns, guide the sorting within each cluster. For instance, the rules might prioritize sorting by ‘TEU’ values and use ‘WEIGHT’ as a tiebreaker. This heuristic ensures an efficient and systematic sorting process. The data is then caterogized into different groups/classes according to specified condition, reflected in ‘Class’ columns. The sorted and classified information is saved into a new Excel file, streamlining data analysis and interpretation.

3.4 Stage 4:

Allocation of containers to bays and slots reads the modified file (‘weight classification cluster file.xlsx’) generated from *Stage 3*. Arrange containers from different ships into bays and slots based on several conditions including ‘TEU’, ‘CLUSTER’, and ‘ARRIVAL DATE’. Allocates bays and slots to containers ina way that optimizes the available space. Generates a final Excel file (‘final container arrangement updated.xlsx’) with the allocation details. The program’s execution begins by receiving input data regarding ships and containers, then systematically processes and manipulates this data through the aforementioned stages, ultimately producing a final allocation arrangement of containers into bays and slots for efficient management handling at the port

3.5 *Flowchart*:

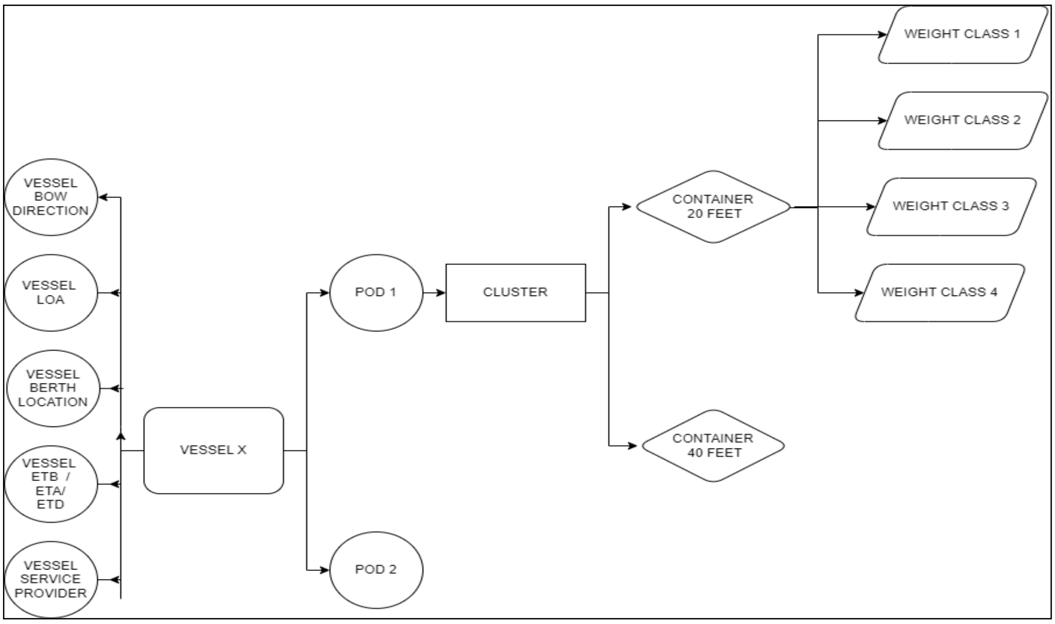

Fig.4: Governing parameters for clusterization of container

- The PORT OF DISCHARGE is taken into consideration as there are different port of discharges for a particular ship
- The containers are then arranged in CLUSTERS
- The containers are arranged in clusters according to the size of the containers i.e. 20 ft. and 40 ft.
- Then the containers are then arranged according to WEIGHT CLASSES
- While making the clusters parameters like vessels estimated time of arrival, time of berthing, berthing location, bow direction, service provider are also taken into consideration.

4. Mathematical Modelling:

To develop a mathematical model for clustering containers using the k-means algorithm and a rule-based heuristic algorithm, we need to consider various factors including the intended port of discharge, weight of containers, available space on the terminal, desired transfer rate of containers, and the type of container in use. Let's denote the following variables:

- $N: Total\ nuber\ of\ containers.$
- $K: Number\ of\ containers.$
- $x_i: Vector\ representing\ the\ attributes\ of\ container\ i.$
- $\mu_k: Centroid\ of\ cluster\ k.$

- $\omega_i : Weight\ of\ the\ container\ i.$
- $s_k : Available\ space\ in\ cluster\ k$
- $r : desired\ transfer\ rate\ of\ containers.$

- $t_i : Type\ of\ container\ for\ container\ i$

We aim to minimize the intra-cluster variance, considering the distance between containers and their respective centroids.

4.1 Objective Function*:* The objective function is to minimize the total intra-cluster variance, which can be expressed as:

$$J = \sum_{k=1}^{K} \sum_{i=1}^{N} \delta_{ik} \parallel x_i - \mu_k \parallel^2 \quad (5)$$

Where δ_{ik} is an indicator variable that equals 1 if container i belongs to cluster k, and 0 otherwise.

4.2 Constraint:

1. Space Constraint:

The total space occupied by containers in each cluster should not exceed the available space:

$$\sum_{i=1}^{N} \delta_{ik} . \omega_i \leq S_k \ \forall k \quad (6)$$

2. Transfer Rate Constraint:

The rate of transferring containers should meet the desired transfer rate:

$$\frac{\sum_{i=1}^{N} \delta_{ik}}{t_i} \geq r \ \forall \ k \quad (7)$$

3. Type of Container Constraint:

Certain types of containers may have specific requirements or restrictions. For instance, hazardous containers must not be clustered with non-hazardous ones.

4.3 K-means algorithm:

Initialization: Randomly select K containers as initial centroids.

Assignment Step: Assign each container to the nearest centroid based on Euclidean distance.

$$\delta_{ik} = \begin{cases} 1 \ if \ k = argmin_j \parallel x_i - \mu_j \parallel^2 \\ 0 \ otherwise \end{cases} \qquad (8)$$

Update Step: Update the centroids based on the mean of containers in each cluster.

$$\mu_k = \frac{\sum_{i=1}^{N} \delta_{ik} . x_i}{\sum_{i=1}^{N} \delta_{ik}} \qquad (9)$$

Repeat steps 2 and 3 until convergence.

4.4 Rule-based Heuristic Algorithm:

1. Initialization: Initialize clusters based on predefined rules or heuristics, considering attributes such as port of discharge, weight, and container type**.**
2. Refinement: Refine the clusters iteratively by considering constraints and objectives, such as minimizing intra-cluster variance and meeting transfer rate requirements.

By combining the k-means algorithm with a rule-based heuristic approach, we can effectively cluster containers in a port terminal, optimizing space utilization, transfer rate, and other relevant factors**.**

CONCLUSION

The effect of using the machine learning integrated heuristic approach on reduced relocation movements of containers, optimal use of space available on the port terminal, maintaining a desired rate of discharge and limiting cranetravel distances has been deeply examined and the core principles have been applied in creating a program that gives an optimized plan for clusterization of the container. The efficacy of the rules defined in the suggested algorithm, determines the quality of the output. Since, we are considering the factors such as port of discharge, type of containers and their weight class and are using rule based heuristic algorithm integrated with Machine Learning (ML). The stowage plan we get is optimized and with every iteration it improves itself and gives more optimized results.

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REFERENCES

[1] A. Van de Ree, 1969. Unitized Cargo Transportation. The Journal of Navigation, *22*(3), pp.311-325, in press.

[2] Preston, P. and Kozan, E., 2001. An approach to determine storage locations of containers at seaport terminals. *Computers & Operations Research*, *28*(10), pp.983-995.

[3] Wang, N., Zhang, Z. and Lim, A., 2014. The stowage stack minimization problem with zero rehandle constraint. In *Modern Advances in Applied Intelligence: 27th International Conference on Industrial Engineering and Other Applications of Applied Intelligent Systems, IEA/AIE 2014, Kaohsiung, Taiwan, June 3-6, 2014, Proceedings, Part II 27* (pp. 456-465). Springer International Publishing.

[4] Wilson, I.D. and Roach, P.A., 1999. Principles of combinatorial optimization applied to container-ship stowage planning. *Journal of Heuristics*, *5*, pp.403-418.

[5] Tuan, C.H., Park, S., Hong, S. and Kim, K.H., A Heuristic Algorithm for Generating Stowage Plans.

[6] Jun Li , Yu Zhang, Jie Ma, and Sanyou Ji , "Multi-Port Stowage Planning for Inland Container Liner Shipping Considering Weight Uncertainties" vol 6 , pp 3-4 , 2018, in press.

[7] Canrong Zhanga,b, Hao Guana,b, Yifei Yuana,b, Weiwei Chenc, Tao Wud, "Machine learning-driven algorithms for the container relocation problem" transportation research part b, pp 104-105 ,2020, in press.

[8] Mordecai Avriel, Michal Penn , Naomi Shpirer " Container ship stowage problem: complexity and connection to the coloring of circle graphs ", pp 272-273 , 1999, in press.

[9] Galle, V., Barnhart, C. and Jaillet, P., 2018. Yard crane scheduling for container storage, retrieval, and relocation. *European Journal of Operational Research*, *271*(1), pp.288-316.

Fore-End WIDAS System and Panting/Pounding arrangements

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ABSTRACT

While in a seaway, vessels experience 6 degrees of motion, three linear (Surging, Swaying and Heaving) as well as three rotational (Yawing, Pitching and Rolling). To counteract the stresses caused by these motions; particularly panting and pounding, which are maximum around the fore-end of the vessel, special strengthening members are provided. These are in the form of plate floors, intercoastal side girders, breasthooks, half-height girders, etc. While these measures largely protect the ship's structure from the dynamic stresses experienced in rough seas, localized stresses can still cause damage over time. Therefore, it is necessary to have some form of a warning/alarm system in case the watertight integrity of the vessel is lost in the stress prone areas. This job is done by a WIDAS or Water Ingress Detection and Alarm System, the fitting of which is mandated in all bulk carrier cargo holds and fore-end watertight spaces as per SOLAS XII.

OBJECTIVE:

To highlight the various strengthening members forward of the collision bulkhead which help mitigate dynamic stresses caused by the 6 degrees of motion experienced by a vessel along with a working WIDAS system (shown separately).

INTRODUCTION:

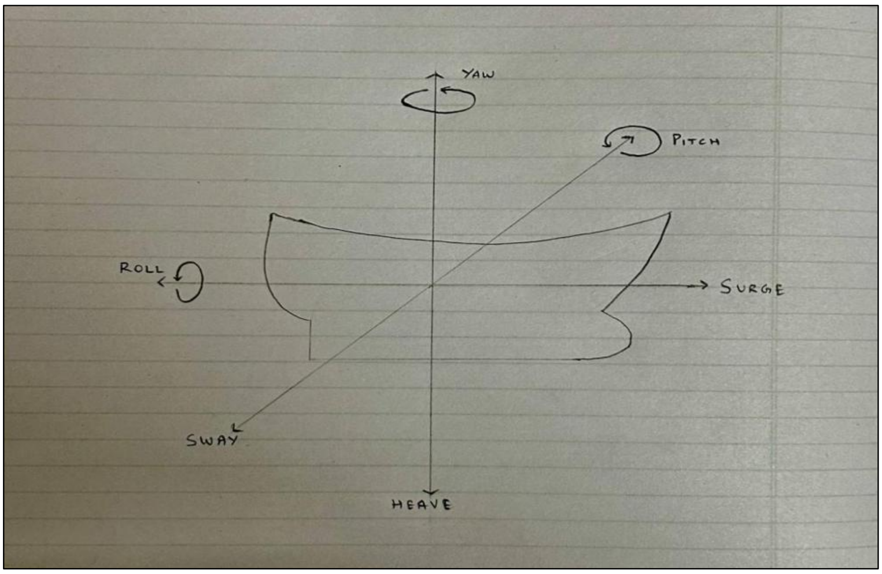


Fig. 1: Degrees of freedom

The 6 degrees of motion are, three linear- surging, swaying and heaving as well as three rotational-rolling, pitching and yawing.

These motions cause various dynamic stresses such as:

1. Pounding- Due to excessive pitching in rough seas and high swells, the bow of the vessel "pounds" onto the water surface as it travels against wave troughs.

2. Panting- As the vessel is going through rough seas, part of it gets submerged and pushed out of the water periodically, the shell plating around the bow experiences dynamic pressure pushing it outwards and inwards.

As a result, various strengthening members are placed in the forward part of the vessel to ensure structural integrity even in rough seas in the form of breasthooks around the forward most part of the stem and bulbous bow, panting stringers around the entire shell plating, plate floored bottom structures, stiffeners and intercoastal side girders.

Fig. 2: WIDAS sensor alarm panel

SOLAS XII also mandates a WIDAS (Water Ingress Detection and Alarm system) system to be fitted on all bulk carriers in cargo holds, watertight spaces forward of the collision bulkhead and dry spaces like the bosun store. It is to give an audible and visual alarm to the bridge in case the water level reaches not less than 10% of the tank capacity in any tank forward of the collision bulkhead.

WORKING:
WIDAS uses a water detector sensor to send an alarm to the bridge in case of water ingress.

CONSTRUCTION:

The major region in which the shell plating is subjected to local forces at sea is at the forward end.

Additional stiffening is provided in the fore peak structure, the transverse side framing being supported by the following arrangements:

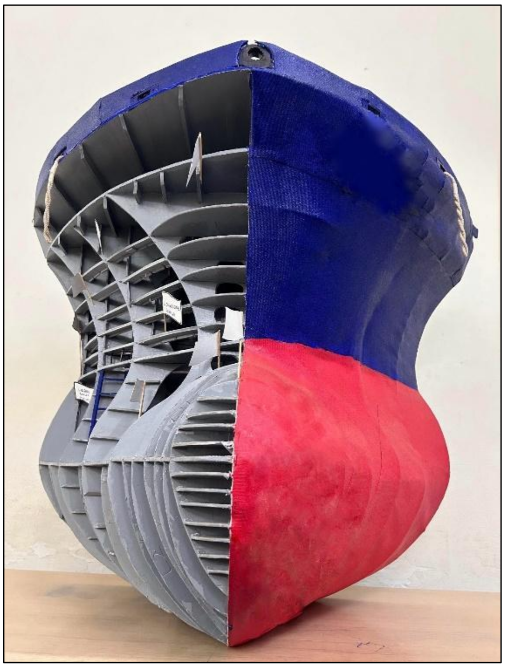
1. Side stringers are spaced vertically about 2 m apart and supported by struts or beams fitted at alternate frames. These 'panting beams' are connected to the frames by brackets and if long, may be supported at the ships centre line by a partial wash bulkhead. Intermediate frames are bracketed to the stringer
2. Side stringers are spaced vertically about 2 m apart and supported by web frames.
3. Perforated flats are spaced not more than 2.5m apart. The area of perforations being not less than 10 per cent of the total area of the flat.

* In the aft of the forepeak tank, in the lower hold or deep tank spaces, panting stringers are fitted in line with each stringer or perforated flat in the fore peak.

* In the aft peak space and in deep tween decks above the aft peak, similar panting arrangements are required for transverse framing except that the vertical spacing of panting stringers may be up to 2.5 m apart.

Where the double bottom is transversely framed, solid plate floors are fitted at every frame space in the pounding region. Intercostal side girders are fitted at a maximum spacing of 3 times the transverse floor spacing, and half height intercostal side girders are provided midway between the full height side girders.
If the double bottom is longitudinally framed in the pounding region, solid plate floors may be fitted at every third frame space and intercostal side girders may have a maximum spacing of 4 times the transverse floor spacing. As the longitudinals are stiffening the bottom shell longitudinally, it should be noted that less side girders are needed than where the bottom is transversely framed to resist distortion of the bottom with the slamming forces experienced.

PHOTOGRAPH :



REFERENCES:

[1] Ship Construction by D.J. Ayres
[2] SOLAS Ch. XII

Fire extinguishing onboard ship using robotics

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ABSTRACT

An Arduino fire extinguishing robot is a device designed to automatically detect and extinguish fires in indoor environments using Arduino microcontrollers. This robot is equipped with various sensors that allow it to detect the presence of smoke, heat, and flames. It then uses a water pump and spray nozzle to extinguish the fire. The robot can be controlled remotely through a smartphone application, allowing users to monitor the robot's activity and adjust its settings. The development of an Arduino fire extinguishing robot is an important step in improving fire safety in indoor environments and reducing the risk of fire-related injuries and property damage.

OBJECTIVE:

Primary objective of this model is to:
1. Improve fire safety in indoor environment on ship.
2. Extinguish the fires in areas which humans cannot access.
3. To send an alert while extinguishing the fire.

INTRODUCTION:

The Automatic Fire Fighting Robot consists of hardware and software design. The hardware part deals with the mechanical and construction design, electric and electronic circuitry. The software parts deals with the programming. Fire-fighting robots can take many forms, but typically consist of a robotic vehicle with a fire-extinguishing payload, such as a water cannon, foam sprayer, or CO2 gas dispenser. By developing a fire extinguishing robot, we can reduce the risk of injury to human firefighters and increase the efficiency of fire-fighting operations. This can potentially save lives of seafarers and reduce the economic and social impact of fires onboard.

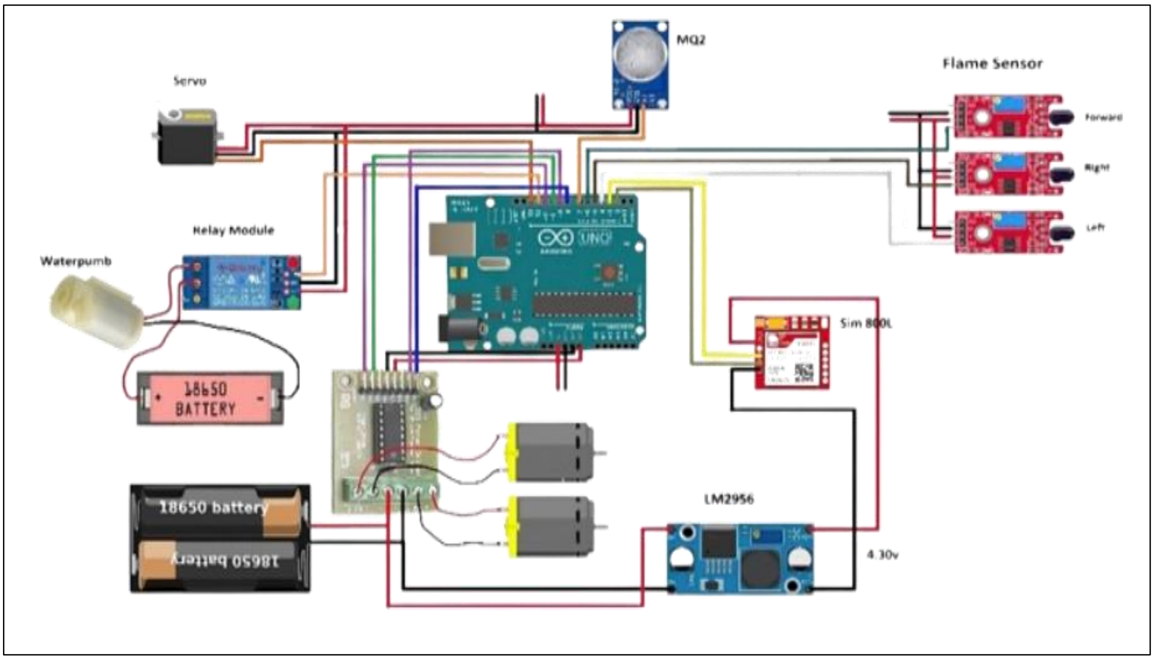
CONCEPT:

The Internet of things (IoT) describes physical objects (or groups of such objects) with sensors, processing ability, software and other technologies that connect and exchange data with other devices and systems over the Internet or other communications networks. Fire Fighting Robots can be operated remotely or autonomously, and are usually equipped with cameras and sensors to help them navigate and detect fires onboard. Some robots are even capable of performing basic search-and-rescue operations, such as locating trapped seafarers and carrying them to safe area.

WORKING PRINCIPLE:

The project model employs the use of IoT i.e. the use of various sensors and ARDUINO board. A program to extinguish the fire and to regulate the robot's fire detection ability using ultrasonic sensors should be included in the code. This code is embedded into ARDUINO UNO board.
The robot is able to sense the fire with the help of the sensors, which send a command through the Arduino board to the motor driver passing the command to start the model to move towards the fire. As soon as the robot senses the fire it will also send an alert call on mobile phone by the usage of a GSM Module.

DETAILED DIAGRAM:



RESULTS:

1. The objective of this project was to design and develop a fire extinguishing robot that can autonomously detect and extinguish fires in various parts of ship. The robot should be able to navigate throughout the vessel, avoid obstacles, and detect the location of the fire, and extinguish it using a water spray any other suitable means of extinguishing the fire.
2. We not only succeeded in fabricating the model for this idea of project also we have included the Calling and SMS feature by embedding a GSM module.
3. The resulting final model has accomplished all the respective features that we tried to include in the planning phase of the project. This robot is just a prototype model of our theorised idea which can also be used for communicative as well as lifesaving purposes.

CONCLUSION:

1. The robot is able to extinguish the fire, it is able to detect fires from a certain distance.

2. The robot is able to communicate with us through a call or a SMS which alerts us about the fire.
3. The trials of the robot have given hopes that its application can be utilized on a much larger scale in maritime industry.

REFERENCES:

[1] A. Parsad, et.al. (2005), "Line Following Robot, "Dept. Elex. & Comm. Eng., Visvesvaraya Technological University, Bangalore, India
[2] Durgesh Sharma, Harshala Gaikwad, Kartavya Verma, et.al. (2021), in "Fire Extinguishing Robot Using Arduino"
[3] K. Rajaram, G. Krishna Chaitanya, K. S. S. Sai Kiran, and P. Sreevamsi, et.al. (2016), in "Design and Fabrication of a Fire Fighting Robot based on Arduino

Solar powered alternators to reduce GHG emissions

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ABSTRACT

This project aims to replace one of the three generators on board a ship with a solar powered motor as a prime mover which is coupled with a ship generator. Motor receives its power from a PV array charged batteries with Inverter. The objective is to explore the feasibility and efficiency of integrating renewable energy sources into marine power systems, thereby reducing dependence on traditional fuel-based generators. This model simulates the performance of the new generator system under various operating conditions and evaluates its impact on power generation, fuel consumption, and environmental sustainability. The project contributes towards the advancement of green technologies in maritime operations and provides insights into optimizing energy management onboard ships.

OBJECTIVE:

The main objectives of this model in shipping industry are
1. To demonstrate the significance of solar energy to run the alternators.
2. To reduce SOx, NOx and CO_2 emission as per MARPOL regulation.
3. Using green energy to power the ship.
4. Cost associated with auxiliary engine is eliminated.

INTRODUCTION:

In this project, we are demonstrating actual setup of one of the Auxiliary Engine which is replaced by solar powered prime mover. Generator is coupled with motor which is powered by inverter. In this model we have demonstrated Main switchboard and Emergency switchboard and as per SOLAS, in case of main generator failure, Emergency generator should start and come on load within 45 seconds.

CONCEPT:

BLOCK DIGRAM

Replace one of the three generators on board a ship with a solar powered motor as a prime mover which is coupled with a ship generator. Motor receives its power from a PV array charged batteries with Inverter and use this green energy to full fill electric energy requirement on board ship.

WORKING PRINCIPLE:

The project shows the actual working generator systems on board by using solar energy, i.e., the configuration of one of the generators coupled with motors which is powered by inverter. During day time battery unit will be charged by PV array and in the night, charged battery will be used to run the motors. Due to specific reasons the running generator can fail and then stop supplying to the Emergency bus bar. At this moment the Emergency generator in our project starts automatically comes on load. As it is essential to supply power for critical bridge equipment and Emergency machinery like Emergency fire pump, steering gear system etc., we must always ensure the satisfactory working of Emergency generator.
In this setup we have inculcated a real life scenarios that show:
In case of one of the generator fails then standby generator automatically starts and comes on load.
After paralleling of solar powered alternators, raise and lower can be done by micro-controller (PMS).

DETAILED DIAGRAM:

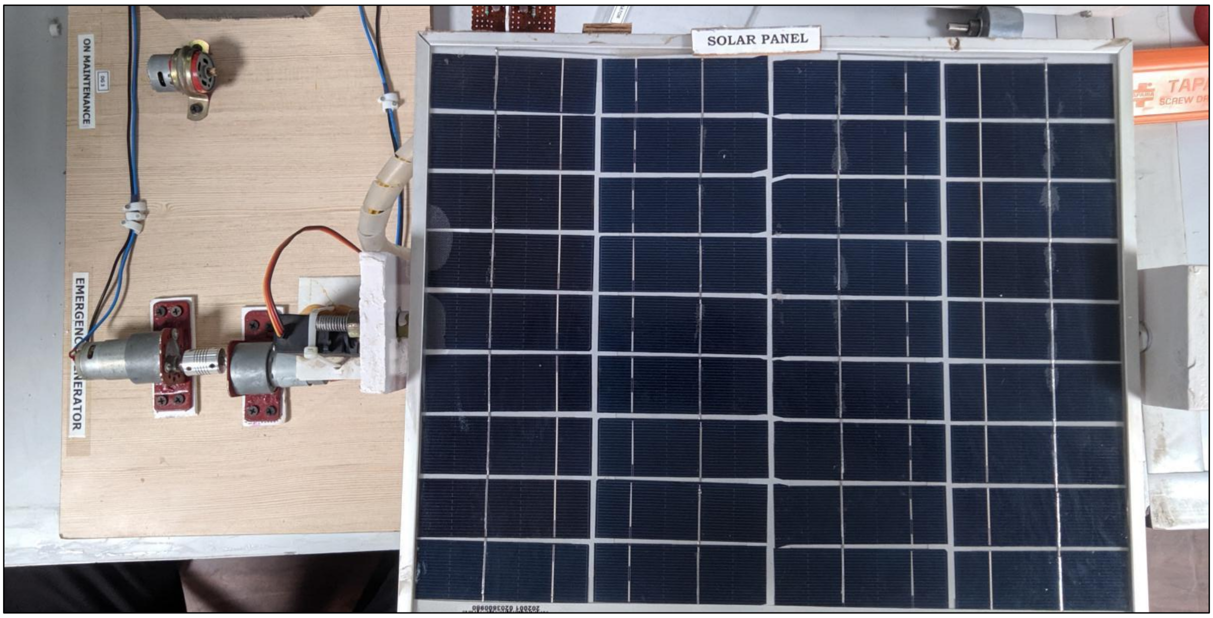

Fig. 1: Model in progress

STATISTICS:

1. On average, 65% of our local solar system's annual energy output is generated between March 21st and September 21st of each year.
2. The other half of the year, between September 21st and March 21st, accounts for the other 35% of annual solar output.
3. Solar panel can usually generate around 10%-25% their standard energy production when it cloudy.

CALCULATIONS:

***** PV MODULE SPECIFICATIONS (1 PV module):

PV module specifications for one PV module:
P_{Max} = 450 Watt ; V_M = 41.39V ;I_M =10.88A
Efficiency = 20.7% [weight = 23.5kg]
Dimensions: 2049* 1038 * 39 mm

Assume battery efficiency = 85%,
Ampere hour (Ah) = battery ampere hour capacity / battery efficiency
= 5.36/0.85
= 6.3 KAh
Assume sunshine hours = 7 hrs
PV array current capacity = I_m = 6.3 KAh/7 hr
= 0.9 KA =900A
PV module I_m = 10.88A
NO.of PV module to be connected in parallel
= 900/10.88
= 82.7
= 83 nos. (For 100kw motor)

RESULTS (TABLES/GRAPHS):

The results of the project demonstrate the viability of incorporating solar-powered generators into marine power systems. The model reveals improvements in fuel efficiency, reduced emissions, and enhanced sustainability compared to conventional generator setups. Additionally, the system's performance under different weather conditions and navigational scenarios is analyzed to assess its reliability and resilience in real-world maritime operations.

CONCLUSION:

In conclusion, the integration of solar-powered generators driven by inverters offers a promising solution for enhancing the sustainability and efficiency of ship power systems. The project underscores the importance of embracing renewable energy technologies to mitigate environmental impact and reduce dependence on fossil fuels in the maritime industry. Further research and development in this area can lead to widespread adoption of green energy solutions, contributing to a cleaner and greener future for marine transportation.

REFERENCES:

[1] Chetan Singh Solanki (2013) :- Solar Photovoltanic Technology And System

[2] Ajay Kumar Gupta (First Edition 2022) :- Solar Pv Power And Solar Product Handbook

[3] Elstan A. Fernandez (Twefth Edition):- Marine Electrical Technolgy

[4] Rick Green & Sue Merriam (2012):-Solar Power Genrator

[5] Pv Magazine/Japan: Green Transport Ship Sets Sailsolar Frontier Cls Panels

[6] Ship&Bunker/K-Line Launches Eco-Ship Featuring Solar Technology

[7] Air Pollution And Energy Efficency /Imo Energy Efficiency Appraisal Tool

[8] Website:-Https://Glomeep.Imo.Org/Technology/Solar-Panels/

Use of modern technology based on automated vacuum mooring for ships in ports

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ABSTRACT

The maritime industry faces challenges with conventional ship berthing methods, particularly in congested ports and adverse weather conditions. Traditional approaches involve tugboats and mooring lines, which often lead to operational inefficiencies and safety concerns. In response to these challenges, our approach aims to display the feasibility and potential benefits of vacuum berthing systems for ships. The major aspect being berthing of ships with just touch of a button in a safe and time-saving manner. Replacement of automated vacuum berthing system over manual mooring method emerges as a more efficient, safer, and environmentally friendly alternative to traditional manual berthing methods. This technology has potential of catering demands of ship and port automation.

OBJECTIVE:

The main objectives of this technology in shipping industry are-
1.To replace the old traditional method of mooring (ropes and wires), which is quite dangerous as being unpredictable, labor intensive, time consuming as well as manual working.
2. Enhance safety by providing a secure connection.
3. Improve efficiency by reducing mooring time.
4. Promote environmental sustainability.
5. Ensure operational flexibility.
6. Achieve cost savings.
7. Optimize port capacity

INTRODUCTION:

The Mooring System remains a crucial component in maritime operations. It serves as a reliable means of securing vessels during berthing and departure. However, manual mooring operations pose several serious disadvantages such as risk of injuries to personnel, potential damage to vessels or port infrastructure, slower turnaround times, and heightened susceptibility to human error during the complex mooring process. Additionally, extended turnaround times and inefficient maneuvers during the mooring process can contribute to increased fuel consumption.
This Automated vacuum berthing technique is a proved solution over all these problems. It optimizes the docking process, minimizing human error and streamlining vessel maneuvers and the integration of intelligent sensors ensures adaptability to diverse maritime conditions, providing a reliable solution for various ports and vessels. Also, this

system aligns with eco-friendly practices, reducing emissions and contributing to a greener maritime industry.

CONCEPT:

Innovating the maritime landscape, vacuum berthing revolutionizes ship docking through a powerful suction-based system for mooring and docking. This technology is applied to create a seal between the ship and the dock, improving stability during berthing process,replacing the mooring lines. The general idea is to use vacuum or suction to berth the ship securely into place at the dock.

WORKING PRINCIPLE:

Automated vacuum mooring systems revolutionized the docking process for seagoing vessels with their innovative technology. Here's a concise breakdown of their working principles:

•Initiating Mooring: When a ship approaches the wharf, the system's vacuum pump activates, gently pulling the vessel towards the dock, typically within a few meters.

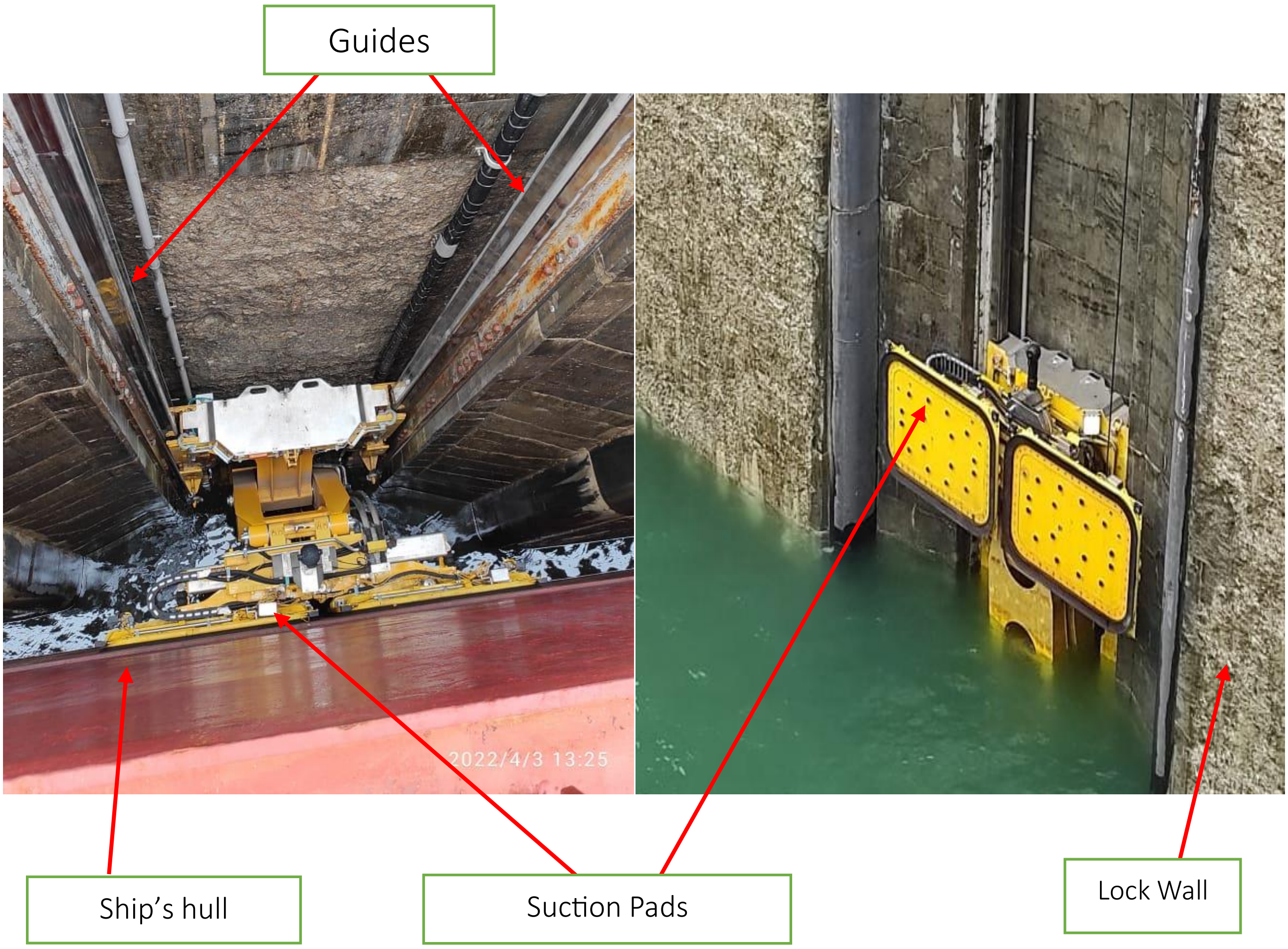
•Constant Suction: Throughout the mooring process, the ship experiences a consistent suction force from the vacuum pad, ensuring a secure and stable connection between the vessel and the mooring system.

•Safety Assurance: Even in the event of a power outage, the automated mooring system maintains suction force, guaranteeing the ship's stability and safety.

•Real-time Compensation: Integrated sensors continuously monitor the ship's movements and adjust its position accordingly, ensuring precise and optimal docking.

•Information Display: Vital data such as vacuum percentage and ship motion is collected by sensors and displayed on the system's interface, providing operators with real-time insights into the mooring process.

DETAILED DIAGRAM:



RESULTS (TABLES/GRAPHS):

Improved Competitiveness-
1.Improved efficiency
2.Highest safety standards
3.Reduced engine time
4.Improved berth flexibility

More time for :-
1.Loading/Unloading cargo
2.Recovering delays
3.Utilization of shore and ship's crew

TABLE: DATA SHOWING EFFICIENCY AFTER VACUUM BERTHING BEING USED

	Port ,Country	Berths	Since (Year)	Moorings
RoPax and RoRo	Port of Helsinki, Finland	L J7 and L J8	2017	9/day
	Wightlink, UK	Portsmouth-Fishbourne	2017	30/day
	Samso Rederi, Denmark	Hou-Saelvig	2015	7/day
	Molslinjen, Denmark	Spodsbjerg-Taars and Ballen-Kalundborg	2009	5/day and 18/day
	Teso, The Netherlands	Den Helder	2014	16/day
	Port of Tallinn, Estonia	_	2020	9/ day
Electric Vessels	Norled, Norway	Lavik-Oppedal and Sydnes-Utboya	2015	52/day
	Asko Maritime, Norway	Horten-Moss	2022	7/day
	Fjord1, Norway	_	2018	50/day
	Ontario Transport, Canada	Amherst, Millhaven, Kingston, Marysville and Wolf island	2019	10/day
	Boreal, Norway	Kinsarvik-Utne-Kvanndal and Skanevik-Matre-Utaker	2019	11/day
	FosenNamsos Sjo, Norway	Flakk-Rorvik	2019	39/day
Container	Port of Salalah, Oman	Transshipment	2006	2-3/day
	Port of Beirut, Lebanon	_	2014	4-5/day
	Napier Port, New Zealand	_	2022	_
Bulk	Port Hedland, Australia	Iron ore loading	2010	3-4/week
Locks	St. Lawrence Seaway, US and Canada	Lockage	2014	4-5/day

CONCLUSION:

The automated vacuum mooring system marks a significant leap forward in mooring technology, effectively mitigating shortcomings of traditional methods. While some technical aspects remain confidential, research indicates challenges in achieving complex movements and adapting to irregular surfaces. Nevertheless, its benefits in terms of speed, safety, stability, and environmental sustainability underscore its potential to revolutionize ship mooring practices. As this technology continues to evolve, it is poised to play a pivotal role in future maritime operations, potentially reshaping the landscape of the green shipping industry.

REFERENCES:

[1] Cavotec: Application and Principles of Vacuum Berthing by Cavotec. Available at: https://www.cavotec.com/en/your-applications/ports-maritime/automated-mooring

[2] Trelleborg: Automated Mooring System Technology by Trelleborg. Available at: https://www.trelleborg.com/en/marine-and-infrastructure/products-solutions-and-services/marine/docking-and-mooring/automated-mooring-systems/automoor

Hydrogen Powered Submarine Using Electrolysis

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ABSTRACT

This project presents an innovative approach to addressing the environmental and economic challenges posed by the traditional reliance on fossil fuels in maritime operations. It introduces the concept of utilizing electrolysis in submarines for hydrogen-powered propulsion, integrated with fuel cells. The integration of electrolysis and fuel cells offers a promising solution to mitigate the environmental impact of submarine operations. By employing electrolysis, submarines can efficiently generate hydrogen from water, providing a clean and renewable fuel source. This hydrogen is then utilized in fuel cells to power propulsion systems, reducing emissions and reliance on fossil fuels.The abstract highlights the potential benefits of this approach, including reduced environmental impact, enhanced operational efficiency, and increased sustainability. Furthermore, it discusses the feasibility of implementing such a system in submarine models, paving the way for advancements in research and development within the maritime sector.

KEYWORDS:

Innovative approach, electrolysis, integration with fuel cells, clean and renewable fuel source, reduced emission, feasibility.

INTRODUCTION:

The maritime industry has faced increasing pressure to mitigate environmental impact and improve operational efficiency. One promising avenue for achieving these goals is the integration of advanced technologies into submarine propulsion systems. This model explores the innovative concept of utilizing electrolysis and fuel cells in submarines to enable hydrogen-powered propulsion. Traditionally, submarines have relied on fossil fuels for propulsion, resulting in significant emissions and environmental degradation. The transition to hydrogen-powered propulsion systems offers a compelling solution to these challenges. By employing electrolysis to generate hydrogen from water and utilizing fuel cells to convert this hydrogen into electrical energy for propulsion, submarines can operate with minimal environmental impact and enhanced efficiency. This model aims to provide a comprehensive overview of the technical aspects involved in implementing hydrogen-powered propulsion systems in submarines. It will discuss the principles of electrolysis, the operation of fuel cells, and the integration of these technologies into submarine designs. Additionally, the paper will explore the potential benefits of hydrogen-powered propulsion systems, including reduced emissions, increased range, and improved maneuverability. Through this technical exploration, we aim to contribute to the advancement of sustainable practices within the maritime industry and inspire further research and development in hydrogen-powered propulsion technology.

OBJECTIVE:

The objective of this model is to present an innovative approach to the maritime sector, focusing on the integration of electrolysis and fuel cells in submarines for hydrogen-powered propulsion. The primary aim is to demonstrate the feasibility and potential benefits of implementing such a system in submarine models, including reduced environmental impact, enhanced operational efficiency, and increased sustainability. Through this development and demonstration, we seek to advance research and development within the maritime industry and promote the adoption of clean and renewable technologies for propulsion systems in submarines. The main objectives will be – reducing environmental impact, enhancing operational efficiency, increasing sustainability and reduce dependency on diesel and nuclear powered submarine.

CONCEPT:

The conceptual framework of the "Hydrogen Powered Submarine" project revolves around the integration of sustainable practices and reduction of carbon emission within maritime sector. The project seeks to leverage the power of hydrogen fuel and replace the conventional fuel and engine by hydrogen fuel cells using it for propulsion system as well completing the electrical demands of the submarine . This system will will utilize oxygen and hydrogen gas extracted from water with electrolysis and stored in compressed form in the submarine . And the water produced as a by-product in the process can be utilized in various domestic as well as engine room services .

WORKING PRINCIPLE:

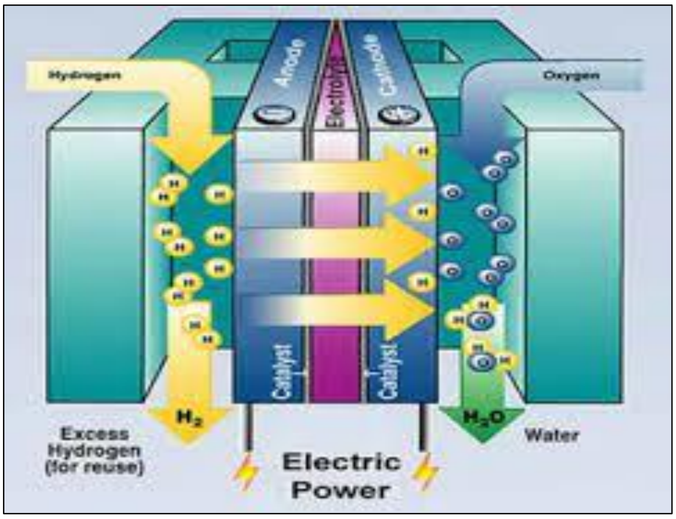
The working principle of the "Hydrogen Powered Submarine" is that we will use the hydrogen and oxygen molecules present in water s a fuel to hydrogen fuel cells . We will extract this by performing electrolysis on seawater which will separate H_2 and O_2 molecules which will then be fed to the fuel cells . A fuel cell consists of two electrodes—a negative electrode (or anode) and a positive electrode (or cathode)—sandwiched around an electrolyte. A fuel, such as hydrogen, is fed to the anode, and air is fed to the cathode. In a hydrogen fuel cell, a catalyst at the anode separates hydrogen molecules into protons and electrons, which take different paths to the cathode. The electrons go through an external circuit, creating a flow of electricity. One kilogram of hydrogen contains approximately 33.6 kWh of energy. Thus , for 1 MW of electricity, you would need around 33.6 kilograms of hydrogen.
A nuclear submarine power plant requires almost 20 megawatts of power for propulsion , thus the hydrogen required for such submarine would be near about 672 kg of hydrogen for its fuel cells.

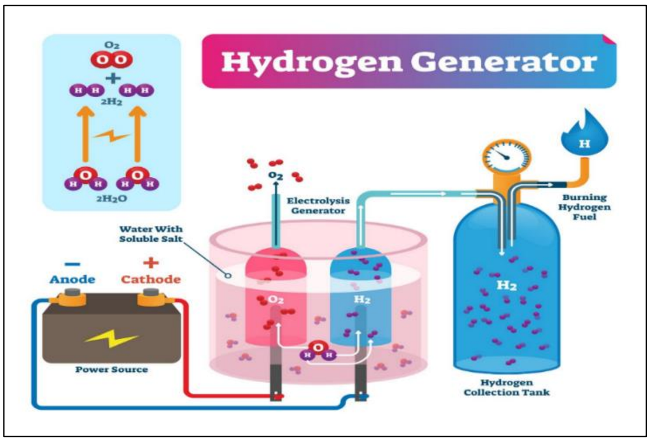
ECONOMICAL:

Factor	Hydrogen-Powered Submarine	Diesel-Powered Submarine	Nuclear-Powered Submarine
Initial Cost (USD)	$500 million	$400 million	$800 million
Operating Cost/year (USD)	$50 million	$60 million	$40 million
Return on Investment (%)	15%	10%	20%
Fuel Efficiency	High	Medium	Very High
Space Considerations	Moderate	High	High
Reliability	High	High	Very High
Environmental Impact	Low emissions	High emissions	Low emissions
Radioactive Waste	None	None	Yes (Requires Disposal)
Noise Levels	Low	High	Low

The hydrogen powered submarine stands out as the most economically advantageous option . While it's initial cost is higher than diesel powered submarine , it offers significantly lower operating costs per year , resulting in a higher return on investment over time . Compared to nuclear powered submarine , the hydrogen powered submarine requires less initial investment and has comparable investing costs , making it a more financially attractive choice .

DIAGRAMS:





CONCLUSION:

In conclusion, the integration of electrolysis and fuel cells for hydrogen-powered propulsion in submarines represents a transformative approach to addressing environmental and operational challenges in maritime operations. By harnessing clean energy sources and reducing reliance on fossil fuels, this technology offers significant environmental benefits, including reduced emissions and improved air quality. Moreover, the enhanced energy efficiency and extended operational range afforded by hydrogen propulsion systems contribute to greater mission capabilities and operational flexibility for submarines. As global efforts to transition towards sustainable energy intensify, the adoption of hydrogen energy technologies is expected to play a crucial role in decarbonizing maritime operations and advancing towards a more sustainable future. Continued research and development in this field are essential to further optimize the efficiency, reliability, and cost-effectiveness of hydrogen propulsion systems, paving the way for broader adoption across the maritime industry. Overall, the integration of electrolysis and fuel cells in submarines represents a promising step towards achieving environmental sustainability and operational excellence in maritime transportation.

ACKNOWLEDGMENT:

This paper is result of in-depth analysis of various researches and their drawback. A generous vote of thank to all the faculties and peers for their constant support and guidance .

REFERENCES:

[1].https://www.asme.org/topics-resources/content/a-hydrogen-powered-green-submarine-for-the-future

[2] https://www.sciencedirect.com/science/article/abs/pii/S0360319923045081

[3]https://fuelcellsworks.com/news/first-green-hydrogen-submarine-amongst-winner-of-clean-maritime-competition/

[4].https://www.energy.gov/eere/fuelcells/fuel-cells

[5].https://www.gantner-instruments.com/blog/fuel-cells-advanced-measurement-techniques-and-navigating-the-hydrogen-market/?utm_medium=ppc&utm_source=adwords&utm_campaign=GI+%7C+GSN+%7C+EN+%7C+Hydro+%7C+EU+USA&utm_term=hydrogen%20fuel%20cells&hsa_mt=b&hsa_src=g&hsa_grp=156094970313&hsa_cam=20480473674&hsa_ver=3&hsa_acc=3462185519&hsa_net=adwords&hsa_tgt=kwd-323422036473&hsa_ad=681162507037&hsa_kw=hydrogen%20fuel%20cells&gad_source=1&gclid=CjwKCAiAibeuBhAAEiwAiXBoJA9OQ_7MevAsyPDrovHwwNaJF7wcVXQfrnsDqI32Sw_lAdkrSNeAxRoCwcMQAvD_BwE

[6].https://batteryuniversity.com/article/bu-210-how-does-the-fuel-cell-work

[7].https://www.hydrogenfuelnews.com/hydrogen-fuel-cells-used-to-power-new-submarine-in-germany/8510716/

Carbon Capture Using Calcium Looping Technology: A Study on Quantities and Flow Rates

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ABSTRACT

This study investigates the use of calcium hydroxide ($Ca(OH)_2$) for carbon dioxide (CO_2) capture from exhaust gases, focusing on optimizing $Ca(OH)_2$ quantities and gas flow rates. Experiments conducted with $Ca(OH)_2$ amounts ranging from 39.60 to 66.11 grams and flow rates of 2, 3, and 4 liters per minute (LPM) revealed the highest CO_2 capture efficiency of approximately 70% with 66.11 grams of $Ca(OH)_2$ at 4 LPM. The results underline the effectiveness of the calcium looping process as an eco-friendly carbon capture method and offer insights into the critical parameters for enhancing system efficiency. Achieving up to 70% efficiency with 50 grams of CaO in a 100 ml water solution at 4 LPM, the study contributes to developing sustainable solutions for combating climate change.

KEYWORD:
Carbon Capture, Greenhouse Gas Mitigation, Calcium Lopping

NOMENCLATURE:

GHG	Greenhouse gas
CCUS	Carbon Capture Utilisation and Storage
CO_2	Carbon Dioxide
CaO	Calcium Oxide
$CaCO_3$	Calcium Carbonate
$Ca(OH)_2$	Calcium Hydroxide
H2O	Water
CaL	Calcium Looping
CCS	Carbon Capture Storage
PPM	Parts Per Million

1. INTRODUCTION:

Anthropogenic greenhouse gas (GHG) levels are at an all-time high, causing significant climate warming. Carbon Capture, Utilization, and Storage (CCUS) technology aims to mitigate this by capturing CO_2 emissions before their release, repurposing them, and safely storing them. Global warming leads to ecosystem and societal disruptions, emphasizing the need for climate change mitigation to prevent extreme weather events. Experts suggest limiting global temperature rise to below 2°C by achieving CO_2-equivalent emissions of around 450 ppm by 2100. This requires reducing GHG emissions by 40% to 70% by 2050 and aiming for net-zero emissions by the end of century. CCUS

captures CO_2 from large sources or directly from the air, utilizing or storing it to reduce net emissions. It offers revenue opportunities through the sale of CO2 for industrial uses, including enhanced oil recovery and the production of synthetic fuels and materials. Technologies like Bioenergy with Carbon Capture and Storage (BECCS) and Direct Air Capture (DAC) enable negative emissions, complementing natural solutions like afforestation **[1-9]**.
Carbon capture is the process of capturing CO_2 emissions from sources like power plants to prevent atmospheric release, playing a key role in climate change mitigation. It involves advanced technologies such as chemical absorption and physical separation for efficiency and cost-effectiveness. CO_2 capture methods include pre-combustion, post-combustion, and oxyfuel combustion, each with specific processes and applications. Captured CO_2 can be used in manufacturing urea, converting to chemicals, or in construction materials, contributing to a sustainable economy. Research shows varying capture efficiencies and the potential for large-scale application in industries.

1.1 Carbon Dioxide Capture Technologies

CO_2 is a major global warming contributor, with emissions expected to rise. Reducing these emissions is crucial worldwide, involving policies and R&D in areas like chemical and fuel production, biological exploitation, and conventional uses to mitigate global warming. Commercial CO_2 capture primarily uses amine-based absorption, facing limitations like solvent degradation and high energy use. Wetlands and carbon capture forestry offer natural sequestration options but face challenges such as land use conflicts. The calcium looping process, using calcium hydroxide to absorb CO_2 and form calcium carbonate, presents an alternative with advantages like cost-effectiveness and environmental friendliness [10-19].
The objectives of this project can be summarized as follows:
1. To design and develop the effective carbon capture technology.
2. To observe the effects for different concentrations of the calcium oxide and water on the carbon capture by different concentrations of the carbon dioxide emissions and captured percentages.

2. CONCEPT AND WORKING

2.1 Materials
The experiment aimed to capture CO_2 using a calcium oxide (CaO) solution, starting with dissolving 1 gram of CaO in 10 ml of water to form a $Ca(OH)_2$ solution. An exothermic reaction was confirmed by a temperature rise from 28.6°C to 32.1°C. The solution, tested alkaline with a pH of 12, successfully absorbed CO_2 to form calcium carbonate ($CaCO_3$) upon introduction of CO_2 gas. Further, using dry cow dung cakes for CO_2 emission, the experiment evaluated the effects of concentration, temperature, and pressure on CO_2 absorption equilibrium in the $Ca(OH)_2$ solution.
Combustion Chamber: Made of cast iron to withstand temperature and pressure during fuel ignition for CO_2 generation. Connected to the chemical chamber for flue gas transport.
Blower: Transfers flue gases from the combustion to the chemical chamber, preventing back pressure and ensuring thorough mixing with the chemical solution to capture CO_2.

Flowmeter: Measures gas flow from the combustion to the chemical chamber in Liters Per Minute (LPM), with a range of 1 to 25 LPM, allowing flow rate adjustments.
CO_2 Detector: Measures CO_2 emissions in Parts Per Million (PPM), with a maximum limit of 10,000 ppm, also recording humidity, temperature, and dew point for up to 1000 readings.
Weighing Machine: Measures chemicals in grams with a maximum capacity of 50 grams, ensuring precise control over experimental quantities.
Fuel: Uses cow dung cakes, a mixture of cow dung, straw, and organic materials, as a sustainable fuel source, generating up to 7860 ppm CO_2 at 4 LPM flow rate.

2.2 Chemical Property

The absorption limit of CO_2 by a $Ca(OH)_2$ solution is reached when the chemical reaction between CO_2 and $Ca(OH)_2$ achieves equilibrium. This equilibrium, where CO_2 absorption and release balance each other, is influenced by the $Ca(OH)_2$ concentration, temperature, pressure, and the chemical potential. High $Ca(OH)_2$ concentration, lower temperatures, and higher pressures favour CO_2 absorption. At saturation, the solution cannot absorb additional CO_2, and excess CO_2 bubbles out.

2.3 Experimental Set-up

Experimental setup established within the workshop to facilitate real-time experiments involving different permutations of chemical concentrations, as shown in Figure 3.1. This setup incorporated a blower designed to facilitate the circulation of flue gases originating from the combustion chamber through a gas flow meter and into the chemical solution. Dry cow dung cakes were utilized as the fuel source, generating flue gases with a moderate temperature and a limited amount of CO_2. The average CO_2 concentration of the ambient air was measured at 427 ppm, and the relative humidity was consistently maintained at approximately 56%, measured by using a CO_2 detector throughout the experiments.

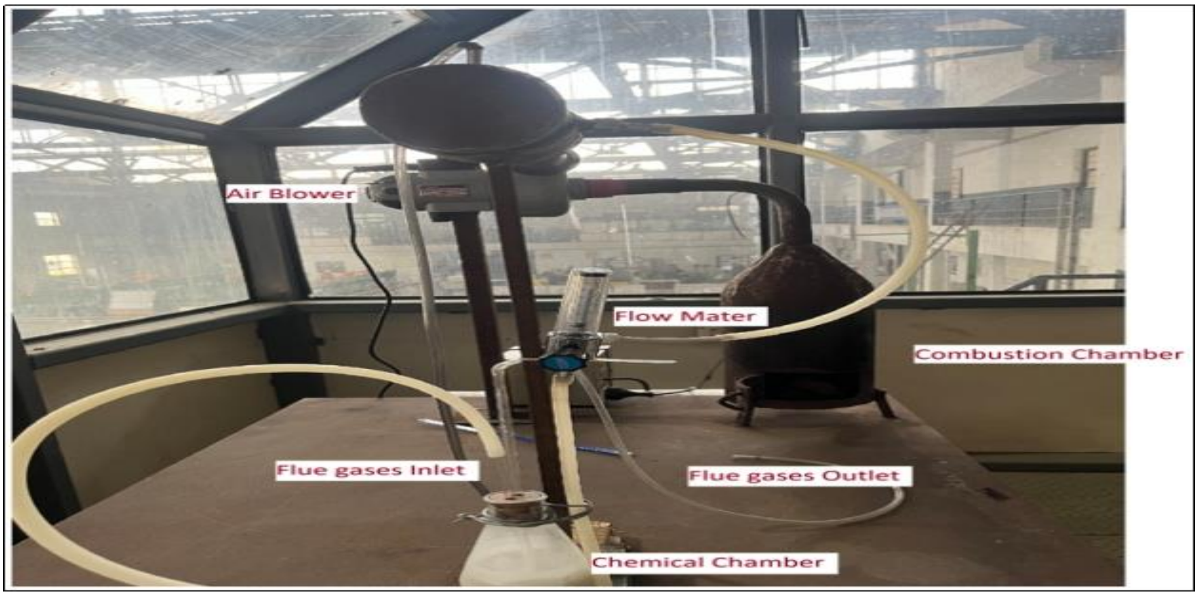
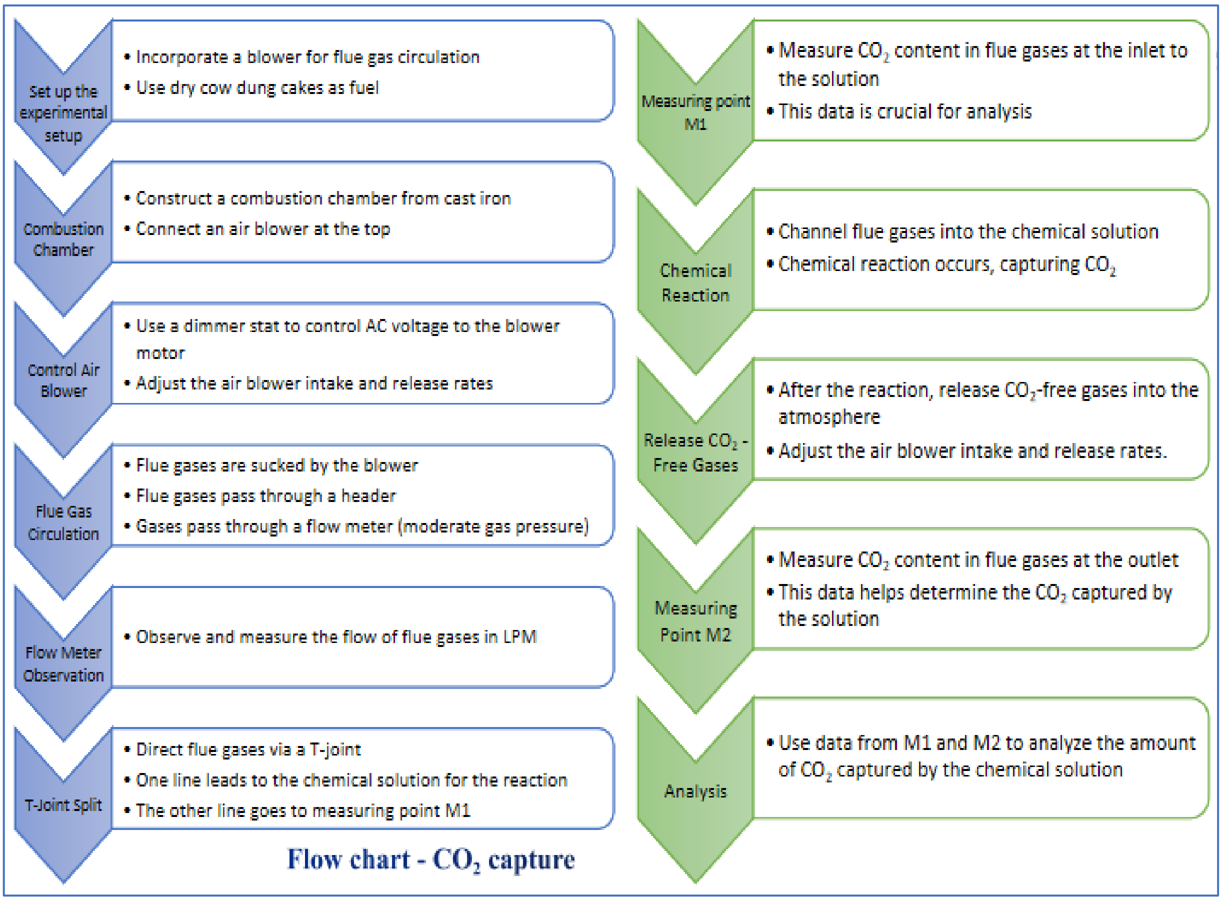


Figure 3.1: Experimental Set-Up for Project

3.3.1 Flow chart - CO_2 Capture:



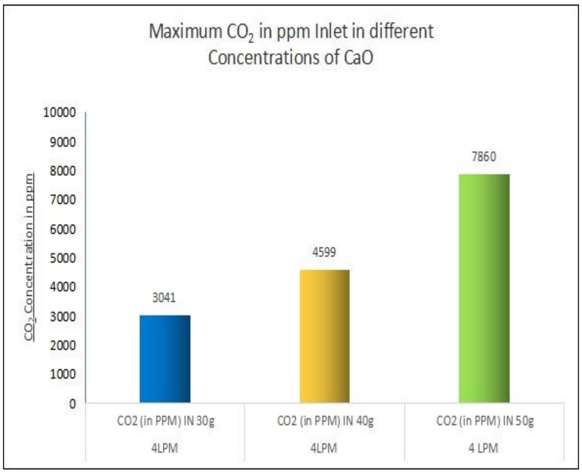
Flow chart - CO_2 capture

3. Results and Discussion

Table 4.1 shows the effect of CaO amount on CO_2 concentration in flue gases. It demonstrates varying CaO influences on CO_2 capture efficiency. With 50 grams of CaO at 4 LPM flow rate, CO_2 concentration decreases from 7860 ppm at the inlet to 2263 ppm at the outlet, indicating role of CaO in CO_2 capture.

Table 4.1: Max. CO_2 (ppm) before and after the chemical solution in the flue gases

CaO in grams	Location of Maximum CO_2 Concentration (ppm) in Flue Gases	Flue Gas Flow Rate		
		2 LPM	3 LPM	4 LPM
30	Inlet	2399	2562	3041
	Outlet	1571	1653	1869
40	Inlet	3524	3795	4599
	Outlet	1868	1934	2094
50	Inlet	6710	7250	**7860**
	Outlet	2117	2174	**2263**



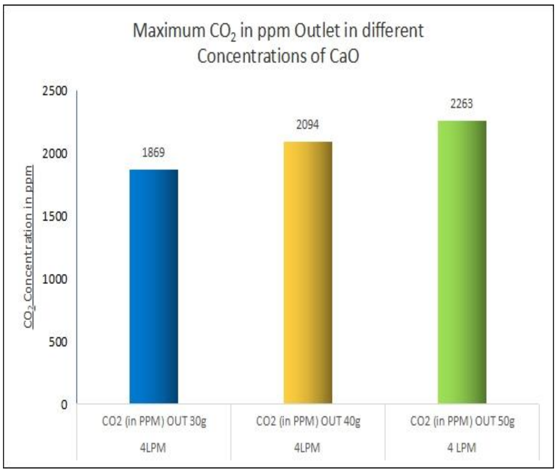
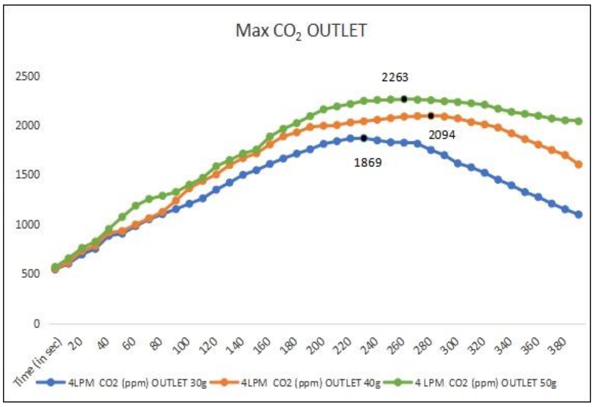


Figure 4.1: Maximum CO_2 in ppm Inlet in different concentration on CO_2
Figure 4.2: Maximum CO_2 in ppm Outlet in different concentration on CO_2

Figures 4.1 and 4.2 show the effect of calcium oxide (CaO) concentration on CO_2 levels in flue gases at 4 LPM flow rate. Using 50 grams of CaO, the inlet CO_2 peaked at 7860 ppm, while the outlet CO_2 was significantly lower at 2263 ppm. This demonstrates the effectiveness of CaO in CO_2 capture at these conditions.

3.1 A Comparative Discussion on the Results of Various Concentrations of CaO in Capturing CO_2 at Different Flow Rates.

Our study assessed effectiveness of $Ca(OH)_2$ in capturing CO_2 from flue gases, using 39.60 to 66.11 grams of $Ca(OH)_2$ at 2, 3, and 4 LPM flow rates. The highest CO_2 capture rates, exceeding 70%, were achieved with 66.11 grams of $Ca(OH)_2$, particularly at higher flow rates. This underscores potential of $Ca(OH)_2$ as an efficient CO_2 capture agent, offering a promising strategy for reducing carbon emissions and combating global warming.



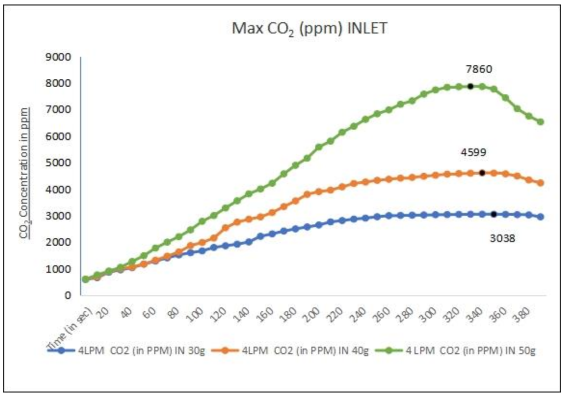


Figure 4.13: CO_2 Concentration in ppm at Inlet of the combustion chamber
Figure 4.14: CO_2 Concentration in ppm at Outlet of the combustion chamber

4. CONCLUSION

Our study rigorously evaluated efficiency of $Ca(OH)_2$ in capturing CO_2 from exhaust gases, testing various amounts of $Ca(OH)_2$ (39.60 to 66.11 grams) at different flow rates (2, 3, and 4 LPM). The findings showed the highest CO_2 capture rates, particularly with 66.11 grams of $Ca(OH)_2$, achieving absorption rates of about 68.45% to 71.21% across the flow rates. This underscores effectiveness of $Ca(OH)_2$ in CO_2 capture, especially at higher concentrations and flow rates. In summary, the research highlighted the potential of the calcium looping process as an environmentally friendly carbon capture method, achieving up to 71.21% efficiency with 50 grams of CaO at a 4 LPM flow rate. This work contributes valuable insights for optimizing carbon capture systems and supports the advancement of sustainable solutions in combating climate change.

- It aimed to develop a cost-effective approach to carbon capture, yielding promising results.
- The study also investigated the impact of different CaO and distilled water concentrations on carbon capture efficiency, shedding light on critical parameters.
- The highest CO_2 capture efficiency, approximately 71.21%, was achieved using 50 grams of CaO in a 100 ml water solution with a 4 liters per minute flow rate.

REFERENCES:

[1] R. Shaw and S. Mukherjee, "The development of carbon capture and storage (CCS) in India: A critical review," *Carbon Capture Science and Technology*, vol. 2. Elsevier Ltd, Mar. 01, 2022. doi: 10.1016/j.ccst.2022.100036.

[2] "IEA - About CCUS," 2021, [Online]. Available: http://www.iea.org/reports/about-ccus

[3]"How does CCUS work?" [Online]. Available: https://www.lse.ac.uk/granthaminstitute/explainers/what-is-carbon-capture-and-storage-and-what-role-can-it-play-in-tackling-climate-change/#:~:t

[4] K. Storrs, I. Lyhne, and R. Drustrup, "A comprehensive framework for feasibility of CCUS deployment: A meta-review of literature on factors impacting CCUS deployment," *International Journal of Greenhouse Gas Control*, vol. 125, May 2023, doi: 10.1016/j.ijggc.2023.103878.

[5] I. Energy Agency, "Technology Perspectives Energy Special Report on Carbon Capture Utilisation and Storage CCUS in clean energy transitions." [Online]. Available: www.iea.org/t&c/

[6] Juan Carlos Abanades (Spain) *et al.*, "IPCC Special Report on CARBON DIOXIDE CAPTURE AND STORAGE," Montreal, Canada, Sep. 2005. [Online]. Available: http://www.ipcc.ch/meet/session20/finalreport20.pdf

[7] K. Calvin *et al.*, "2.6: Limiting climate change to 450 ppm CO2 equivalent in the 21st century," *Energy Econ*, vol. 31, no. SUPPL. 2, 2009, doi: 10.1016/j.eneco.2009.06.006.

[8] Intergovernmental Panel on Climate Change. Working Group III and O. Edenhofer, *Climate change 2014 : mitigation of climate change : Working Group III contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*.
[9] S. Kammerer, I. Borho, J. Jung, and M. S. Schmidt, "Review: CO2 capturing methods of the last two decades," *International Journal of Environmental Science and Technology*. Institute for Ionics, 2022. doi: 10.1007/s13762-022-04680-0.
[10] "IEA - CCUS Projects Explorer," Mar. 2023, [Online]. Available: https://www.iea.org/data-and-statistics/data-tools/ccus-projects-explorer
[11] S. J. Han, M. Yoo, D. W. Kim, and J. H. Wee, "Carbon dioxide capture using calcium hydroxide aqueous solution as the absorbent," *Energy and Fuels*, vol. 25, no. 8, pp. 3825–3834, Aug. 2011, doi: 10.1021/ef200415p.
[12] "Planting trees as carbon offsets is trickier than it seems _ Popular Science," *Hannah Seo*, Oct. 2023.
[13] S. Naveen Kumar Vidyarthi *et al.*, "Carbon Capture, Utilization and Storage (CCUS) Policy Framework and its Deployment Mechanism in India." [Online]. Available: www.niti.gov.in
[14] Guillermo Galan, Marino Martin, and Ignacio E. Grossmann, "Systematic comparison of natural and engineering methods of capturing CO2 from the air and its utilization," 2022.
[15] R. Beck, "Optimizing Carbon Capture, Utilization and Storage to Meet Ambitious Sustainability Goals White Paper," 2022. [Online]. Available: aspentech.com
[16] Ankur Malyan and Vaibhav Chaturvedi, "Carbon Capture, Utilisation, and Storage (CCUS) in India: From a Cameo to Supporting Role in the Nation's Low-Carbon Story," Aug. 2021.
[17] Z. Chi, J. V. O'Fallon, and S. Chen, "Bicarbonate produced from carbon capture for algae culture," *Trends in Biotechnology*, vol. 29, no. 11. pp. 537–541, Nov. 2011. doi: 10.1016/j.tibtech.2011.06.006.
[18] I. Hazra Chowdhury, A. Hazra Chowdhury, P. Sarkar, and S. M. Islam, "Chemical Fixation of Carbon Dioxide by Heterogeneous Porous Catalysts," *ChemNanoMat*, vol. 7, no. 6. John Wiley and Sons Inc, pp. 580–591, Jun. 01, 2021. doi: 10.1002/cnma.202100074.
[19] H. Al Baroudi, A. Awoyomi, K. Patchigolla, K. Jonnalagadda, and E. J. Anthony, "A review of large-scale CO2 shipping and marine emissions management for carbon capture, utilisation and storage," *Applied Energy*, vol. 287. Elsevier Ltd, Apr. 01, 2021. doi: 10.1016/j.apenergy.2021.116510.

Digitalization of transportation and logistics

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ABSTRACT

A tech-based logistics company specializes in the transportation and delivery of goods using innovative technology solutions. The company uses data-driven algorithms to optimize routes and delivery times, reducing costs and increasing efficiency. our platform integrates with existing systems, allowing real-time tracking and communication with customers. The company prioritizes sustainability, utilizing efficient delivery methods and minimizing damage through smart packaging solutions. The ultimate goal of the tech logistics company is to revolutionize the delivery industry, providing fast, reliable and efficient solutions to meet the evolving needs of businesses and consumers.

OBJECTIVE

Focus on helping your customers through market turbulence and leave carrier connectivity and shipment workflow automation to us. The only platform that can provide you with the visibility, analytics, and workflow capabilities you want, seamlessly integrating with your systems and partners, is Movement by Ocean freight Global. Finally, real-time supply chain visibility that goes above and beyond shipment tracking to deliver trustworthy insights that save your team time and money

INTRODUCTION

Sticking to the theme of the topic we have decided to create and publish a web page on the internet which will explain our model. The web page will simulate a shipping or logistics company and will have all the features expected to be seen in a professional company website. Such as but not limited to:

a) Real time route tracking
b) Placement of order
c) Ship schedule
d) About the company
e) Routes and dates
f) Technology backed services the customer can avail.

In addition to this web page there will be a physical model of the supply chain structure of the shipping industry on the over view of a warehouse to warehouse structure and this will be used to explain the various web pages and how it will benefit both the consumer and operator.

There we will also explain how a tech backed company will reduce the work force and reduce the error from the shipping company side making transportation of goods more reliable.

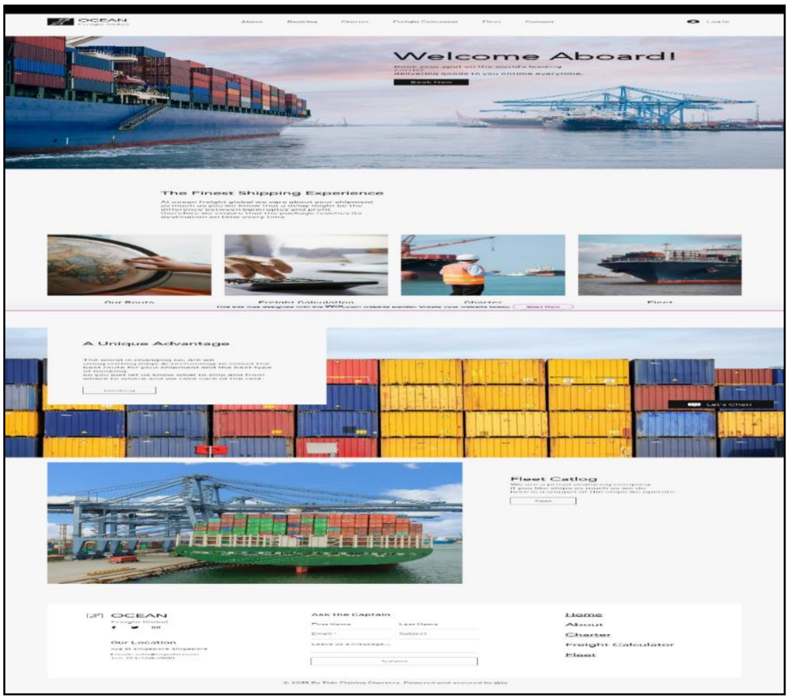
CONCEPT

We believe that technology is the future of business se we are trying to create a website which replicates a company which uses AI and ML backed technology to provide the consumer with real time data and optimized personal solutions for the consumer to choose from for the transport of his/her goods in the fastest and the most efficient way.

WORKING PRINCIPLE

Application of AI and ML algorithms with the addition of existing logistics frame work to provide the best solution for the consumer.

DETAILED DIAGRAM



RESULTS (TABLES/GRAPHS)

a) IMPROVED PERSONNEL PRODUCTIVITY- Machine-learning delivers quality, order-level data with less time spent manipulating spreadsheets.
b) PROACTIVE MANAGEMENT- ETAs and alerts focus teams on what’s important while predictive insights keep you ahead of the curve and set you apart from the competition.
c) REDUCED LOGISTICS COST- Avoid burdensome D&D fees with better and more timely visibility, reducing excessive costs from unnecessary expedites.
d) REALTIME GLOBAL VIEW OF PORTS- Gain real-time insights to port, terminal, and vessel activity To help manage port congestion, blind spots, and black swan events, Port Intel delivers global, accurate, real-time intelligence on port and vessel activity so supply chain professionals can plan proactively, respond to exceptions, and meet customer expectations. Use macro global views to understand regions of risk and changes

in congestion for any lane and any port, globally. Stay informed for any port of interest with an interactive web application. Gain real-time insights on container import and export dwell, vessel anchor and berthing dwell, vessel counts, congestion, and more. Get the latest information on global ports via API for integration with your TMS, ERP, Planning, or system of record.

e) SERVICE VOYAGE DETAILS- We provide you with all shipment details, e.g. departure and arrival dates, service names and codes, as well as vessel and voyage numbers from all shipping lines. This ensures smooth operational handling for your cargo and supply chain management. Discover all connecting services and feeder trans-shipments that are available to get your cargo from A to B with detailed information for up to two trans-shipments, including trans-shipment port information.

f) OPTIMIZED PLANNING WITH BARGE VISIBLITY- Accurately assess and optimize capacity for barge moves with accurate water depth data for inland waterways, improving reliability of barge legs of multimodal shipments.

g) REDUCED IT AND OPS COST- With Ocean freight global's easy-to-use SaaS platform, you can finally retire inflexible, obsolete legacy systems that monopolize development time and require complex integrations.

CONCLUSION

With visibility into your supply chain operation you can take the right actions at the right time and be in control of your logistics operations. OCEAN FRIEGHT GLOBAL can get you there and keeps your cargo flowing and transitioning towards integrated supply chain management, mass flow allows you to know everything, upload and share post, track activities in progress, manage all your bookings from one place, monitor crucial processes, documentation and cargo milestones. It assists you in overcoming challenges and disruptions, brings end-to-end visibility and control to your supply chain operations which is easy and quick to implement. Reduction manual work due to introduction of digitalization in our supply chain helps you execute your supply chain as planned and gives you access to performance data so you can work smarter not harder.

REFERENCES

[1] www.wikipedia.com
[2] www.stockarea.io
[3] www.yoh.com
[4] www.aeologic.com
[5] www.bluedart.com
[6] www.builtin.com
[7] www.bms.com
[8] www.bimco.org
[9] www.wix.com
[10] www.incodocs.com
[11] www.cma-cgm.com
[12] www.hapeglloyd.com

VOORING

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ABSTRACT

This project focuses on the new approach towards the mooring operations. In today's era of autonomous vessels, automated container yards, ai, 5g and electrification we are still dependent on the same slow, dangerous and conventional way. Compared with the traditional mooring methods, vooring system can meet the development needs of largescale ship automation, port automation and environmental protection.
In the project we have proposed an efficient and safe way of a mooring operation by making the use of fenders aided with a vacuum system and completely elemenating the use of mooring ropes. It will optimize the quay utilization and will expand the product transfer operational window throughout a greater range of berthing.
This project provides valuable insights into design requirements, challenges and future perspectives of the vooring system.

OBJECTIVE

The number of ships and ports is increasing to accommodate the growing transportation demand and increasing number of mooring operations. For thousands of years, ships were moored by human hands using cables. this traditional mooring method is not only inefficient, but dangerous. with the continuous increase in ship tonnage and development trend of intelligent ships, the traditional rope mooring method is becoming increasingly difficult and time consuming. According to incomlete statistics, there are hundreds of accidents due to mooring with ropes every year.

Statistics from the european harbour master's committee indicate that, of all registered mooring injuries, 95% are caused by ropes and wires, and 60% of these injuries happen during mooring operation. most of the accidents occur in the process of rope/wire handling, in which rope/wire breakages account for 53% of the accident rate and rope/wire jumps/slips from the end of the drum/bite account for 42% of accident rate, of which 5% of accidents are caused by actual equipment failure.
Therefore, there is an urgent need for safe and effective mooring system to solve above problems. our project provides an innovative method by making the use of fenders aided with a vacuum system and completely elemenating the use of mooring ropes, making mooring operations more efficient and safe.

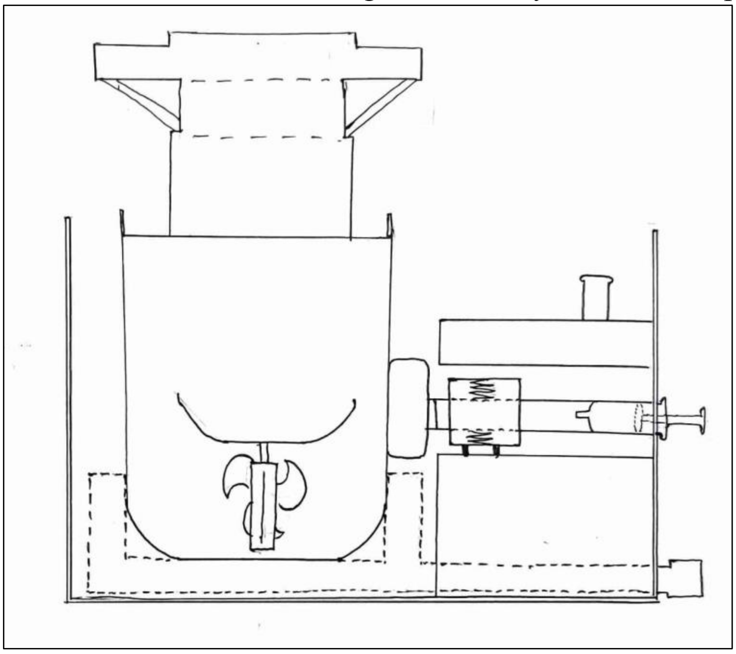
INTRODUCTION

In the rapidly evolving landscape of maritime transportation, the need for efficient and sustainable solutions within port operations has never been more pronounced. The traditional methods of mooring ships, often reliant on labor-intensive processes and conventional equipment, are facing challenges in meeting the demands of modern

shipping. Tn response to these challenges, the vacuum mooring project emerges as a groundbreaking initiative poised to redefine mooring practices in ports worldwide.
This project represents a shift in port technology, aiming to replace conventional mooring systems with a more efficient and environmentally friendly approach. The fundamental principle of vooring system involves utilizing advanced suction technology to securely hold vessels in place during loading and unloading operations. this departure from traditional mooring methods not only enhances operational efficiency but also presents a host of benefits, including reduced carbon emissions, minimized wear and tear on ships, and improved safety for both maritime personnel and vessels.

CONCEPT

Our idea will provide an efficient and environment friendly atlernative for traditional, labor intensive and outdated mooring methods by using advance suction technology. Vessels will be securely held in place during loading and unloading operations, enhancing operational efficiency. This project will offer benefits such as minimized wear and tear on ships, reduced carbon emissions, and heightened safety for maritime personnel.



WORKING PRINCIPLE

Vooring system works on the principle of advance vacuum system generated with the help of hydraulics.
The main components are:
1. Modified fenders
these modified fenders works as a shock absorbent and also as a air tight system holding the hull of a vessel.
2. Advance vacuum system
this arrangement will connect the hydraulic system with the modified fenders.
3. Gantry track
this will allow the whole arrangement to adjust, depending upon the size of the vessel.

4. Spring arrangements
this will control the surge and swell movements of the vessel.
5. Hydraulic system
this will be responsible for creating a vacuum in the above system.

DIAGRAM

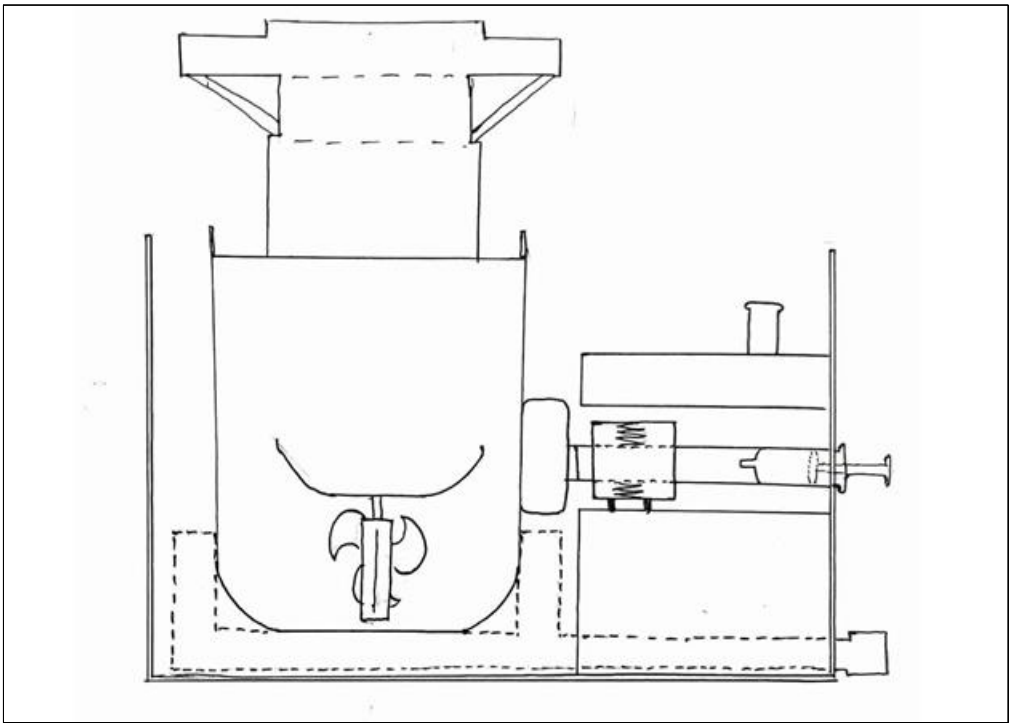


Fig. 1: CROSS-SECTION VIEW OF THE MODEL

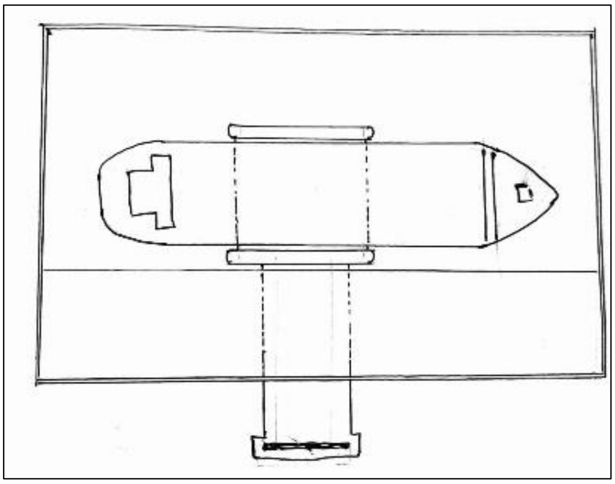


Fig. 2: LEVER ARRANGEMENT

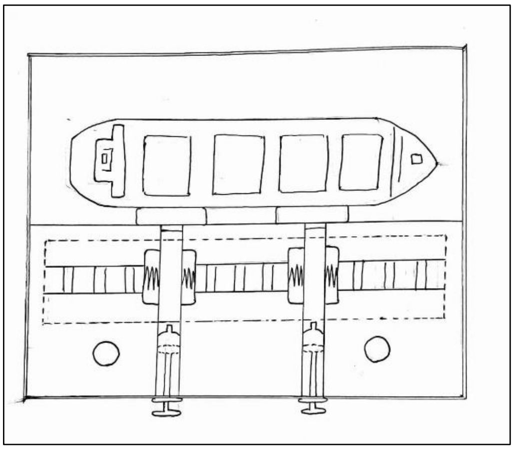


Fig. 3:TOP-VIEW OF THE MODEL

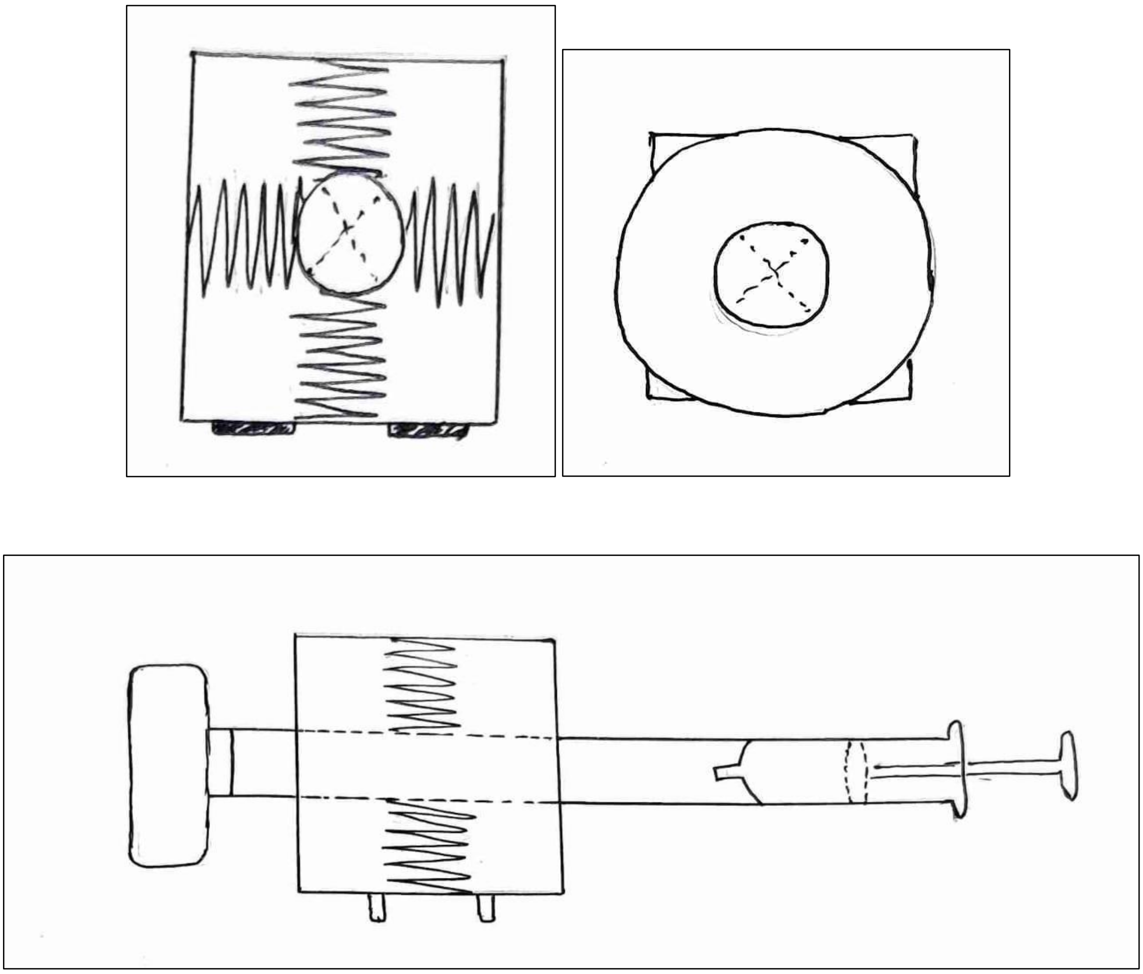


Fig. 4: VACUUM ARRANGEMENT

RESULTS

1. vacuum aided fenders that attach to any flat surface.
2. can be used with a wide variety of vessels and applications, irrespective of vessel size and design.
3. fast and simple connection to shore power.
4. reduced erosion of seabed driving cost savings.
5. reduced risk of mooring accidents as there are no snap-back zones and personnel do not need to perform hard manual labor in hazardous area.
6. mooring can be undertaken from any location, thereby increasing flexibility of operations.
7. the system offers the ability to adjust the level of vacuum or pressure applied, accommodating different vessel sizes and weights.
8. the system will incorporate a quick-release mechanism for efficient departure when needed.
9. a vacuum mooring system could be designed to minimize disturbances to the marine environment, supporting environmental conservation efforts.

CONCLUSION

This system might be capable of replacing the traditional and inefficient mooring methods with the help of vacuum aided fenders. the system can meet the development needs of largescale ship- automation, port automation and environmental protection.

REFERENCES

[1] Worldcargonews.Com

[2] Journal Of Marine Science And Engineering

[3] European Habour Master's Committee Report

[4] Ntnu Report

Samriddh Samudramanthan:
Seamlessly Combining Sustainability and Seafarer Awareness through port infrastructure

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ABSTRACT

The "Samriddh Samudramanthan" project presents a cutting-edge virtual model of modernized port infrastructure, focusing on sustainability and seafarer awareness. Utilizing free and open-source tools such as Blender and the Godot game engine, along with assistance from AI models like ChatGPT and Google Gemini, the project aims to showcase a sustainable and efficient port environment.

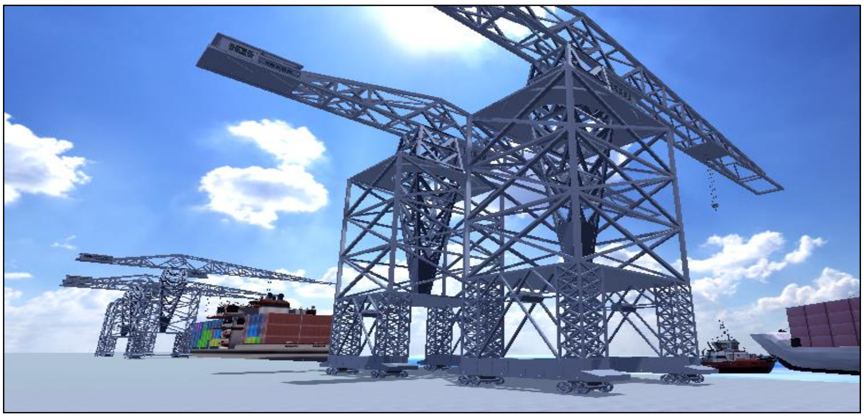

Figure 1:Image from "Samriddha Samudramanthan"

OBJECTIVE:

The objective of the "Samriddh Samudramanthan" project is to develop a virtual model of modernized port infrastructure that emphasizes sustainability and seafarer awareness. By utilizing free and open-source tools like free game engine(GODOT), Free 3D editing software(Blender) and more, the project aims to demonstrate innovative solutions for enhancing port efficiency while minimizing environmental impact. Additionally, the project seeks to educate people about maritime sector.

INTRODUCTION:

The maritime industry plays a pivotal role in global trade and economic development. However, traditional port operations often contribute to environmental degradation and pose challenges for seafarers. Recognizing the need for sustainable solutions, and with the momentum of the government initiatives like "Sagarmala" made to improve country's logistics and port modernization the "Samriddh Samudramanthan" project aims to make some additional suggestions to revolutionize port infrastructure through the development of a virtual model that prioritizes environmental sustainability and seafarer well-being.

CONCEPT:

The conceptual framework of the "Samriddh Samudramanthan" project revolves around the integration of sustainable practices and seafarer awareness within modernized port infrastructure like use of wind and tidal energy generation and locomotive connectivity to ports. The project seeks to leverage free and open-source tools such as Blender and the Godot game engine to create a virtual environment that showcases green energy solutions, digitized documentation processes, and enhanced connectivity for efficient port operations.

WORKING PRINCIPLE:

The working principle of the "Samriddh Samudramanthan" project involves the collaborative utilization of free and open-source tools, AI models, and expert guidance to develop a virtual model of modernized port infrastructure. The project begins with research and reference gathering from Google Earth to understand port layouts and infrastructure. Using Blender, 3D models of port facilities, vessels, and landscapes are created. The Godot game engine is then employed to program the virtual interface, incorporating interactive elements and educational features. ChatGPT and Google Gemini assist in generating GDScript snippets and additional programming tasks.

DETAILED DIAGRAM:

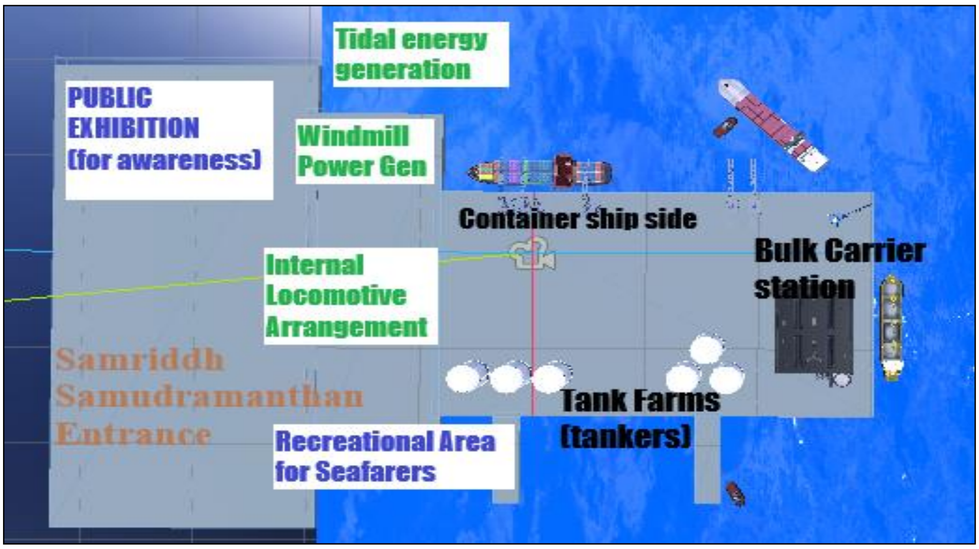

Figure 2: The diagram below depicts the prospective plan of port Samriddh Samudramanthan and may be slightly different from final model

RESULTS

The implementation of green port initiatives aim to significant environmental and economic benefits in existing ports worldwide:
1. Reduction in Carbon Emissions:
 - Green ports have achieved substantial reductions in carbon emissions through the adoption of renewable energy sources and energy-efficient practices.
2. Energy Efficiency Improvements:
 - Green ports have made significant strides in improving energy efficiency through the implementation of smart technologies and optimized operations.

Table 1: Tabular representation of prospective carbon emissions reduction trends in Green Port A and Green Port B from 2024 to 2029.

Samriddh Samudramanthan	Year	Carbon Emissions Reduction (%)
Green Port A	2024	25
Green Port B	2029	50
Green Port A	2024	30
Green Port B	2029	55

Table 2: Prospective Energy consumption trends and efficiency improvements in Green Port A and Green Port B from 2024 to 2029.

Samriddh Samudramanthan	Year	Energy Consumption (MWh)	Energy Efficiency Improvement (%)
Green Port A	2024	1000	-
Green Port A	2029	800	20
Green Port B	2024	1200	-
Green Port B	2029	900	25

3. Economic Impact:
 - Green port initiatives will have positive economic impacts, including cost savings, increased competitiveness, and job creation.
4. Awareness Impact:
 - Green port will also significantly raised awareness about sustainability and seafarer well-being.

CONCLUSION

In conclusion, the "Samriddh Samudramanthan" project represents a significant step towards revolutionizing port infrastructure through sustainability and seafarer awareness. By leveraging free and open-source tools, AI models, and expert guidance, the project demonstrates the feasibility of creating a virtual model that integrates green energy solutions, digitized documentation processes, and enhanced connectivity for efficient port operations. Moving forward, the project's findings underscore the importance of adopting sustainable practices in maritime transportation and port management to ensure a resilient and prosperous future.

REFERENCES

[1] Google Earth & Google Maps
[2] ISPS Code
[3] Marine Insight
[4] ChatGpt and Google Gemini
[5] Godot Documentations
[6] Sketchfab.com and Turbosquid.com (for free 3D models)

Magneto hydrodynamics drive (mhd) coupled with azipod system

Sub theme - Green Shipping and Environmental Sustainability

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ABSTRACT

The demand for sustainable and efficient energy sources has led to the exploration of unconventional technologies for power generation. This abstract aims at introducing Magneto Hydrodynamics (MHD) Drive Turbine for harnessing energy from fluid flow through the integration of magnetohydrodynamic principles. The system consists of a streamlined turbine structure, embedded with magnet arrays and electrodes, immersed in a conductive fluid. The MHD drive is used in conjunction with the Azipod system for better efficiency.

The research involves the comprehensive design of the MHD Drive Turbine, considering key parameters such as magnetic field strength, fluid conductivity, turbine geometry and operational conditions. Graphs are employed to evaluate the turbine's performance under various scenarios, providing insights into its efficiency, power output, and overall feasibility as a sustainable energy solution. The presented model showcases the feasibility of a Magneto Hydrodynamics Drive Turbine as a viable and environmentally friendly energy conversion solution.

OBJECTIVE:

Project deals with eliminating conventional slow speed engines and using MHD drive for propulsion in sea water and azipod system for sailing through fresh water.

INTRODUCTION:

The magneto hydrodynamic system can best be described as a system that can move electricity conducting fluids without any moving parts. This means that the usual wear and tear on pumps and engines could be a thing from the past if this system is applied on your vessel. When the conducting fluid is charged with an electric load it will become controllable by magnetism. Speed could be built up and be converted to pressure, a pump action is created. Another possibility is that the kinetic energy of the ions in the water will produce electricity. Azipod system in conjunction to it transfers the electrical energy produced aboard the ship to the AC electric motor which directly transmits the moment of rotation of the propeller-type thruster.

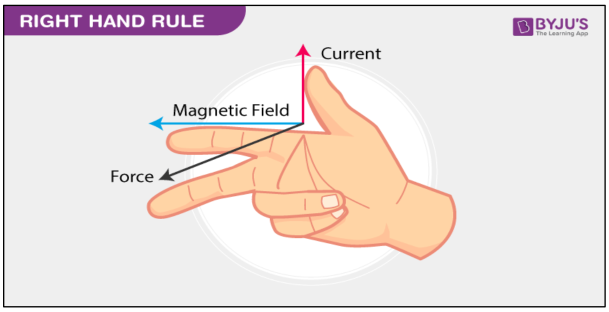
In this respect, they eliminate the classic components of a propulsion system such as: long shafts, reducer, adjustable pitch propellers, etc; they reduce the space occupied by the propulsion system engine room on board the ship, in favor of cargo or passenger spaces; they also reduce noise and vibration levels; they ensure operational safety, low fuel consumption as well as low maintenance costs; in addition, they are solid and easy to build and assembly; they ensure both the propulsion and steering of the ship, provide the ship with special maneuverability in rough weather conditions as well as at low speed, where classical rudder systems have low efficiency; they eliminate the classic components of a steering gear: the rudder, the rudder engine, the bow thruster, etc. No rotating parts in MHD drive saves the cost on maintenance and lube oil.

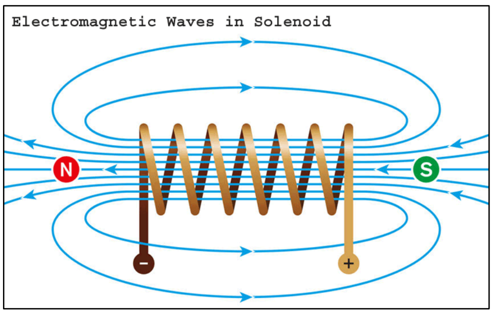
CONCEPT:

A magnet produces force lines, these lines of force run from pole to pole. Inside the magnet the lines run from the south pole to the north pole and outside the magnet the force lines run from the north pole to the south pole. All the force lines together form the magnetic field. This magnetic field is produced by the movements of the electrons inside the material. Our idea is a long tube and around this long tube are coils of electric wires such as copper-wire. If there is a high amperage current on these coils it creates an intensified electric field. This electric field produces the Lorentz force.
The Lorentz force was discovered by Hendrik Lorentz. The Lorentz force is an electric-magnetic force. This electric magnetic force creates an electric-magnetic field. The Lorentz force says that these electric-magnetic fields wield power on electric charges. This force can accelerate or slow down a charged particle. And in our idea we want to accelerate the charged particle. Seawater consists of multiple elements. The sodium and magnesium ions among them are the ions we are going to accelerate as charged particles.

One of the formulas of Hendrik Lorentz is:
F=Lorentz force, I=amperage, B=magnetic field, L=length of the conductor, n=amount of coils

F = ILBsin(theta)

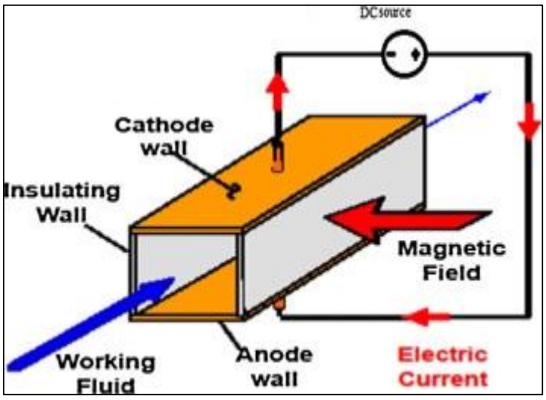


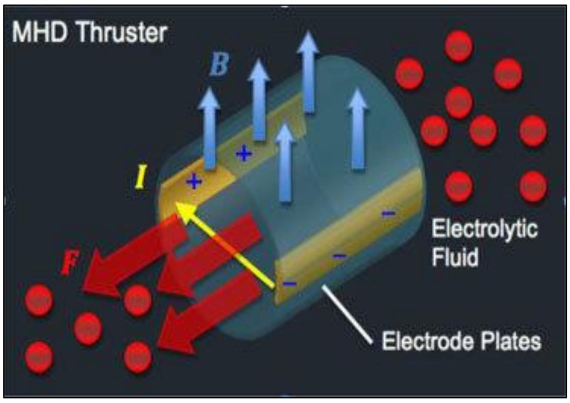


WORKING PRINCIPLE

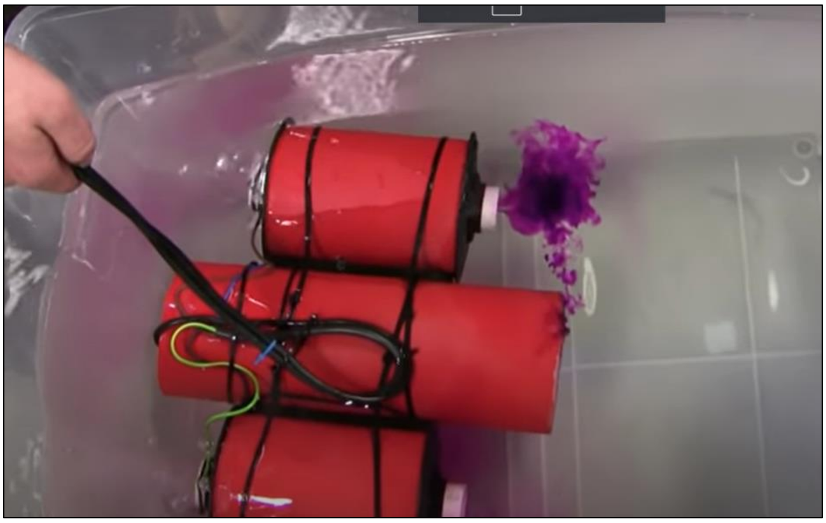
In MHD drive turbine, the materials used are cylindrical metal containers as electrodes, permanent magnets, wires, power supply (0-30V), etc. Four rectangular neodymium

(250N) magnets are placed in the system because of their strong magnetic force. The inner container and outer metal containers are provided with a potential difference. The saline water will acts as conducting medium between both the containers and allows electricity to flow through it creating an electric field. As a result of both electric and magnetic field, force is generated on water propelling it backwards due to ions present in sea water. Here when the supply of current is reversed the ship can move in astern direction.

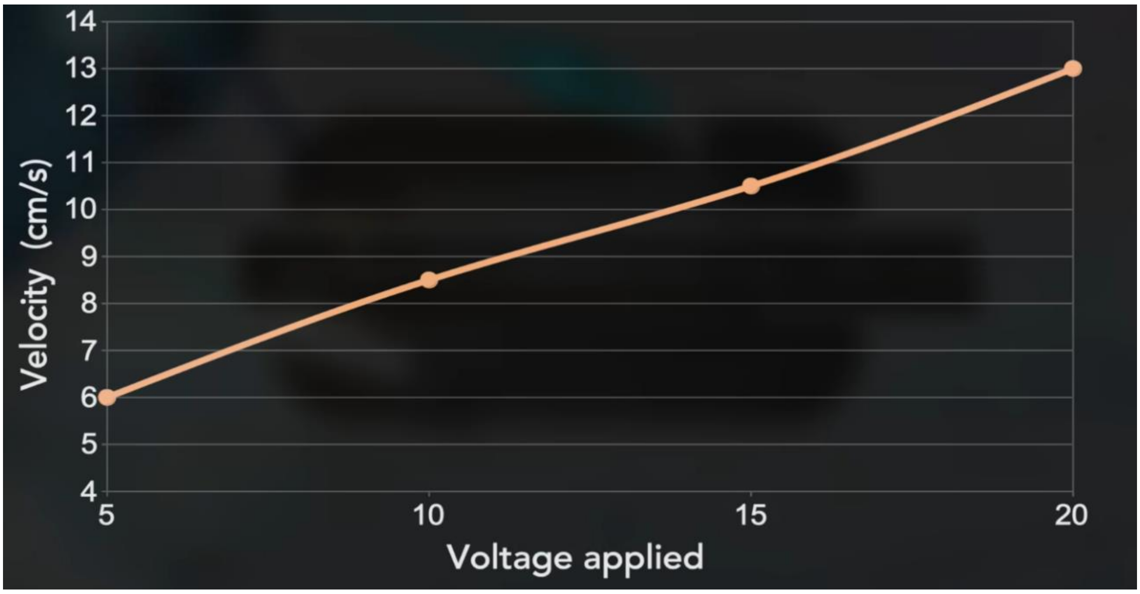




While arriving at ports or making a passage through freshwater azipod system is made into use. In the prototype, we have used a DC motor at center between two MHD turbines powered by the battery to represent azipod system. It can also be used in conjunction with MHD to direct the ship instead of rudder arrangement.The model we made is shown below:



RESULTS (TABLES / GRAPHS)



Here, as we increase the voltage, magnetic field, electrode length, the velocity of the ship with which it moves also increases.

CONCLUSION

More importantly we proved with an experiment that this system really works. The visual of the moving water was enough for most sceptics to believe this system might have a future in the maritime industry. An MHD vessel will benefit from close to none vibrations, improving the durability of a lot of instruments and machines on board. This vessel will be fully diesel-electric which will result in a more environmental friendly vessel. With the advancements and innovations in superconductor technology, we can make it practical.

REFERENCES

[1] http://web.tue.nl/cursor/bastiaan/jaargang47/cursor29/achtergrond/oz_2.html

[2] http://tesladownunder.com/Magnetohydrodynamics.html

[3] http://www.wisegeek.com/what-is-a-magnetohydrodynamic-drive.html

[4] http://en.wikipedia.org/wiki/Environmental_impact_of_shipping

[5] https://www.wired.com/story/the-magnetohydrodynamic-drive-is-realand-you-can-build-one/

[6] https://www.youtube.com/watch?v=bPSowtQ9rjI

Mobile ballast water treatment boat (bwt boat)

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ABSTRACT

The International Convention for the Control and Management of Ships' Ballast Water mandates stringent measures. Port-based Mobile Ballast Water Treatment Boats offer shared services to alleviate the burden on ships, reducing onboard retrofitting. This innovation targets regional and coastal vessels, enhancing compliance and marine environmental protection at discharge ports.

OBJECTIVE

The objective is to implement effective ballast water treatment measures to mitigate the spread of invasive species and protect marine ecosystems. This includes promoting the adoption of onboard treatment systems and exploring innovative solutions such as Port-based Mobile Ballast Water Treatment Boats to ensure widespread compliance and environmental preservation.

INTRODUCTION

International Convention for the Control and Management of Ships' Ballast Water and Sediments requires less than 5% of the world tonnage for ratification. Subsequently, many merchant vessels have to comply with effective ballast water management. This will include control measures and support measures extending to both shipboard and shore platforms. Currently, these measures are mostly oriented towards shipboard adaptation. Exchange and treatment of ballast water are the recognized, major shipboard measures.

As most of the ships are spending more time at sea than the ports and the number of ports in turn number of berths therein, are quite lesser than the total number of ships, it is possible to provide Port-based Mobile Ballast Water Treatment Boats (BWTBoats) to cater service to ships for Ballast Water Management on the shared basis. Thus it eliminates the option of fitment of Ballast water treatment systems onboard Ships.

Though IMO came long ahead with the approach of the onboard fitment of Ballast Water Treatment Systems, by this reinvented concept of BWTBoats, we can at least cover Regional and Coastal Trading Ships. This will reduce the burden of 78500 ships for Global Implementation of the BWM convention. Also, to avoid detentions of ships due to Noncompliance at discharge ports, BWTBoats can be used as a Contingency Measure. From a technology point of view, as the Ballast Water treatment systems fitted on the BWTBoats can be customized concerning ballasting port water qualities, there will be lesser chances of noncompliance as well as better marine environmental protection at the discharge port.

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The objective is to implement effective ballast water treatment measures to mitigate the spread of invasive species and protect marine ecosystems. This includes promoting the adoption of onboard treatment systems and exploring innovative solutions such as Port-based Mobile Ballast Water Treatment Boats to ensure widespread compliance and environmental preservation.

Ballast water, vital for maintaining stability and trim in ships, poses a significant ecological threat due to the accidental transport of invasive species across vast marine ecosystems. The International Convention for the Control and Management of Ships' Ballast Water mandates stringent measures to mitigate this risk. These regulations necessitate adopting effective ballast water treatment systems to safeguard marine biodiversity and ecosystem health.

The introduction of onboard treatment systems represents a pivotal step in addressing this global challenge. These systems facilitate the removal or neutralization of harmful organisms before discharge, thereby reducing the risk of ecological disruption in receiving environments. However, the implementation of onboard treatment solutions faces logistical and operational challenges, particularly for vessels operating in regional and coastal trade routes.

In response to these challenges, innovative approaches such as Port-based Mobile Ballast Water Treatment Boats are emerging as complementary solutions. These mobile units offer shared services and customizable treatment options, ensuring compliance and environmental protection even in remote or underserved ports. This introduction outlines the critical importance of ballast water treatment and the ongoing efforts to enhance regulatory compliance and ecological sustainability in maritime transportation.

WORKING PRINCIPLE

Ballast water treatment is a critical aspect of maritime environmental management, aiming to mitigate the ecological impact of global shipping. Ships use ballast water to maintain stability during voyages by taking in water at one port and releasing it at another. However, this water often contains a plethora of aquatic organisms, including invasive species, which can disrupt ecosystems in new regions.

Effective ballast water treatment systems are essential to prevent the spread of harmful organisms. These systems typically utilize physical separation, chemical disinfection, or biological methods to remove or neutralize organisms and pathogens from ballast water before discharge. Implementing robust treatment measures is crucial for safeguarding marine biodiversity, protecting coastal communities, and preserving economic activities reliant on healthy marine ecosystems.

Despite significant advancements in technology and regulations, challenges remain in developing universally effective treatment methods. Collaboration between industry stakeholders, governments, and environmental organizations is essential to address these challenges and establish standards for sustainable ballast water management. By prioritizing innovation, regulation, and cooperation, the maritime industry can mitigate the environmental risks associated with ballast water discharge and contribute to the conservation of global marine ecosystems.

DETAILED DIAGRAM

CONCLUSION

Thus, ballast water management using the BWTBoats approach is much economical for ship owners against the huge investments in the onboard fitment of BWTS.

Also due to the customized design of BWTBoats concerning port water not only effective disinfection will be achieved for better environmental protection but also there will be fewer chances of non-compliance at the port state inspection.

In the future a system as a separate mobile container, which can be put on board or moved around the port on a truck can be designed to further reduce the overall installation cost as well as increase the flexibility of the ballast water treatment operation.

REFERENCE

[1] Marine Engineers Review (India)
[2] www.imare.in
[3] Indian Register of Shipping
[4] www.google.com
[5] www.bwtboat
[6] InvaSave Co.

Artificial Intelligence Operated Hyper Mist Nozzle for firefighting

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ABSTRACT

The physics of fire and the fundamentals of fire suppression techniques are briefly covered in the theoretical section of this research paper. To find out more about the 360-degree rotating firefighting and fire prevention technology and how they may be applied to guarantee the fire safety of UMS class vessels, a number of research publications were examined. The 360-degree fire detection and extinguishing technology, structural fire protection, and possible high-risk sources are all covered in this research paper.

OBJECTIVE

The project aims to create an advanced automatic hyper-mist system with a sophisticated control panel.

INTRODUCTION

The device uses clever mechanisms and servo motors to efficiently detect and put out fires. With its capacity to spin and orient itself towards the fire source, together with a water dispersal mechanism, this system assures speedy and efficient fire suppression. By providing a proactive and automated approach to fire prevention.

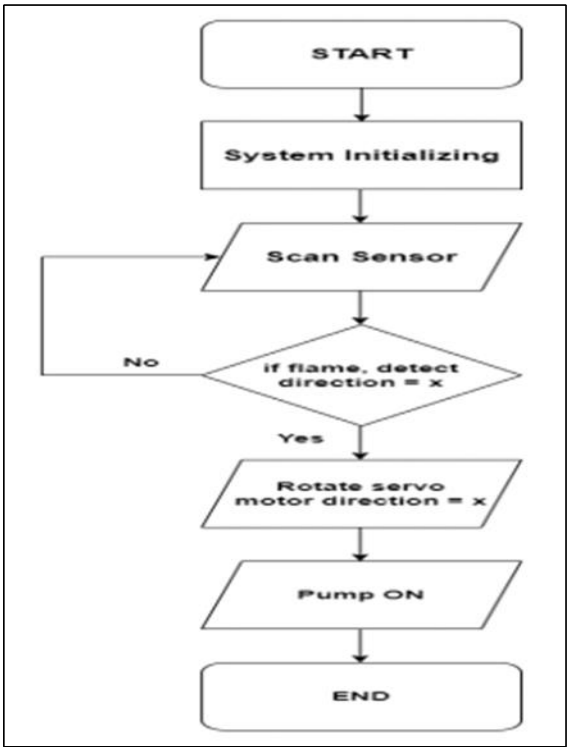
CONCEPT

Implemented a basic prototype using a servo motor controlled by a heat sensor Arduino microcontroller. Achieved successful automation of the nozzle movement in response to detected heat sources.

WORKING PRINCIPLE

This paper presents an intelligent fire extinguishing system based on heat sensor coverage. The system employs a high-precision servo motor to precisely position the extinguisher nozzle in addition to jet and spray mode of the nozzle.

DETAILED DIAGRAM



RESULTS (TABLES/GRAPHS)

Its complete coverage, fast fire detection and extinguishment, and adaptable design make it a dependable and effective option for increased safety and security. To guarantee that the system continues to successfully prevent fires, it is imperative to address its limits.

CONCLUSION

For both residential and commercial applications, the AI based Fire Protection System" is a promising fire safety solution. The system's capacity to identify and put out fires employing servo motors, cutting-edge sensor technology, and a modifiable design, making it a dependable and effective solution for increased security and safety.

REFERENCES

[1] R. Divya and D. Mageshwari, “A Novel Fire Detection System using Image Processing and Artificial Intelligence Techniques”, IJCA Proceedings on Emerging Technology Trends on Advanced Engineering Research-2012, ICETT (2):15-18, 2013.

[2] Braidech, M.M., Neale, J.A., Matson, A.F. and Dufour, R.E., "The Mechanisms of Extinguishment of Fire by Finely Divided Water," Underwriters Laboratories Inc. for the National Board of Fire Underwriters, NY, p.73, 1955.

[3] Rasbash, D.J. and Rogowski, Z.W., "Extinction of Fires in Liquids by Cooling with Water Sprays," Combustion and Flame, Vol. 1, 1957.

[4] Rasbash, D.J., Rogowski, Z.W. and Stark, G.W.V., "Mechanisms of Extinction of Liquid Fuel Fires with Water Sprays," J. of Combustion and Flame, Vol. 4, 1960, pp. 223-234

Artificial Intelligence Operated Crawling Robot for Tank Inspection

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ABSTRACT

Seagoing vessels have to undergo regular inspections, which are currently performed manually by ship surveyors. The main cost factor in a ship inspection is to provide access to the different areas of the ship, since the surveyor has to be close to the inspected parts, usually within hand's reach, either to perform a visual analysis or to take thickness measurements. The access to the structural elements in cargo holds, e.g., bulkheads, is normally provided by staging or by 'cherry-picking' cranes. To make ship inspections safer and more cost-efficient, we have introduced new inspection methods, tools, and systems, which have been evaluated in field trials, particularly focusing on cargo holds.

OBJECTIVE

To design and develop a crawling robot for tank inspection.

INTRODUCTION

For obvious reasons, large tonnage vessels, such as bulk carriers, dry cargo ships, or tankers, undergo regular inspections to prevent structural damage that can compromise the vessel's integrity. These inspections are usually performed in accordance with an inspection programme that depends on the requirements of the so-called classification societies (in short, the classes), and comprise visual close-up surveys as well as thickness measurements obtained by means of non-destructive testing methods (NDT) (Tanne berger and Grasso, 2011). For a close-up survey, the surveyor has to get within hand's reach of the part under observation for adequate visual inspection.

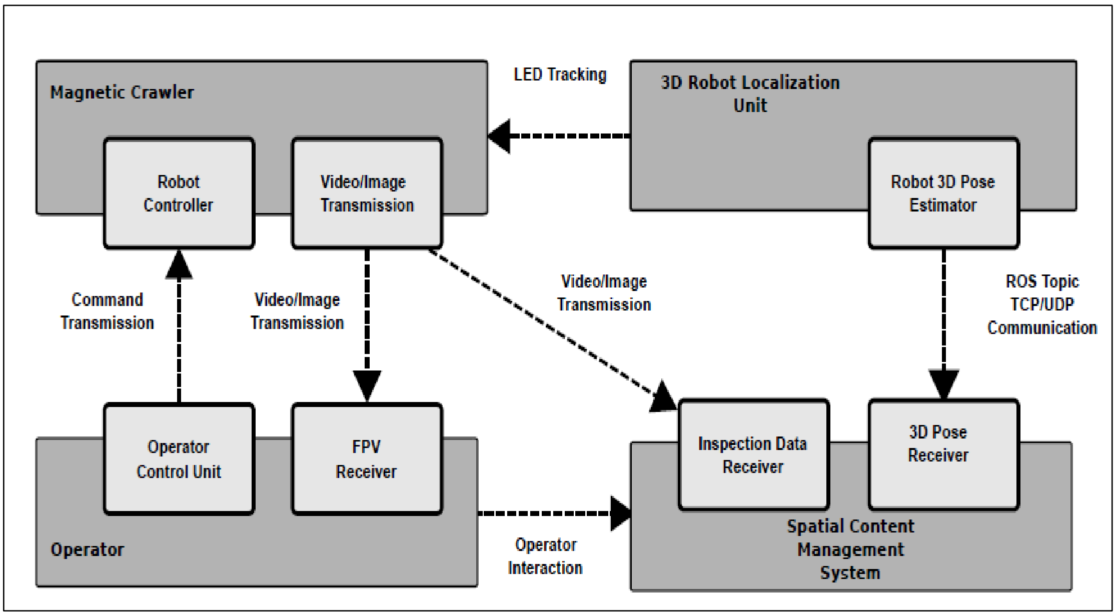
CONCEPT

This paper reports results of the introduction of heterogeneous robots to the area of close-up surveys of the structural elements of large-tonnage vessels, where most of the work is still performed manually. The effort is a mixture of novelty and integration, and the proportion of each is different for every platform. Nevertheless, the main contribution is the fully integrated inspection system, covering all the stages of an inspection procedure based on the use of robots and supporting software.

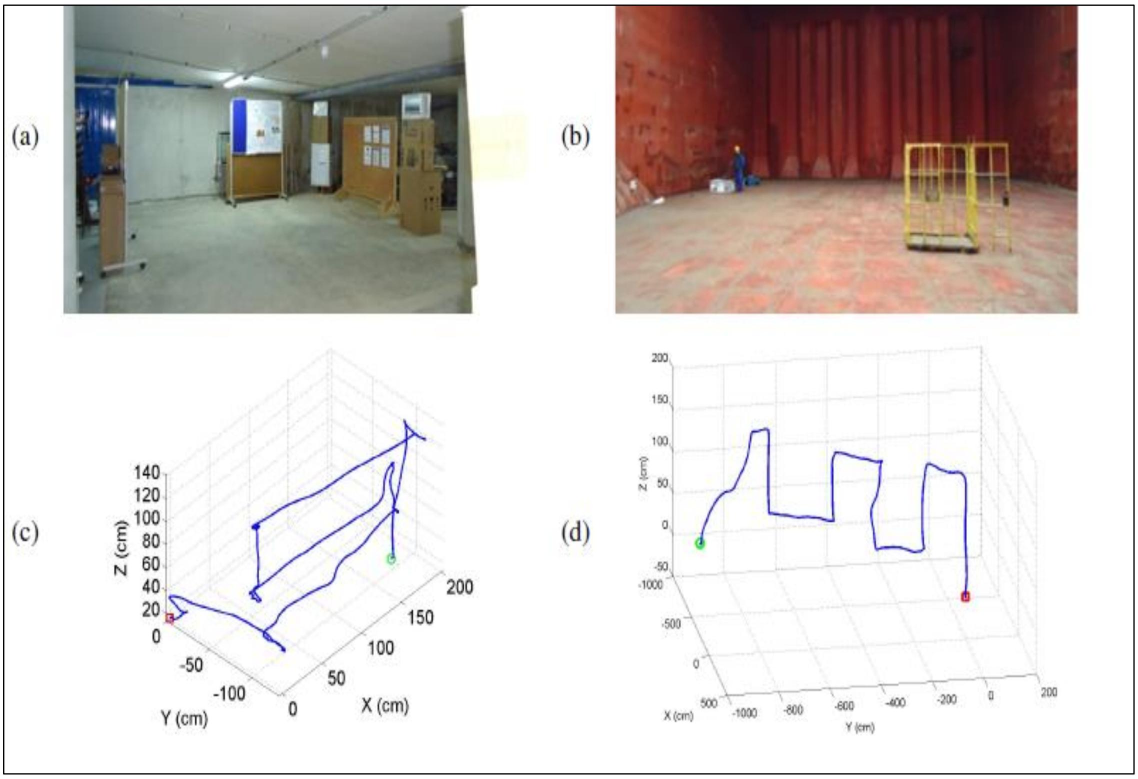
WORKING PRINCIPLE

Visual information is collected by means of a flexible vision system with an appropriate structure for supporting one ground-looking camera and two additional units, which can be tailored for the inspection mission to be performed, such as: two forward-facing cameras forming a stereo vision system, one camera facing forward and the other facing upwards.

DETAILED DIAGRAM



RESULTS (TABLES/GRAPHS)



CONCLUSION

Robot will be able to inspect tank as per the camera output.

REFERENCES

1) Achtelik, M., Achtelik, M., Weiss, S., and Siegwart, R. (2011). Onboard IMU and Monocular Vision Based Control for MAVs in Unknown In- and Outdoor Environments. In Intl. Conf. Robotics and Automation, pages 3056–3063.
2) Achtelik, M., Bachrach, A., He, R., Prentice, S., and Roy, N. (2009). Autonomous Navigation and Exploration of a Quadrotor Helicopter in GPS-denied Indoor Environments. In Intl. Aerial Robotics Competition, pages 582–586.
3) Bachrach, A., Prentice, S., He, R., and Roy, N. (2011). RANGE-Robust autonomous navigation in GPS-denied environments. J. Field Robotics, 28(5):644–666.
4) Bibuli, M., Bruzzone, G., Bruzzone, G., Caccia, M., Giacopelli, M., Petitti, A., and Spirandelli, E. (2012). MARC: Magnetic Autonomous Robotic Crawler Development and Exploitation in the MINOAS Project. In Intl. Conf. Comp. and IT Appl. in the Maritime Industries, pages 62–75.
5) Bonnin-Pascual, F. (2010). Detection of cracks and corrosion for automated vessels visual inspection. Master's thesis, University of Balearic Islands. Available at http://srv.uib.es/ref/1233.html.
6) Bonnin-Pascual, F., Garcia-Fidalgo, E., and Ortiz, A. (2012). Semi-Autonomous Visual Inspection of Vessels Assisted by an Unmanned Micro Aerial Vehicle. In Intl. Conf. Intell. Robots and Systems, pages 3955–3961.
7) Bouabdallah, S., Murrieri, P., and Siegwart, R. (2005). Towards Autonomous Indoor Micro VTOL. Autonomous Robots, 18:171–183.

SMART AGNISHAM SYSTEM ON SHIP

INTRODUCTION

Traditional firefighting methods on ships have often relied on extensive water usage, presenting logistical challenges and environmental concerns. The smart agnishaman system addresses these issues by employing misting techniques that require significantly less water while delivering precise targeting to limit damage to surrounding areas. This not only conserves valuable resources but also reduces the environmental impact of firefighting efforts. By automatically detecting fires and taking immediate action, the need for human intervention and potential delays in response time are greatly minimized. This ensures a swift and effective response to fire emergencies, safeguarding the lives of crew members, passengers, and the integrity of valuable cargo.

MOTIVATION

The motivation behind development of smart hypermist cooling system geared towards the effective extinguishment of shipboard fires while minimizing water usage, collateral damage, and human intervention stems from a critical need for safer, more environmentally responsible, and technologically advanced firefighting solutions in the maritime industry. Traditional firefighting methods on ships often entail excessive water usage, which not only poses logistical challenges but also environmental concerns. Additionally, the potential for collateral damage and the inherent risks associated with human intervention during fire emergencies necessitate a paradigm shift in our approach. By harnessing state-of-the-art misting technologies, automation, and precise targeting, this initiative seeks to revolutionize maritime firefighting, ensuring enhanced safety, reduced ecological impact, and more efficient resource utilization for the benefit of both ship crews and the environment.

OBJECTIVES

To design and develop a control system to operate automatically upon detecting a fire on ships, thus minimizing human intervention and latency.

To optimize the mist control technology to minimize water damage to equipment and property during firefighting, making it suitable for sensitive environments.

EXPECTED OUTCOMES

An automated system that can detect fire on ships (in vessels).and monitors intensity of flames, temperature, oxygen level in the vessel.

Establish communication with control room.

A system that takes decision whether the jet, mist, or hypermist needs to be enabled based on the fire intensity.

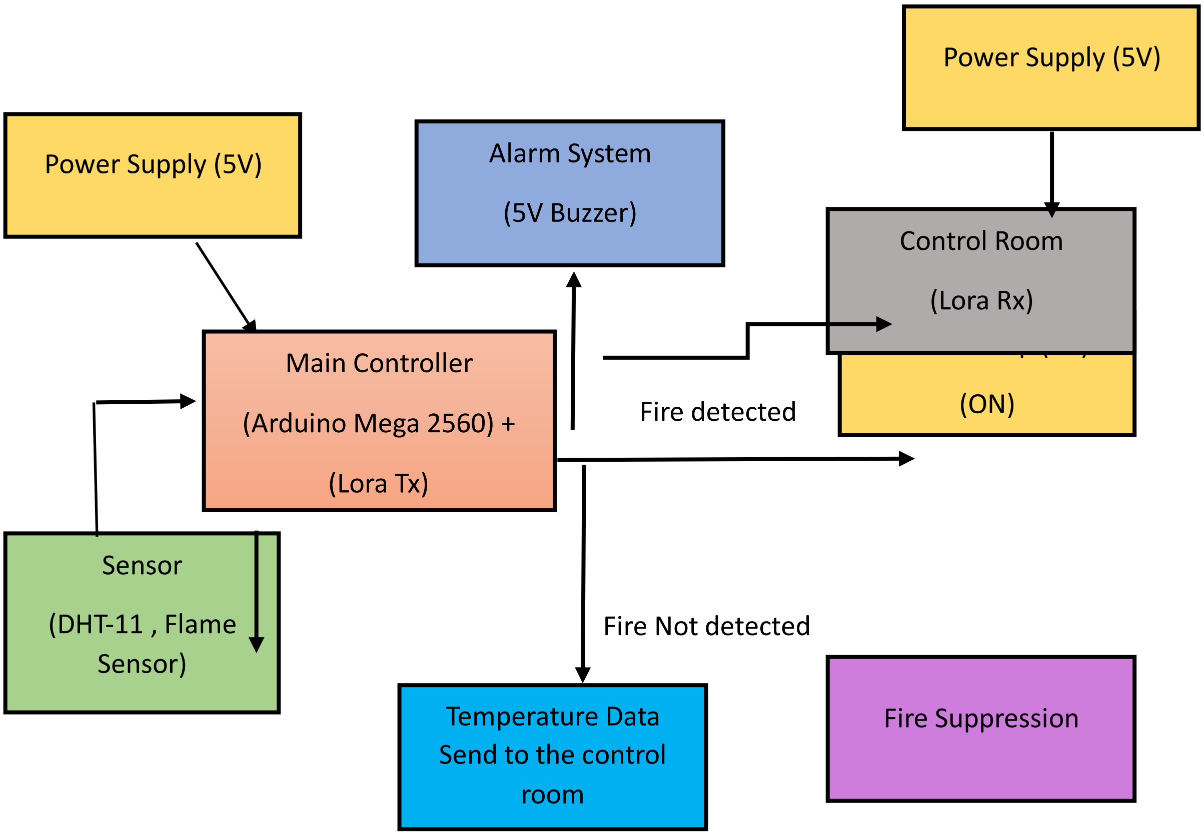
System that generates fire alerts on ship.

WORKING OF THE PROJECT

Whenever there is fire in container sensor will sense the fire.

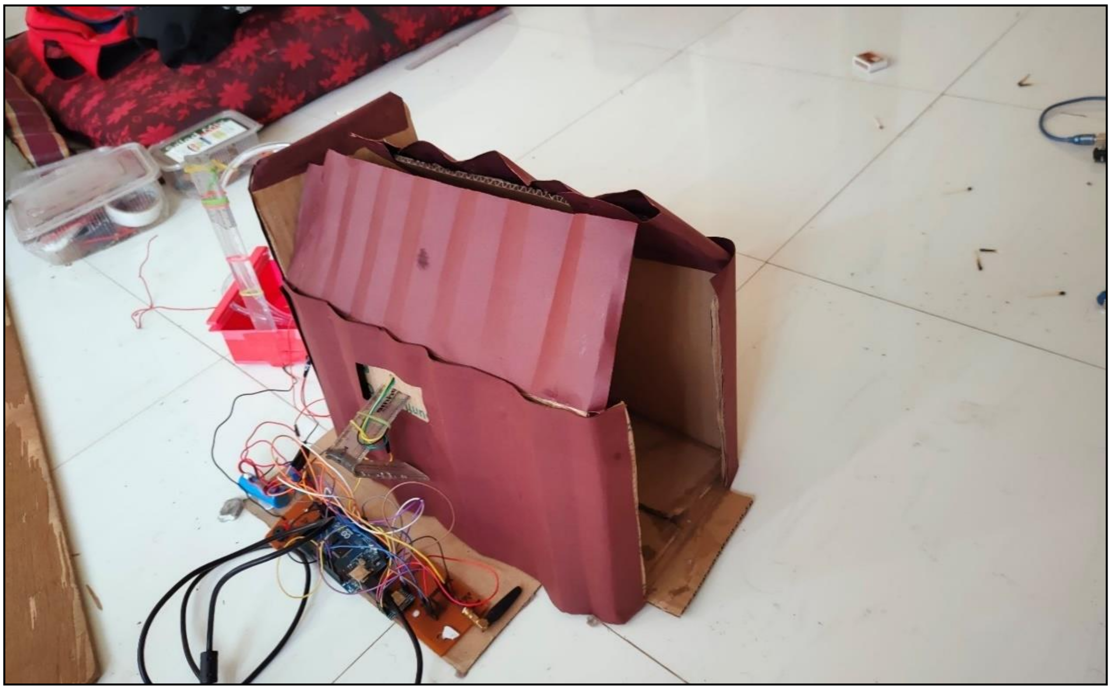
After Sensing the fire, it will send signal to master microcontroller.
Then Master Controller will trigger the camera module.
Camera modules detect the position as well as intensity of fire.
According to intensity it will decide whether to turn on mist or jet.
Also, master will send all data to control room using LORA module.

Block Diagram and Specification



Sr. No	Components	Specified Name	Required Voltage in Volts (according to datasheet)	Operating temperature (according to datasheet)	Required Current in mA (according to datasheet)	Quantity
1.	DHT -11	Temperature Sensor	3.3 V	0°C to 50°C	0.3mA	1
2.	Arduino Mega	Microcontroller	7 - 12 V	- 40°C to 125°C	20 mA	1
3.	LORA (Tx)	Communication model	1.8 - 3.7 V	-55°C to 115°C	12-20mA	1
4.	LORA (Rx)	Communication model	1.8 – 3.7 V	-55°C to 115°C	12mA	1
5.	Relay	Actuator	5 V	-20°C to 85°C	70mA	1
6.	Flame Sensor	Fire detection Sensor	3.3V	-20°C to 85°C	15mA	1

ACTUAL PROTOTYPE



REFERENCES

[1] https://ieeexplore.ieee.org/document/9887678,YOLO Algorithm Implementation for Real Time Object Detection and Tracking, Prakhar Agrawal; Garvi Jain; Saumya Shukla; Shivansh Gupta; Deepali Kothari,2022

[2] Prototype of Early Fire Detection System for Home Monitoring Based On Wireless Sensor Network, Ferry Astika Saputra, M. Udin Harun Al Rasyid, Bey Aryo Abiantoro Politeknik Elektronika Negeri Surabaya (PENS),2022

[3] https://ieeexplore.ieee.org/document/8997877, Design and Implementation of small monitoring wireless network system based on LoRa, Jianing Wang; Shiyu Yi; Donglin Zhan; Weihua Zhang, 2023.

[4] Water Mist Fire Suppression Systems for Building and Industrial Applications: Issues and Challenges, Kyle Farrell, Md Kamrul Hassan, Md Delwar Hossain, Bulbul Ahmed, Payam Rahnamayiezekavat, Grahame Douglas and Swapan Saha,2023.

Different Medium Obstacle Sensor

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ABSTRACT

Simulation of a Radar Model for Object Detection.

This abstract provides an overview of the design, implementation, and simulation of a radar model for object detection applications. Radar technology plays a pivotal role in various fields, including aerospace, defence, automotive, and meteorology, offering unparalleled capabilities in detecting and tracking objects over long distances. The proposed radar model utilizes electromagnetic waves to detect the presence, location, and velocity of objects within its field of view. By emitting radio frequency signals and analysing the echoes reflected off objects, the radar system can create high-resolution images of the surrounding environment, enabling accurate object detection and tracking. Key components of the radar model include an Arduino UNO board, Ultrasonic sonar sensor, servo or stepper motor, breadboard, jumper wires, other accessories for base and body development. To validate the performance of the radar model, extensive simulations are conducted using software tools such as Processing IDE and Arduino program installed on laptop. In conclusion, the developed radar model represents a valuable tool for object detection in diverse settings, ranging from military surveillance and air traffic control to autonomous driving and environmental monitoring. By leveraging advanced radar technology and simulation, this project contributes to the advancement of research and innovation in the field of remote sensing and detection systems.

KEYWORDS

Arduino, Sensor, Anti Collision.

INTRODUCTION

This model is a simple sensor including set-up which is operated on the basics of electronics engineering and hydraulic system. The applications of the model are highly used in modern day practices in various systems and onboard ships.

OBJECTIVE

To show the working of the ultraviolet sonar sensing radar which can be used in shipping for navigation following the detection of obstacles under and overwater. The primary use of sonar is to develop nautical charts, locate underwater hazards to navigation, search for and identify objects in the water column and on the seafloor such as shipwrecks, and map the seafloor itself.

WORKING PRINCIPLE

This basic model includes obstacle sensing Sonar which can sense the obstacles and objects through ultrasonic sound waves. It is technique that uses sound propagation (usually underwater, as in submarine navigation) to navigate, measure distances (ranging), communicate with or detect objects on or under the surface of the water, such as other vessels and also in air. In simple words this is how the project works, the ultrasonic sensor can be mounted on a servo motor or a stepper motor which rotates sideways. The sensor scans the area within its distance (around 40-200 cm). If there is no object in a specified range let's say that there is nothing in front of the sensor at about a distance of 40cm then all green lines are display on the radar. On the other hand, if we place an object within the 40cm range then the sensor detects the object and that is indicated by the red lines on the radar. The hardware connections are done first which will help to remember the pin number while writing the code. Firstly, the Ultrasonic sensor relates to the Arduino Board in the following way: - VCC -5V, GND-GND, PIN TRIG -2 0R 10, ECHO-3 OR 11. Then next the servo motor is connected as follows: RED wire - 5V, BROWN OR BLACK wire- GND, ORANGE OR YELLOW – 4V PIN 12. Once all the connections are done, the ultrasonic sensor is stick on the servo motor with a glue gun (it does not stay for long but is great as a temporary solution) and other physical connections as per the working model and circuit diagram. Moving forward with the coding part a function is created to measure the distance from the sensor and then inside a loop, command is given to rotate the motor from left to right. In the Processing IDE simply open the code for radar and mention the PORT name and then run the program. It will show us the objects on the screen. Now as mentioned, the setup of the radar sensor is mounted on the sides of the ship body. One sensor will be availed to sense the objects over the surface water and the other is used to sense the objects underwater. The objects in the range of the working model will be showed on the screen through the Processing IDE program installed on the laptop server.

CONCLUSION

In conclusion, the radar model developed and detailed in this project showcases the potential of radar technology in object detection applications. By harnessing electromagnetic waves and sophisticated signal processing algorithms, the radar system demonstrates impressive capabilities in accurately detecting and tracking objects in various media. Through extensive simulations and analysis, we have validated the effectiveness and reliability of the radar model across different scenarios, including stationary and moving targets. These findings underscore the robustness of the radar system and its suitability for real-world deployment in different fields.