ISSN: 0974-8474
Volume 14, 2021 March/April
Tolani Maritime Institute, Pune - 410507.
www.tolani.edu

Bulletin of

MARINE SCIENCE AND TECHNOLOGY

Bulletin of Marine Science & Technology, ISSN: 0974 – 8474

The journal is yearly publication of the institute. It covers technical articles/papers on science and technology, focusing marine field and its application area. It also covers patent abstract and book review.

Tolani Maritime Institute, Induri, Pune

Tolani Maritime Institute is one of the largest maritime educational centers offering **Marine Engineering and Nautical Technology** degree programs.

The Marine Engineering and Nautical Technology degree programs at TMI have been awarded Grade A1 (Outstanding) by Class NK in the Comprehensive Inspection Program of DG Shipping. The degree programs are also awarded Grade 1 (Outstanding) by Crisil. The assigned grade reflects TMI's excellent placement track record, qualified and experienced faculty, industry leading infrastructure, strong financial standing and professional & committed promoters.

Disclaimer

The institute shall not be responsible for the statements or opinions advanced in the papers included in the current issue. Presentation or publication of a paper or any other document shall not be taken as an endorsement of any claims and technical accuracy of the contents be verified. The journal serves the purpose of knowledge building and exchange of ideas between the industry and academia.

Address for Correspondence

The Technical Publication Committee
Bulletin of Marine Science & Technology (BMST)
Tolani Maritime Institute
Talegaon Chakan Road
Taluka Maval, Induri
Pune -410507, Maharashtra, India
Tel: 91-2114-669600/01
E-mail: info@tmi.tolani.edu
Web: www.tolani.edu

Advisory Board

Capt. Krishnamurthy Iyer
FNMIS, MNI, External Examiner for Master & Mates
Principal, TMI

Dr. Sanjeet Kanungo
MIEI, MIMET, Member Technical Committee IRS
Vice Principal ME, TMI

Capt. Manoj Hirkane
MCMMI, External Examiner for Master & Mates, Vice Principal NS, TMI

Capt. Raj Razdan
Member AIMA
Provost, TMI

Editorial Board

Dr. Sanjeet Kanungo
MIEI, MIMET, Member Technical Committee IRS
Vice Principal ME, TMI

Capt. Manoj Hirkane
MCMMI, External Examiner for Master & Mates, Vice Principal NS, TMI

Cdr. Bhaskar Walimbe (Retd.)
Sr. Assistant Professor, TMI

Dr. Shrikant Madiwale
Sr. Assistant Professor, TMI

Prof. Shailendra Kumar
Sr. Associate Professor, APCME, TMI

Prof. Indranath Banerji
Sr. Associate Professor, APCNS, TMI

Prof. Naresh Kumar Mishra
Sr. Associate Professor, CFO, TMI

Dr. Dhiren Dave
FIE, Life Member ISTE
Sr. Associate Professor, TMI

Publication Committee

Dr. Nitin Junnarkar
Sr. Associate Professor, MIE, Chairperson TPC, TMI

Dr. Sanjay Dabadgaonkar
Sr. Associate Professor, TMI FIE, LMISTE, FIETE

Cdr. Bhaskar Walimbe (Retd.)
Sr. Assistant Professor, TMI

Dr. Shrikant Madiwale
Sr. Assistant Professor, TMI

Prof. Anirudh Kumar
Associate Professor, TMI
FIMarE (India), Member ISTE

Prof. Vaibhav Karlekar
Lecturer, TMI

Prof. (Ms.) Unnati Chaudhari
Associate Professor, TMI

Prof. Pratibha Kaninde
Assistant Professor, TMI

Ms. Swati Bhise
HR Manager, TMI

Guidelines for Paper Submission

Bulletin of Marine Science & Technology (BMST – ISSN: 0974 – 8474), is the yearly technical journal of Tolani Maritime Institute (TMI).

The journal covers technical articles/papers, marine science and technology abstracts, book reviews, patent abstracts and technological developments, in general engineering or in marine related areas.

Call for Papers

Technical articles discussing various aspects of science and technology including innovations in the marine field, original research work, experimental investigations with results, industrial practices, case studies are invited for publication. The paper may be please be mailed to nitinj@tmi.tolani.edu or vaibhavk @tmi.tolani.edu

Guidelines for paper submission

- Enter manuscript in MS word, Times New Roman, main text - font 12, subtitle - font 14 and the main title - font 16, with main text in the single line spacing double column on A4 sheet.
- Provide every article with an abstract not exceeding 150 words.
- Provide 4-6 keywords.
- Organize paper in smooth flow of title, subtitle and sub-sub title.
- Keep length of the paper to the limit of 8 pages approx.
- Provide 1inch margin on all sides of the paper.
- Provide figures, drawings and graphs in black color on white back ground.
- Submit figures, drawings and graphs in JPEG format with 300 dpi minimum resolution.
- Number the figures and tables as per standard practice.
- Provide mathematical equations and functions in suitable equation editor.
- List the references at the end of the article with serial number.
- Submit hard copy of the full length paper on the address of correspondence mentioned in the journal.
- A declaration to the effect that – the work is original and has not copied or published earlier elsewhere – needs to be submitted along with the paper.
- On behalf of all the co-authors, the corresponding author shall bear the full responsibility for submission and shall provide his/her full address, contact number and email.
- Follow the suggested order for manuscripts: (In some cases all the points may not come in order as suggested)

Template to Write Article
• Title, Authors, Affiliations • Abstract • Keywords (provide a maximum of five keywords) • Introduction • Main text (may include information based / knowledge based/ theory based / experimental based/ model based method) • Data Collection / Data Analysis (if any) • Result and Discussion (If any) • Conclusion • References

Technical Publication Committee - Message

We are pleased to present 14th issue of Bulletin of Marine Science and Technology (BMST). Tolani Maritime Institute (TMI) has completed this year, successful 23 years in imparting Marine Education at pre-sea and post sea level. TMI has created its benchmark in the Marine Education area.

This year (2020-21) has brought unimaginable change in work culture of industries and especially in education field. This has happened because of pandemic situation across the world. Post pandemic situation is also going to be the challenging task for all the universities, educational institutions and for face to face teaching and learning methodology. "Technology has the potential to achieve universal quality education and improve learning outcomes. But in order to unleash its potential, the digital divide must be addressed". As online classes have been used as an alternative to regular classes under the circumstances of the Covid19 pandemic, internet and technology services should be considered as a necessity and not a luxury. Access to online libraries, books, journals needs to be created to promote learning remotely. Adequate facilities must be developed for differently-abled students. There is a need to work collaboratively with other universities and edutech companies to bring about innovative solutions in making digital learning hassle-free and effective. In a face-to-face environment, students get an opportunity to interact with the facilitator and other peers. In such an environment, meetings with teachers, classroom debates and discussions promote social connectedness among teachers and students.

The one more alternative in education after the Covid-19 pandemic may be a blended mode of teaching and learning. Thus, educationists, academic leaders and others are constantly trying to find out whether the students are actually intellectually engaging with the course and its materials when they are at home or at any other place away from the university campus and when there is no scope for face to-face learning. The Bloom's taxonomy acts as a tool to assess the intellectual complexity of the learning activities of the student and thus, gives an opportunity to focus on the cognitive processes that the students should engage in.
Teaching-learning to continue on an online platform requires students to understand how the course will be carried out online, including discussions from textbooks, class room activities, home works and submissions and assessments. Thus, there is a need to make the students understand the structure and requirement of the course when carried out on a digital platform. There is a need to work on creating social presence during the online course. Some tools can be used to make the presence felt by the participants of the online course such as asking student's personal information, encouraging interaction exchange between students, supporting video communications so that the facial expressions of the students and their voices are also clearly heard and seen.

Bulletin of Marine Science and Technology provides the platform for the readers and authors to take up the activity of writing and publishing scholarly articles in varied fields of Science and Technology. This year, the journal issue is going to be in digital form.

We are sure that the issue of the journal will keep interest alive of the readers and writers. Enjoy Reading and Writing!!

Technical Publication Committee
Tolani Maritime Institute, Pune

Index

RECENT TECHNOLOGIES TO CONTROL THE CAVITATION IN THE HYDRAULIC MACHINES

Dr Sagar Mane Deshmukh
Tolani Maritime Institute
manedeshmukhsagar5@gmail.com

ABSTRACT

The performance of different hydraulic machines is based on cavitation conditions occurring at various locations. The cavitation occurs mainly in the low pressure regions. Process. The cavitation in the hydraulic machines occurs when the pressure of the liquid falls below vapour pressure of the liquid at a given temperature. The pressure article emphasizes mainly on the recent technologies used to control the cavitation in the hydraulic machines.

Keywords

Hydraulic Machines, Cavitation, Technologies

Introduction

The cavitation in the hydraulic machines is nothing but the formation of the vapour bubbles in the liquid zones because of the reduction of the pressure below vapour pressure of the liquid. The bubble formation occurs in the low pressure zones. The suction sides of the pumps (centrifugal or reciprocating) and outlet side of the reaction turbine (Francis, Kaplan or Propeller) generally faces the low pressure. The bubbles formed in the low pressure region are carried towards the high pressure regions where it breaks and forms the cavities in the flow. The pump performance characteristics strongly depend on the cavitation conditions. The cavitation has a negative impact on the performance of the hydraulic machines.

The causes of the cavitation in the hydraulic pumps are as follows:
(a) More length of the inlet pipe
(b) Higher viscosity of the fluid
(c) Faulty inlet valves (or clogged inlet valves)
(d) Poorly working filters or strainers
(e) Wrongly selected pumps
Similarly in hydraulic turbines
(a)Very low pressure at the outlet of the reaction turbine
(b) Installation of the turbines at higher heights
(c) In the regions near to fast moving blades where static pressure is very low

The various effects of the cavitation are as follows:

(a) The flow rate is reduced by certain amount because of the voids/cavities in the flow,
(b) The formed bubbles break on the metallic surfaces multiple times and it starts eroding the surface. The cyclic stress reduces the life of the metallic parts of the reciprocating pump,

(c) The noise is also generated because of the collision of the liquid at the time of the breaking of the bubbles,
(d) The vibration is set because of the breaking of the bubbles at multiple locations (the liquid collisions with liquid molecules or the metallic parts set the vibrations),
(e) The power consumption increases,
(f) The efficiency of the pump decreases etc.
The cavitation in the pump is avoided by maintaining the net positive suction available (NPSH)a must be higher than the net positive suction required (NPSH)r on the inlet or suction side of the reciprocating pump [1].The present research article discusses the recent efforts made to control the cavitation in the hydraulic machines.

METHODS TO AVOID THE CAVITATION

Use of the Organic Rankine Cycle

The efforts to avoid the cavitation in diaphragm pumps (reciprocating pump without or less leakage) were made by the Wenguang L. [1]. The diaphragm pumps are generally used for handling low flow rates and high heads with higher efficiency. The study included the use of the thermodynamic effect and organic Rankine cycle/system in reciprocating/diaphragm pumps to correct the cavitation conditions. In this method we develop two regions which are (a) region where cavitation is occurs and (b) the liquid surrounding (cavitation spot/region). The two regions will be at different temperatures. The heat transfer from the surrounding liquid to the cavitation region helps to improve the cavitation conditions by balancing the temperature and pressure head.

Following Table presents the data related to the studies carried out to correct the cavitation conditions by using the organic Rankine cycle.

Table: Various studies on Organic Rankine cycle

Sr No	Type of the pump	Organic fluid used	Speed RPM	Temp ^{0} C	Remarks	Ref. No.
1	Axial piston pump with swash plate design	R11 and R113	1750-3000	20 - 80	The curves were plotted between the discharge/flow rate and NHSHa. The cavitation characteristics were plotted only for R11 and R113. NPSH condition were found to be improving by using the organic fluids.	[2]
2	Positive displace-ment pump (with sliding vane)	R11 and R113, Blend of R11 and R113	different rotating speeds	-	The vapour quantity was found to be more for R11 compared to R113	[3]
3	Positive displace-ment pump (with sliding vane)	R236fa	700–1200	17–24	The pump total efficiency was found to be decreasing during the studies conducted	[4]
4	Recipro-cating pump and scroll compressor	R123	< 600	20	It was found that the smaller torque was developed because of the cavitation occurring at higher speeds in the pumps	[5]

5	Diaphra-gm pump (G03X, G10X)	R134a, R404 and a mixture of NH3 and H2O	Nominal rotational speed	-	The net positive suction head required was found to be 0.24 bar for R134a compared to 0.36 for water at the nominal rotational speed	

Use of Optimum Number of Bends and Valves

The optimum number of the bends and valves in the pumping system avoids unnecessary pressure drop, which helps to reduce the cavitation in the pumps.

Use of the Air Injection

The suction side of the pump faces the low pressure and bubble formations occurs at rapid rate. The formed bubble reduces flow rates and causes damage to the metallic parts. The air injection in the suction side breaks the bubbles formed and reduces the number of bubbles formed in the suction side which in turn reduces the stresses produced in mechanical parts and increases the life of mechanical components [9]. It also helps in reducing the noise and vibrations set in the pumps.

Method of Obstacles

In this method cavitation in the fluid flow is controlled by placing the obstacles on the blades. The 3-D unsteady flow simulations were performed by using the modified shear stress transport model with the Kubota cavitation model [6]. In this method the obstacles of the required height are formed on the blades of impeller which disturbs the flow and induces the relatively high pressure which optimizes the flow structure to suppress the cavitation. In this method the height of the obstacle must be optimized to avoid the adverse effect of the short and long obstacles.

Figure 1: Cavitation patterns in the impeller [6]

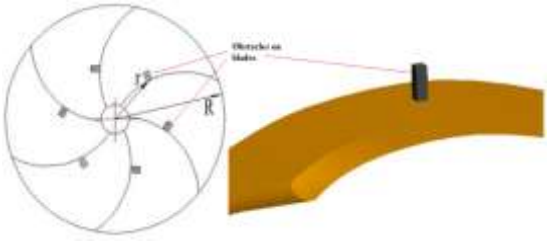


Figure 2: Placement of the obstacle on the blade [6] [r-Radial location of the obstacle from Centre, R-radius of the impeller]

Figure 1 shows the white colored region where cavitation is observed, which gave an idea about the location where obstacle is to be placed. Figure 2 shows the obstacle placed on blade.

Use of the J-Grooves

In this method J-type of grooves were introduced on the metallic surfaces which were facing the cavitation in the reaction turbines. The use of J-grooves in the outlet side of the Francis turbine (in the draft tube) was proposed by Van T T C [7] to control the cavitation conditions.

During the partial flow rates the cavitation and cavitation surges makes the problems and must be reduced. The swirls created at the inlet of draft tubes must be reduced to avoid the cavitation conditions. The use of J-grooves on the draft tube surfaces suppressed the swirls and controlled the cavitation. The same method can be applied at various locations facing the cavitation in the turbines. Figure 3 shows the J-grooves used to control the cavitation in draft tube.

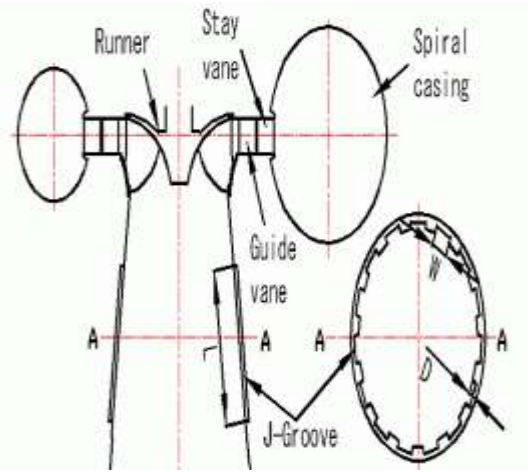


Figure 3: Use of the J-Grooves to control the cavitation in reaction turbines [7]

Use of Rough Surface

This method suggests the use of the rough surface over smooth surface in the vicinity where cavitation is observed in the pumps. The length of the cavities is reduced by selecting the proper size of the roughness on the surface where cavitation is occurring in the flow. It also helps to delay the inception of cavitation and to avoids boundary layers separation in the flow [8]. The smooth surfaces produce more number of micro-bubbles compared to rough surfaces and intense cavitation is observed.

Conclusions

In the present paper cavitation phenomenon is discussed in brief. The following important methods were suggested to control the cavitation: (a) use of Organic Rankine cycle, (b) Use of optimum number of bends and valves, (c) Use of the air injection, (d) Use of the obstacles on blades, (e) introduction of J-grooves and (f) Use rough surfaces. It was observed that all these methods are useful in controlling cavitation in different machines like pumps, turbines etc.

References

[1] Wenguang L., Andrew M., Zhibin Y. (2020) “Correction of cavitation with thermodynamic effect for a diaphragm pump in organic Rankine cycle systems”, Energy Reports, Vol.6, pp. 2956–2972.

[2] Bollina, E., (1984) “Head-flow and npsh performance of an axial piston pump working with organic fluids at different temperatures”, International Journal of Heat Fluid Flow Vol. 5, No.2, pp.93–100.

[3] Bala E.J., O’Callaghan P.W., Probert S.D., (1985) “Influence of organic working fluids on the performance of a positive-displacement pump with sliding vanes”, Applied Energy, Vol. 20, pp.153–159.

[4] Bianchi G., Fatigati F., Murgia S., et al., (2016) “Modeling and experimental activities on a small-scale sliding vane pump for ORC-based waste heat recovery applications”, Energy Procedia, Vol.101, pp.1240–1247.

[5] Yang X.F., Xu J.L., Miao Z., et al., (2015) “Operation of an organic Rankine cycle dependent on pumping flow rates and expander torques”, Energy, Vol. 90,pp. 864–878.

[6] Weiguo Z., Guoshou Z., (2017), “An active method to control cavitation in a centrifugal pump by obstacles”, Advances in Mechanical Engineering, Vol. 9 No.11,pp 1–15.

[7] Van T. T. N., Young-Do C., (2015),”A study on supresssion of cavitation surge by J-Grooves by Francis turbine”, Abstract of the ASME-JSME-KSME Joint Fluids Engineering Conference 2015 AJK2015-FED July 26-31, 2015, Seoul, Korea.

[8] Coutier-Delgosha O., Devillers J.F., Leriche M., et al. (2005), “Effect of wall roughness on the dynamics of unsteady cavitation”, Journal of Fluid Engineering: ASME, Vol. 127,pp. 726–733.

[9] Arndt A. E. A., Ellis C. R., Paul S., (1995), “Preliminary investigation of the use of air injection to mitigate cavitation erosion” ,Journal of Fluids Engineering,Vol.117, pp.498-504.

EMOTIONAL MATURITY FROM MARITIME TRAINING PRESPECTIVE: A CONCEPTUAL DISCUSSION

Dr Deepchand Dhankher
Tolani Maritime Institute
deepchandd@tmi.tolani.edu

ABSTRACT

The present paper discussed on emotional maturity and emotional immaturity from maritime education and training perspective. The study attempts to bring the various aspects of emotional maturity and its ingredients to be developed among maritime students. The end of the twentieth century and beginning of the twenty first century have seen on unprecedented upsurge in activities revolving around the teenage adolescence students and maritime students are no exception to this. It is the dire need of the hour that cadets as they are adolescence should be guided and mentored so as they have proper emotional development to rightly use and control their emotions the right way. Emotional maturity refers to ability to understand, and manage, emotions. Emotional maturity enables to create the life desired. Mental health is synonymous with maturity. Emotional maturity refers to that stage of individual which the individual is able to face reality of life and deal with it. Emotions are the building block of each relationship in our lives, and the power of those emotions cannot be ignored. Emotions often over power our thoughts and greatly influence our behaviour. Most people seek relationship counselling to find answers to their problems. They sometime believe that they themselves are responsible for their conflict, but at times there are more basic issues at the root of such problems. Sometimes, extremely talented seafarers can lag behind in emotional development, resulting in workplace immaturity. These seafarers are often worth the effort to mentor and develop. Everyone understands the idea of physical age, but emotional maturity age is another matter. Emotional maturity at the pre sea training stage of cadet's life takes a vital role for development of cadet's personality. A seafarer who cannot properly develop a positive response to emotional maturity he/she cannot be successful both in professional and personal life as a perfect SAILOR and a successful man.

Keywords

Emotions, Maturity, Emotional Maturity, Maritime Education and Training

Introduction

The main purpose of maritime education & training is to provide trained well matured man power to shipping industry.

It is especially the maritime academy which conducts pre sea training These institutes put their best to transform a boy into a seagoing man by brining all-round personality development including progress of Physical, social, emotion, and wisdom in cadets According to World Health Organization the period of adolescence begins with the onset of physiologically normal puberty, and ends when an adult identity and behavior are accepted. This period of development

corresponds roughly to the period between the ages of 10 and 19 years and the individuals fall in this category are called adolescents.

Life at sea is beautiful, but not always easy, as it passes through the various vulnerable stages

A Cadet undergoing pre sea training is neither an adult and nor we can consider as a spoon fed child. Cadets undergoing pre sea training are at adolescence stage. It is a turbulent period in the life and varied changes takes place because of the transitions from the childhood to adulthood.

The major changes are biological, cognitive, social and emotional, moral

Boys and girls are said to have achieved emotional maturity if, by the end of adolescence, they do not "blow up" emotionally when others are present, but wait for a convenient time and place to let off emotional steam in a socially acceptable manner (Hurlock E. , 1981). An important indication of emotional maturity is that the individual assesses a situation critically before responding to it unthinkingly as like an immature person or a child. This results in adolescents ignoring many stimuli that would have caused emotional outburst when they are younger. Emotionally mature adolescents are stable in their emotional responses and they do not swing from one emotion or mood to other, as they did earlier. **Emotional maturity** is the ability to bear tension and it is the ability to develop high tolerance for disagree circumstance. Pre sea Training is one of the important microsystems of cadets 'life which influence personality. The residential educational settings in maritime campus not only offer knowledge but also provide opportunity to interact with the instructors, wardens, batch mates and friends of same-sex and/or opposite-sex. Since, adolescent girls and boys differ physically as well as psychologically; traditional people believed that both genders require different educational settings but in maritime academy there is no such difference.

Due to technological advancements, Indian society is going through transformation thereby Life style has drastically changed. Advancements, undoubtedly, have made our lives comfortable, but there is a cost to every comfort. We are paying this cost in the form of stress, anxiety, depression and alienation.

We are paying this cost by disturbing our psychological, physical and social well-being. People have become less tolerant and losing patience. Understanding self and others, empathizing, cooperating, such words are losing their meaning and expression in society. It is not only adults who are affected and suffering, even children are paying the cost.

Conceptual Discussion

Definitions of Term Emotion, Mature, Maturity & emotional Maturity

Before defining emotional maturity, it is necessary to define the terms emotion and maturity separately so that the meaning of term emotional maturity becomes clear.

Emotion: The term emotion is derived from Latin word 'movere' which means to move out, or 'stir up'. Emotion may be

defined as the stirred-up condition of organism involving internal and external changes in body. The role of emotions in each and every individual's life is as important as life itself. Life would be a drab without emotions. Instead, it can be said that from the moment we wake Up in the morning and accomplish the proceedings of the day, till the moment we sleep and even after that our dreams, our subconscious, everything is a product of our emotions, of our using the emotions. The term refers to a feeling and its distinctive thoughts, psychological and biological states and range of propensities to act (Goleman, 1995)

Emotions are a natural human response - we can all recall when we felt sad, fearful or angry, as well as when we felt elevated and happy.

People differ in how they express their emotions and how aware they are of their feelings. Strongly felt emotion may cause us to behave immaturely - like a child who cannot have what he or she wants.

According to Young, (1996) Emotion is an acute disturbance of the individual as a whole, physical in origin, involving behavior, conscious experience and visceral functioning. According to Megan, B. (1999) Emotion is nonetheless required as a foundational presence, the crucial counterbalance and reflective mirror opposite to reason's superiority.

D Charles G. Morris defines emotion "as a complex affective experience that involves diffuse physiological changes and can be expressed overtly in characteristic behavior patterns.

The word emotion is described differently by the psychologists. Emotion has been defined as upset state, feeling of euphoria, a transitory state, an enduring state, an intense feeling or the chronic anxiety.

Emotions may range from hate, terror, affection, attention, interest, romantic love, ambition, zeal, a brief attention. These emotions may lead to euphoria, an enduring interest that leads one to achieve a difficult goal, or may be hindrance to the harmonious development of personality.

Maturity: the word 'mature' means 'ripe' or full development, psychological meaning is more flexible. A student is said to be mature in sense that he/she has reached the development which is typical for the act.

Maturity may involve emotional control that means emotionally mature cadet is able to keep lid on his feelings, so it is not merely restrictions control but also the positive possibilities inherent in human nature.

In the context of Seamanship, a cadet will be called emotionally mature if he/she is able to feel proper emotion in proper situation and express it in proper words with proper tune. Maturity is the ability to stick with the given assignment or a situation until it is finished. It is the capacity to face unpleasantness, frustration, discomfort and defeat without complaint.

Maturity is the ability to live up to the responsibilities of a love relationship and this means being dependable. It is the ability to harness one's abilities and one's energies and to do more than is expected in one's relationship. Maturity is thus the ability to make a decision and stand by it.

Emotional Maturity: Emotional maturity describes the process of becoming more intelligent about our emotions and our relationships (Goleman, D., 1999, p-285). The process goes on with age and experience from childhood to adulthood. According to Walter Smithson, 1974, (as cited in Singh & Bhargava, 1990) emotional maturity is a process in which the personality is continuously striving for greater sense of emotional health, both intra-psychically and intra-personally.

Emotional maturity can be defined as the strength and courage to actualize individual abilities within the frame of social demands (Landau, E. & Weissler, K., 1998) Emotional Maturity implies controlling your emotions rather than letting your emotions get the better of you. Emotional maturity depicts your capacity to manage and to check your emotions, to evaluate others emotional state and to persuade their judgment and actions.

According to Bernard, (1954) (as cited in Singh & Bhargava, (1990) following are the criteria of emotionally mature person;

1) Inhibition of direct expression of negative emotions.

2) Cultivation of positive, up building emotions.

3) Development of higher tolerance for disagreeable circumstances.

4) Increasing satisfaction from socially approved responses.

5) Increasing dependence of actions.

6) Ability to make a choice and not brood about other choices.

7) Freedom from unreasonable fear.

8) Understanding and actions in accordance with limitations.

9) Awareness of the ability and achievements of others.

10) Ability to err without feeling disgraced.

11) Ability to carry victory and prestige with grace.

12) Ability to delay the gratification of impulses.

13) The enjoyment of daily living.

Singh & Bhargava, (1990) prepared a list of five broad factors of emotional immaturity as follows:

1) Emotional Instability: factors like stubbornness, irritability, short temperedness,

2) Emotional Regression: this includes factors like feeling of inferiority, restlessness, hostility, aggressiveness, self-centeredness, etc

3) Social Maladjustment: this includes factors like lack of social adaptability, show hatred, liar and shirker.

4) Personality Disintegration: this includes factors like extreme reactions, phobia formation, pessimism, immorality, and distorted sense of reality.

5) Lack of Independence: this includes parasitic dependence on others, lacks objective interests, irresponsible and unreliable.

Ingredients of emotional maturity

Age and time have little to do with maturity there are plenty of mature young cadets and just as many from older seafaring generations who are childish maturity is about the way you act and interact with world around you.

How to be mature?

You have to act and behave in certain ways you have to think differently a mature person embodies various traits that distinguish them from others some 15 values /traits are listed below to be followed practiced in daily life.

- SELF AWARNESS
- SELF CONTROL
- ACCOUNTABILITY
- HUMILITY
- SELF ACCEPTANCE
- GRATITUDE
- COMPASSION
- BEING OTHER ORIENTED
- OPEN MINDEDNESS
- A SENSE OF WONDER
- OPTISM WITH REALISM
- FLEXIBILITY
- RESSILENCE
- PATIENCE
- HONESTY

Stabilizers for emotional maturity

What can be done to counteract emotional IMMATURITY?

Answer is PSYCHO NEUROBIC MEDITATION

How does meditation help in stabilizing emotions?

When you start to make efforts to develop yourself and do inner work, deeply buried issues come to surface dealing with these is one of the aims of your meditation and personal efforts. Unless there is some catalyst, the hidden and deeply buried psychological injuries cannot be brought to your attention. Only when they emerge, can you deal with them, remove them and become free from their subtle and stultifying influence the stabilizers provide you with the power to do just that following are the best stabilizers to practice:

Tolerance

It is important to develop the power to tolerance certain thought and attitude help you to tolerate painful realistic

You say to yourself I do not mind that I feel bad it will pass, even if I feel very bad and my mind is in turmoil the level of tolerance means that unresolved issues may be burning up inside you but they do not overwhelm you

Settlement of karma

Whatever karma debts you accumulated over this life or in the former life needs to be settled through some means it may be a pain in body or mind it may be through financial, social, emotional or physical adverse circumstances.

If the pain is greater than your power to withstand it, the collapse of your resistance may take a form of an inability to restrain your anger or your tears both anger and tears are expressions of undesirable physical or emotional pain

Flexibility

Resto fracture therefore flexibility is important for the structure of your inner being to remain under pressure

Emotional temperature

Check your emotional temperature are you hot reactive quick to get angry rash and reckless when provoked? or are you cold hard and calculative? is your reaction delayed and vindictive? do you stay somewhere in between or do you oscillate between the two?

By practicing the above will help you maintain your emotional stability

Conclusions

As the cadets are the pillars of the future seafaring professional and leaders of shipping industry, therefore their value pattern of Emotional Maturity and self-concepts are vital. Emotional maturity is very essential for the cadets in their early (pre adolescence) educational field and adult life as seafarers. This should be promoted in the minds of the students to improve their educational status without fear. The present discussion in this paper reveals the importance of emotional maturity and main ingredients to be developed to increase emotional maturity among cadets. The success of the institutes depends upon the leadership qualities. Hence the instructors and faculty should be a well versed in modern methods of student's psychology. It is high time for stakeholders to get up and share the responsibility of making life easy for today's cadet and future prospective seafarers, there is a need to nurture cadets with love, care and compassion.

Recommendation and suggestions

Need for enhancing emotional maturity of faculty

It is very easy to enumerate few characteristics of a good faculty/instructor like good content knowledge, innovative teaching methods, creative teaching, understanding cadets and their problems, helping cadets by counselling and mentoring.

A value-added course on emotional wellbeing may be conducted for all pre sea trainee

References

[1] Buck, Max and Brown, "The relation between self concept and under achievement, ElimicolPsy, 1962, 18,181-182. 1962.

[2] Mathur (W.G)"The courtship ideals of high school youth" Sociology and Social Research, 19, 166-172.2006.

[3] Amatora.M. "Self Appraisal in Teacher Personality", Journal of Educational Psychology, pp.44, 94-110, 1955.

[4] Aray A, Emotional Maturity and value of superior children in family. Buch M.N Educational Survey, IV / Vol.II/Pg.1327. 1984.

[5] Brown Fain.J.J. "Stability of the Self-conception as a dimension of Personality" J. Abnorm Soc. Psychol.47, 597-606.1999.

[6] Kanlukukui, Gay, Hinano, Related Emotional Maturity in the study of Psychology Dissertation Abstract. 2000.

[7] Myers.D.G&Diner.E , Who is happy Psychological science, 6,10-19. 1999.

[8] Siddiqui M M, Social Psychological study of Student behaviours with special reference to indiscipline Buch 1327 IV/2. 2002.

[9] Allen Brad Brake, Emotion and its influences on problem solving, Dissertation Abstract, 1997.

[10] Varghese, P.J. 'Affective correlates of Process outcomes in emotional maturity'. Unpublished M.Ed. Dissertation. University of Calicut.1989.

A REVIEW ON NATURAL CONVECTION HEAT TRANSFER OF DIFFERENT TYPES OF FIN ARRAYS

Ankush Lahu Pawar
Tolani Maritime Institute
ankush.pawar.phdme@ghrcem.raisoni.net

Dr Nitin Korde
G. H. Raisoni Institute of Engineering and Technology, Pune
nitin.korde@raisoni.net

ABSTRACT

Fins are additionally called as expanded surfaces the fundamental motivation behind that is to build the heat transfer rate Fins offer a prudent and inconvenience free arrangement as a rule requesting natural convection heat transfer. These fins are used for many applications such as assortment of designing applications, investigations of heat transfer and liquid stream related with such arrays are of extensive designing importance. Calculation of balance arrays assume a significant part in heat transfer rate for that different sorts of balance arrays are utilized such as rectangular, round, three-sided and trapezoidal are utilized. This examination might be done with score and without indent by utilizing different kinds of material many analyst chips away at the fins by different exploratory arrangement to consider the impact of natural convection in this audit paper, the principal objective of this paper is to give a brief outline of improve heat transfer rate with the assistance of perforated and notched fins till.

Keywords

Fine Array, Natural convection

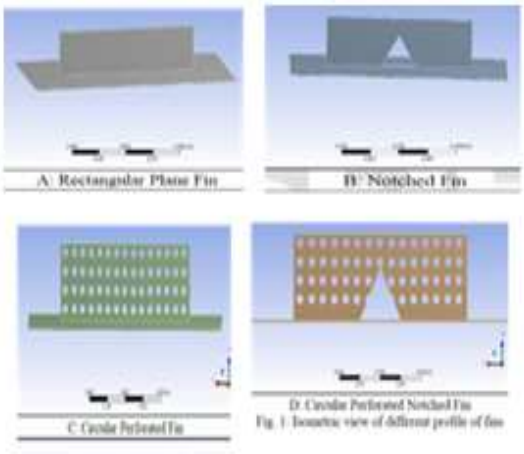
Introduction

Fins are widely utilized in air-cooled auto engines, airplane engines, cooling-off generators, engines, transformers, fridges, cooling-off computer processors and other electronic gadgets, and so forth Already, an extraordinary number of test and mathematical works have been completed to consider the impact of fin boundaries like fin tallness, fin dividing, and so forth on heat the transfer rate from fin exhibit by the agents. The dynamic heat transfer enhancement procedures have not discovered business interest on account of the capital and working expense of the enhancement gadgets. Enhancement of heat transfer is of imperative significance in numerous mechanical applications. One of the strategies for improving heat transfer is the utilization of expanded surfaces or fins. Stretched out surfaces are utilized to improve heat transfer in a wide scope of designing applications and offer a down to earth implies for accomplishing a huge all-out heat transfer surface zone. Fins are normally applied to heat the board in electrical machines, for example, computer power provided, or other applications incorporate IC motor cooling, for example, fins in a vehicle radiator.

Literature Survey

Pawan Chaurasiya, Dharmendra Singh Rajpoot [1] explored the during this examination, the fins level was adjusted by eliminating the focal fin half by cutting multilateral states of rearranged score in addition offer hole of the circular form to in addition upgrade heat transfer and deem the exhibition of multilateral form upset notched fin with plane robust fin and circular perforated fin. It's been established that circular perforated notched fin provides the utmost heat transfer rate compared to others due to its mathematical profile. It's been in addition seen that a notched fin provides a

Figure 1: Different fin geometry



most heat transfer rate compared to a perforated fin. The related focuses square measure vital from the present examination work on mathematical investigation for execution attributes of the varied profiles of a fin having the same expanse. At the same limit condition and steady heat transfer surface region, circular perforated notched fin provides the upper cooling rate compared to others profile of fin for all estimations of improper platter temperature it's likewise uncovered that the plane rectangular fin

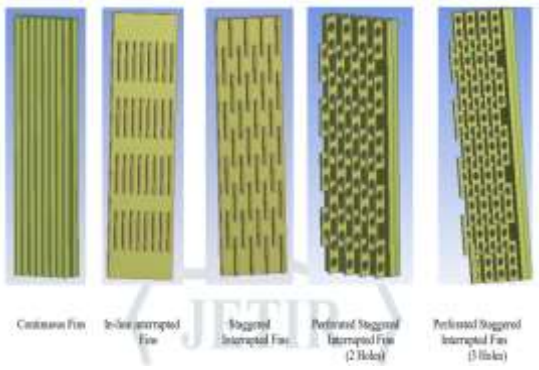


Figure 2: Different Heat sink geometry

Provides a coffee cooling rate compared to totally different.

.J.S. Chavan, R.D. Shelke, H.N. Deshpande[2] investigated the Mathematical examination of intruded on perforated fins under characteristic convection. The intruded on perforated fins are examined by utilizing mathematical techniques under common convection. The mathematical examination is to be accomplished for the examination of blade interference impacts. The constant, inline interfered, perforated inline intruded, staggered intruded on and pperforated staggered intruded on aluminium composite warmth sinks are planned and tried by changing different mathematical boundaries. The quantities of holes and the size of holes are chosen by figuring blanking proportion. Blade dividing (s) utilized in this investigation is 6.5 mm, 8 mm, 9 mm, 9.5 mm, 10.50 mm, 11 mm and so on Also, interference lengths (G) 10 mm, 15 mm, 20 mm, 25 mm, and so on are thought of.

They found the accompanying features • from the mathematical investigation, it is cleared that, heat move upgrade is better if there should be an occurrence of staggered Perforated course of action when contrasted with the other three plans. What's more, 50W information

power shows higher normal divider temperature likewise heat move rate. For example, heat moves execution increments by expanding input power. • Perforated staggered intruded on balance with blade separating 9.5 mm gives better warmth transfer. • If there should be an occurrence of staggered balance, the course of action with G = 15mm shows the ideal outcome for example higher warmth move coefficient and Nu number. Dr. N.P. Salunke, I.N. Wankhede [3] investigated the holes through the balance base are acquainted with improving ventilation with cold air from underneath the balance base. Aluminum blade clusters with length L= 380mm, balance stature H = 38mm, balance thickness tf = 1mm, and balance separating S = 10mm are examined tentatively and mathematically utilizing ANSYS 14.0 in order to acquire the temperature dissemination along the balance tallness and balance length. In this work, the blade exhibit arrangements are tried tentatively with two diverse warmer contributions as 50W and 65W.

Figure 3: Fin array geometries

They found The accompanying ends are as per the following.

For the balance cluster with a hole, there is an observable drop in most extreme and least temperature along with the stature of balance when contrasted with blade exhibit without a hole. A temperature drop of 10-16% is seen between the blade arrangements with and without hole which unmistakably demonstrates improved warmth transfer because of consideration of holes in the balance base.

For a blade exhibit with uniform warmth applied on the base surface at its center part and longitudinal holes outside the warmth source area, critical warmth transfer upgrade by a factor of 1.49 is accomplished with improved ventilation in the blade channels the convective warmth transfer coefficient for the punctured balance cluster increments with expanding radiator input.

The rate blunder among trial and mathematical outcomes got with ANSYS 14.0 lies between 5 to 9 %.

Ram Adhikari , Dawood Beyragh , Majid Pahlevani and David Wood [4] researched the Light-transmitting diode (LED) develop lights are progressively utilized in enormous scope indoor cultivating to give controlled light force and range to amplify photosynthesis at different development phases of plants. Just as changing over power into the light, the LED chips create heat, so the sheets should be appropriately cooled to keep up the high effectiveness and unwavering quality of the LED chips. As of now, LED develop lights are cooled by constrained convection air cooling, the devotees of which are frequently the purposes of disappointment and buyers of a lot of force. Characteristic convection cooling is promising as it doesn't need any moving parts, however, one significant plan challenge is to improve its generally low warmth move rate.

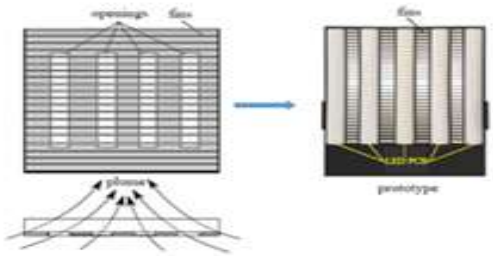


Figure 4: Fin array setup

They found The aftereffects of form heat move reenactments of a rectangular balance cluster without openings in more extensive balance exhibits demonstrated that the wind current from the cluster sides toward the middle diminished impressively, bringing about a critical abatement in warmth transfer. To improve wind current around the blades and the cluster place, openings were made in the base of a similar balance exhibit, which significantly improved the vertical wind stream and warmth move. Because of these findings, a model LED develop light with the new warmth sink configuration was created and tentatively tried for warm execution.

S. A. Wani , S. G. Patil, and S. S. Awati,[5] investigated the "Exploration on a Blackened Aluminum Plate with V-blades under Natural convection heat move conditions" This paper manages the experimentation of a vertical aluminum plate on which balances are joined.

Figure 5: Plain Aluminum Plate

The balances are connected so that they structure a V-balance cluster the whole Plate is darkened to likewise discover the radiation heat move. The warmth move execution boundaries like average warmth move coefficient and Nusselt number are determined and thought about. The rectangular blades are masterminded to frame a V-shape and are tried for various warmer information sources like 50W, 100W, 125W, etc. According to the outcomes it is presumed that the darkened v-balances plan with peak downwards is the best course of action when contrasted with rectangular course of action.

They found 1) For Blackened V-Fins with Apex confronting Downwards arrangement, the average warmth move coefficient is in the scope of 7.16 – 7.73 W/m2 K. As this value is higher when contrasted with different values, it is reasoned that this course of action is best when contrasted with different game plans. 2) The Blackened V-Fins plan has great warmth move execution than a plain vertical plate since it upsets the stream and because of this, the progression of warmth becomes violent, along these lines expanding the warmth move rate.

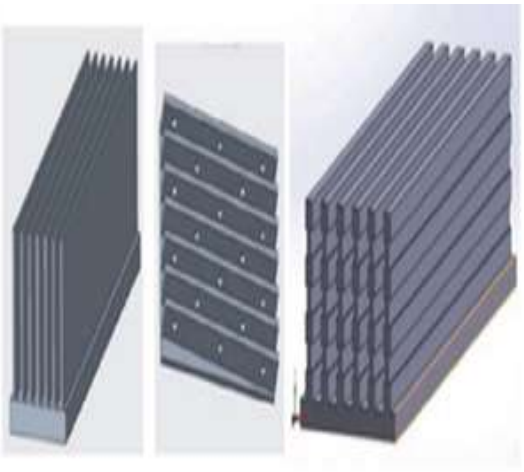


Figure 6: Rectangular inclined and non-uniform arrays

Rasika Mhatre, Vishakha Pathari, Shilpika Patil, Kshamata Patil, Prof. S. D. Khetree[6] explored the "CFD Analysis of Perforated FINS" In this paper, they had planned distinctive punctured balance calculations like slotted balance, slanted punctured balance, tighten with tendency balance, spline blade. CFD investigation

of these balances is finished utilizing ANSYS CFX for the steady warmth transition and execution of these blades are assessed. Warmth move coefficient esteem is assessed for each punctured balance at various speeds of 1m/s, 4m/s, and 8m/s thus the Nusselt number and Reynolds number. Results show that for higher Nusselt No and Reynolds No. esteem, the slanted punctured blade had given better outcomes. At the higher speed of 8m/s, it is seen that warmth move coefficient esteem is expanded practically 12% for inclined punctured blade whenever contrasted and rectangular balance. Slanted punctured balance configuration is seen to be better balance contrasted and different plans.

They found in a warm examination of the spline with opening balance, slotted blade, and tighten with augmentation balance, slotted balance gives better results. Considering the lower speed of 1m/s slotted balance and spline with opening balances are giving almost the same warmth dissipation. At the most elevated speed of 8m/s slotted balance gives preferable warmth move rate over rest two balances. Out of all-out 5 balances, slanted punctured balance gives a better warmth move rate. There is a 12.34% of expansion in warmth move rate in Inclined Perforated balance when contrasted with Rectangular blade. Nusselt no. is an element of warmth move coefficient. At the lower speed of 1m/s stream causes no change or somewhat increments in warmth move rate. At a higher speed, 8m/s higher impact of liquid particles occur. Due to higher impact among liquid particles heat move rate increments. So relying upon the stream Reynold's no. influences the Nusselt no. As indicated by the objective of expanding heat move rate a blade with the most extreme warmth move rate out of over 5 balances is to be manufactured. At low speeds like 1m/s, the stream rate is less and as the speed increments up to 8m/s, the stream rate additionally increments with it. As warmth move rate is straightforwardly relative to stream rate, with expanded in stream rate heat move rate additionally increments.

Ashish Sontakke, Narendra Wadaskar[7] explored the In many designing circumstances the hardware is set at various geological areas which are not available to standard upkeep and which requires cooling of the surfaces persistently and normal/free convection heat move measure is liked for this applications. Natural Convection is one of the significant methods of warmth move that can be arranged as far as being common, constrained, gravitational, granular, or thermomagnetic. In the previous decade, a few investigations on convection heat move in much math, upgrade of warmth move by adding restricted strip (blade), impacts of the attractive field in warmth move, heat move in a permeable medium have been accounted for. The impacts of Prandtl (Pr), Reynolds (Re), Grashof (Gr), and Rayleigh numbers (Ra), balance length, blade tallness, balance dividing, and their direction have likewise been explored. This paper audits different analyst's work on liquid stream and warmth move conduct which is completed by implies various sorts of blade connections, their direction, and point of the tendency of the base plate

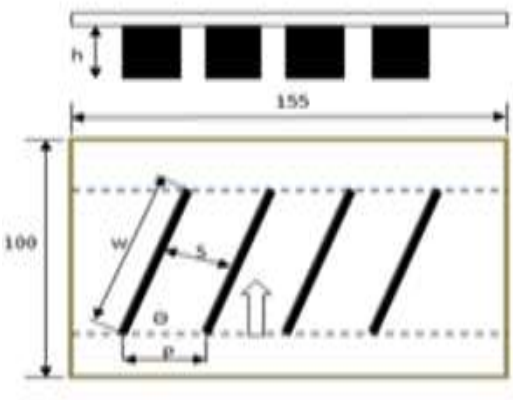


Figure 7: Schematic view of base plate

They found the reason for this work is to examine the presentation of the slanted thin plate under characteristic convection. The test study was directed for vertical plated slanted fins and vertical plate with vertical fins. The boundaries that differed during the experimentation are baseplate temperature and the tendency point of fins. As the tendency point of fins changes, the blade dividing additionally changes as indicated by the tendency point. The exploratory outcomes are acquired can be summed up as below; It has been seen that the test results show upgrade of warmth move coefficient is unequivocally subject to the Rayleigh number and balanced spacing.• The warmth move execution improved until the tendency point came to 60˚ and afterward started to crumble over a tendency point of 60˚. Accordingly for functional applications 60˚ tendency point is best for better warm execution. • The convective warmth move rate is upgraded by 8.46 % at a most extreme temperature of the base plate, Tb= 90˚C and θ = 60˚ from the level plane in examination with the vertical finned surface.

Conclusions

As the fins are a very important part hence it's the study is very important for an improved plan and furthermore improving the warmth dispersal rate execution of the plate by utilizing diverse fin calculation and fin cluster also by different boundaries, for example, fin tallness, fin separating, This the idea is trailed by various explores for their application. Yet at the same time part, numerous works stays to be carried out in the future. This paper gives the foundation of fin to carry out additional examination work in future.

References

[1] Pawan Chaurasiya, Dharmendra Singh Rajput "FVM Analysis for Comparison the Performance of Different Profile of Fins"IJSRD - International Journal for Scientific Research & Development| Vol. 5, Issue 04, 2017 | ISSN (online): 2321-0613, (2017)

[2] J.S. Chavan1, R.D. Shelke2, H.N. Deshpande3 "Numerical analysis of interrupted perforated fins under natural convection"August 2017, Volume 4, Issue 08 JETIR (ISSN-2349-5162),(2017)

[3] Dr. N.P. Salunke, I.N. Wankhede"Heat transfer coefficient Enhancement in natural convection from horizontal rectangular fin Arrays with perforations"International Journal of Mechanical Engineering and Technology (IJMET) Volume 10, Issue 01, January 2019, pp. 306–315, Article ID: IJMET_10_01_031, (2019)

[4] Ram Adhikari , Dawood Beyragh , Majid Pahlevani and David Wood "A Numerical and Experimental Study of a Novel Heat Sink Design for Natural Convection Cooling of LED Grow Lights"Energies 2020, 13, 4046; doi:10.3390/en13164046
www.mdpi.com/journal/energies,(2020)

[5] S. A. Wani , S. G. Patil, S. S. Awati, C. D. Patil & S. M. Gheji"Research on a Blackened Aluminium Plate with V-fins under Natural convection heat transfer conditions"Journal of Shanghai Jiaotong University ISSN:1007-1172,Volume 16, Issue7, July - 2020 ISSN:1007-1172 https://shjtdxxb-e.cn/ Page No: 475 ,(2020)

[6] Rasika Mhatre, Vishakha Pathari, Shilpika Patil, Kshamata Patil, Prof. S. D. Khetree"CFD Analysis of Perforated FINS"IJARST ISSN (Online) 2581-9429 International Journal of Advanced Research in Science & Technology (IJARST) Volume 7, Issue 3, July 2020

[7] Ashish Sontakke, Narendra Wadaskar"Experimental investigation of heat transfer enhancement for using different arrangement of rectangular fin"International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056,Volume: 07 Issue: 06 | June 2020 www.irjet.net p-ISSN: 2395-0072 (2020)

WATT IN WATER : ENERGY FROM THE OCEANS TO PROPEL SHIP

Cdt. Shree Waghmare
Tolani Maritime Institute.
Shreewaghmare1899@gmail.com

ABSTRACT

The paper deals with the alternative source of energy in the transportation sector focusing on the maritime industry. Due to strickening norms the maritime sector is finding for an alternative clean source of energy. There are currently two all-electric ships but, they are used only in inland navigation. Acknowledging the disadvantages of electric propulsion in long voyages, this paper offers a solution to long voyages electric propulsion using floating tidal platforms.

Keywords

Tidal Energy, Ocean, Electrical, Technology, Electric Ship

Introduction

In the last decade, the utilization of clean and renewable energy has drawn increasing interest due to climate change and limited fossil fuels. In the maritime sector, the ever strictening norms regarding emissions, the maritime sector by the vision of The International Maritime(IMO) has been asked to cut down the sulphur content of its emissions to 0.5%. This has led to the installation of scrubber towers in ships, leading to an increased installation cost and its maintenance. Above all, the IMO in its 2050 vision aims to reduce the greenhouse gas emissions from the maritime sector to 50% of what the emissions were in 2008. This would lead to a further complications and an increased transportation cost. Hence, to avoid these norms and thus, sacrificing on the economy, the maritime industry is looking for an alternative in the sector of renewable energy.

In this context, the oceans deserve a special attention, due to their vast potential in providing renewable energy in different ways. Ocean energy is available from salinity gradients, waves, ocean currents and tidal currents. In this paper we will focus on the potential of ocean currents. In the generation of electricity from the tides, a conversion of potential energy into kinetic energy, which further drives the turbine. This turbine is coupled to a generator shaft via a series of speed enhancement gears. The energy in the ocean currents is already available in the form of kinetic energy. This reduces the use sluice gates which were in the case of tidal power plants.

The obstacles faced by the installation of power plants to harness the energy potential from the ocean currents has been overcome by the use of a BlueTec Floating Power Plant, which shall be discussed in detail in the paper.

Tidal Energy

Tidal power is taken from the Earth's oceanic tides. Tidal forces are periodic variations in gravitational attraction exerted by celestial bodies. These forces create corresponding motions or currents in the world's oceans. Due to the strong attraction to the oceans, a bulge in the

water level is created, causing a temporary increase in sea level. As the Earth rotates, this bulge of ocean water meets the shallow water adjacent to the shoreline and creates a tide. This occurrence takes place in an unfailing manner, due to the consistent pattern of the moon's orbit around the earth. The magnitude and character of this motion reflects the changing positions of the Moon and Sun relative to the Earth, the effects of Earth's rotation, and local geography of the sea floor and coastlines.

A tidal generator converts the energy of tidal flows into electricity. Greater tidal variation and higher tidal current velocities can dramatically increase the potential of a site for tidal electricity generation. Because the Earth's tides are ultimately due to gravitational interaction with the Moon and Sun and the Earth's rotation, tidal power is practically inexhaustible and classified as a renewable energy resource.

Conventional ways of harnessing tidal energy

Tidal Barrages

Tidal barrages make use of the potential energy in the difference in height (or hydraulic head) between high and low tides. When using tidal barrages to generate power, the potential energy from a tide is seized through strategic placement of specialized dams. When the sea level rises and the tide begins to come in, the temporary increase in tidal power is channeled into a large basin behind the dam, holding a large amount of potential energy. With the receding tide, this energy is then converted into mechanical energy as the water is released through large turbines that create electrical power through the use of generators. Barrages are essentially dams across the full width of a tidal estuary.

Dynamic Tidal Power

Dynamic tidal power (or DTP) is a theoretical technology that would exploit an interaction between potential and kinetic energies in tidal flows. It proposes that very long dams (for example: 30–50 km length) be built from coasts straight out into the sea or ocean, without enclosing an area. Tidal phase differences are introduced across the dam, leading to a significant water-level differential in shallow coastal seas. The turbines are rotated by the tidal power. The turbine is coupled to a generator which is underwater. A cable connects the underwater facility to the shore installations, to transfer the electricity generated.

Disadvantages of the Conventional way

1. It has a humongous initial cost.
2. Due to tidal energy reliability the expensive upfront cost of these generators will slowly be paid off.
3. The turbines being installed at the bottom of the sea bed harnesses tidal energy but, the ocean velocity is lowest at the bottom. Hence, it is unable to utilize the maximum of what it was installed for.
4. They require substantial civil engineering works to form the impounding basin.
5. Most are mounted on the seabed as rigid structures which require large high-end offshore installation.
6. Due to the above reason, the maintenance is also difficult.
7. The installation of seabed mounted turbines in remote places

is a complicated task due to lack of infrastructure.

Due to the above reason the era of technological revolution has come up with the solution in the form of a floating platform.

Blue TEC: A floating Tidal Power Plant

The demerits of a rigid, seabed installed tidal power plant which couldn't optimize the maximum of the ocean energy, called for the invention of a floating tidal power plant.

The BlueTEC is a floating tidal energy plant (Fig 1). It is a moored platform which holds a tidal turbine underneath in order to generate renewable electricity from moving water currents. This is the world's first floating tidal plant and was installed in the Mardiep inlet, a channel connecting Wadden and the North Seas. (Ref I)

Figure 1: BlueTEC Floating Tidal Power Plant

The BlueTEC was designed as a modular system composed of three modules with the dimension of standard shipping containers so that it can easily be shipped worldwide at relatively low costs (Fig 2). The interior of the containers allows for easy access for maintenance and dry storage of all critical electrical equipment. The platform was kept in place of four mooring line, and by four drag anchors, attenuating its movement even under extreme environmental conditions. The plant was connected to the local electric grid onshore by a hybrid power and optical fiber cable.

Figure 2: Three modules, the size of shipping containers

The energy extraction takes place by means of a free tidal stream turbine, which is installed beneath the floating platform attached to a vertical strut. Some compare tidal turbines to wind turbine, but the underwater blades are much smaller and rotate slower. It is in fact slower than a ships propeller. [1]

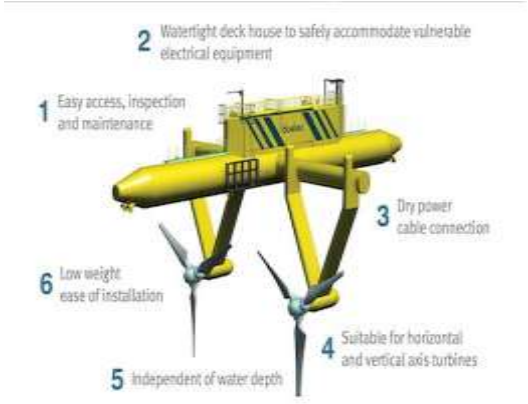


Figure 3: A detailed picture of The BlueTEC Floating Tidal Plant

To achieve very high availability, the turbine was kept as simple and as robust as possible. This implies no turbine yawing and no blade pitching system, except to rotate blades according to direction of flow. As the tidal turbines are intended to work with flow coming from both directions, during flood and ebb tidal phases, the orientation of the blades changes according to the flow direction. The bi-directional rotor design makes it possible to turn the two blades 180 degrees simultaneously for reverse flow operation.

The first large ocean-system proposal is for a 2.4-mile system that would link Samar and Dalupiri islands in the Philippines. The Dalupiri project is estimated to cost $2.8 billion, produce 2,200 megawatts at tidal peak and offset 6.5 million tons of carbon dioxide a year

Energy from Ocean Currents

The relatively constant flow of ocean currents carries large amounts of water and energy across the earth's oceans. Although there has been no commercial development in the United States, technologies are being developed so that ocean currents may provide a source of renewable, clean energy that can be extracted from ocean currents and converted to usable power.

Ocean currents flow in complex patterns and pathways and are affected by several elements such as wind, temperature, topography of the ocean floor, the earth's rotation and water salinity. Most ocean currents are driven by wind and solar heating of surface waters, while some currents result from density and salinity variations of the water column.

Ocean currents have a relatively constant and directional flow, in contrast to tidal currents along the shore. While ocean currents may move slowly relative to wind speeds, due to the density of water, they carry a great deal of energy. Water is more than 800 times denser than air, so for the same surface area, water moving 12 miles per hour exerts the same amount of force as a constant 110 mph wind. Due to this physical property, ocean currents contain an enormous amount of energy that can be captured and converted to a usable form. [1]

Ocean-Current Energy Technology

The United States and other countries are pursuing ocean current energy; however, marine current energy is at an early stage of development. Relative to wind, wave, and tidal resources, the energy resource potential for ocean current power is the least understood, and its technology is the least mature. There are no commercial grid-connected turbines currently operating, and only a small number of prototypes and demonstration units have been tested. More advanced technologies have been developed for use with tidal currents in near-shore environments. There are a number of different current technology concepts under development. Prototype horizontal axis turbines, similar to wind turbines, have been built and tested, and over the next 5 to 7 years would be the most likely commercial development scenario. Although ocean current technology is still in its early stages of development, several tidal and in-stream current turbine applications are near commercialization. These devices take advantage of the daily tidal cycles in near-shore ocean environments, or steady water flow from freshwater rivers.

However the current technology limits the use of turbines to seabed applications where it is difficult to maintain.

Electricity the Way Forward

As the world is looking for an alternative to fossil fuels, the electric sector is living up to its expectations. In India, the government is stressing on the use of less polluting alternative fuels like CNG which are comparatively cheaper and thus economical. However the ambitions of many nations do not stop at a reduce emission fuel. The competition to the zero emission fuel is on. However, no other fuel produces zero emission except those derived from electricity. Many of the shore facilities have started shifting to electrically powered machines. The automobile sector has started shifted to vehicles that derive their locomotion from electricity. The maritime sector has also opened its mind to such technological advancement with ships fully running from electricity. This has led to zero emission by the ship and is the first of its kind.

The shift is officially on. North Sea oil rigs are being dismantled. The run of coal as energy champion of Europe is over, and plans for hundreds of new coal plants across Asia have been shelved. The business case for solar power is solid. Electric trains in the Netherlands run on wind energy. Google announced that its server farms and offices will be powered entirely by renewable source of energy—mostly wind and solar. [3]

An all-electric ship

In china, a 2000 dwt fully battery powered coal carrier is being used to carry shipments of coal to power plants along the Pearl River, driven by a 2,400 kWh battery system. The coal is unloaded at the power plant while the vessel charges its batteries using coal-fired power during the offloading phase. It then proceeds to its destination at a maximum speed of 7 knots. This is however only used for inland navigation. It does though, provide an important insight into how zero-emission battery technologies may eventually displace or replace hydrocarbon- fuelled tonnage on domestic water. [2]

Yara Birkeland

Yara Birkeland, a futuristic full-electric vehicle also launched this year, is using a battery power bank of 9MWh, charged by a sustainable Norwegian shore power, based on supply of clean hydro-electric energy. Yara Birkeland will replace 40,000 truck journeys every year, effectively making it a negative-emission vehicle, rather than a zero emission vehicle.
Both vessels are sure to serve as blueprints for the introduction of many more battery-powered vessels on short routes in the years to come. [2]

Figure 4 : Yara Birkeland

Solution for Long Voyages

Though the present technology limits electric propulsion to inland navigation and defers it from being used in long voyages, it is of the authors mind that the feat could be achieved in long distance voyages too. The invention of a floating tidal platform has paved a way for long voyages electric propulsion. With the use of that invention, the generation of electricity isn't just focused on shore

based plants or coastal hydro-electric tidal plants.

The use of the BlueTEC plant has made it possible to generate electricity even in the middle of the ocean, a feat never imaginable before. If the floating platforms were to be placed on a large scale basis to harness ocean-current energy on the routes of the major currents (fig 5) instead of the tidal plants it was made for, we could harness an unimaginable energy.

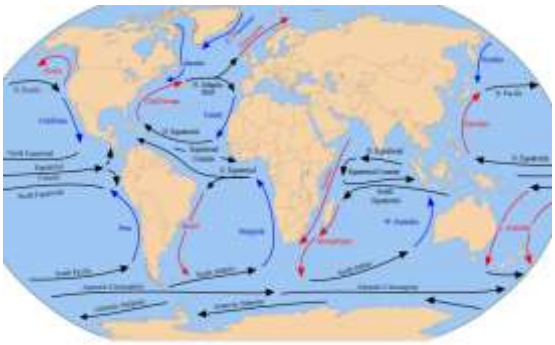


Figure 5 : Ocean Currents of the World

The thing is, we don't have to send the electricity generated by the floating plants to the shore facility. They could be placed well within the shipping routes (fig. 6) which intersect with the ocean currents. Thus even though electric propulsion won't take a ship far enough, we can increase the total distance by the introduction of these plants, well before the exhaustible limit is reached. Thus these floating plants may acts as petrol-pumps, or to better say, electric pumps for the ship. Thus long voyages could be achieved.

Figure 6 : Major sea-routes

Conclusion

The oceans make up almost 70% of the earth's surface. Till now we have limited our search to the rest of the 30% but in order to sustain our growth, we need to find an alternative. There is almost 200 Trillion Watt Hour (ref III) of energy in our oceans currents in the form of kinetic energy. It isn't possible to extract it all but even if we could extract 1% of it, it would be suffice of run the maritime industry. The ocean-current technology is new to us and we haven't realized the potential it carries. The, problem of harnessing the ocean current energy deep into the seas, has been resolved by the invention of the floating power plant. Even though the initial technology is limited and the initial cost is high, with a market for such installations the efficiency is bound to go up.

References

[1] Journal of Marine Science and Technology, volume 24, number 3, 2019
[2] Marine professional (September/October 2019)
[3] https://www.hakaimagazine.com /features/watts-water/

ALTERNATIVE IN AMMONIA: A SUFFOCATING WAY TO PROPEL SHIPS

Cdt. Shree Waghmare
Tolani Maritime Institute.
Shreewaghmare1899@gmail.com

ABSTRACT

Due to the IMO's sulfur cap being enforced from 1st January, 2020, the owners were put in a spot, either switch to low sulfur fuel oil and ultra-low sulfur fuel oil, depending on the region they were in. IMO has announced its vision for 2050. It has a vision to reduce the Carbon Dioxide emission levels 40% by 2030 and 70% by 2050, when compared to the level of 2008. As for its vision for total greenhouse gas emission reduction, IMO envisions to reduce it to 50% by 2050, when compared to levels of 2008. In this paper we will be concentrating on the possibility of ammonia as an alternative to the fossil fuel derived propulsion. The advantage and disadvantage will be carefully weighted and judged, along with some case studies of the leading shipping companies and experimentation of analyzing an 'ammonia propelled future'.

Keywords

Ship, Ammonia, Propel, Fuel, Emission, Combustion

Introduction

While the maritime industry was struggling to keep up with the enforcement of IMO 2020 regulations, limiting the Sulfur emissions to 0.5% outside Sulfur Emission Control Areas (SECA) and below 0.1% inside SECA regions, IMO has announced its vision for 2050. It has a vision to reduce the Carbon Dioxide emission levels 40% by 2030 and 70% by 2050, when compared to the level of 2008. As for its vision for total greenhouse gas emission reduction, IMO envisions to reduce it to 50% by 2050, when compared to levels of 2008.[1]

Hence shifting to low sulfur fuel or even ultra-low sulfur fuel might not be the solution in the long run. We are escaping one trap, just to be trapped into another. For that matter even shifting to carbon based fuels such as LNG and LPG is not the solution. It is neither economical nor advisable to shift to different fuels every decade or retrofit new equipment such as scrubber towers to meet the ever rising demands of the industry. It would be foolish to even consider doing so, now that we know what IMO has in store for us. Some of the alternatives to fossil fuels include hydrogen, electricity, fuel cells, ammonia, etc.

In this paper we will be concentrating on the possibility of ammonia as an alternative to the fossil fuel derived propulsion. The advantage and disadvantage will be carefully weighted and judged, along with some case studies of the leading shipping companies and experimentation of analyzing an 'ammonia propelled future'.

Impact of IMO 2020 Sulfur Cap on Shipping

As discussed earlier due to the IMO's sulfur cap being enforced from 1st January, 2020, the owners were put in a spot, switch to low sulfur fuel oil and ultra-low sulfur fuel oil, depending on the region they were in. The second option which was give to them was retrofitting of Scrubber Towers onto the ships. The capital which was required was high plus the time taken for retrofitting these emission reducing towers would be high. If the needs of IMO are evolving every decade, it would be an arduous task to not only install the retrofits but also train the manpower to operate them efficiently and safely.

The use of open loop scrubbers have entered into a controversy with 21 countries banning the discharge of wash water from these scrubbers, Saudi Arabia being the latest one.[2] Many more countries have issued restriction or guidelines regarding the discharge of the wash water from such plants.

Impact of Covid 19 on Shipping

For the owners who chose to not retrofit the scrubber towers, the only option left is to change over to low sulfur fuel oil and ultra-low sulfur fuel oil. This enhanced fuel is highly refined and is bound to cost more, further increasing the cost of shipping. Based on the analysis, the switch to IMO compliant LSFO prices as of 1 January resulted in a nearly two-fold increase in assessed fuel costs across covered routes, equivalent to an average rise in nominal voyage freight rates of 20%, or US$5 per ton, to around US$30 per ton.[3]

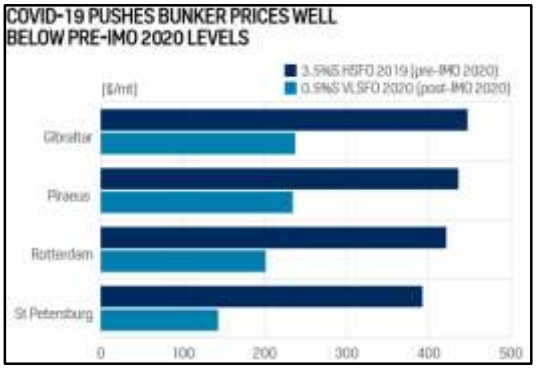


Figure 1: Comparing of Fuel Prices of HFO and VLSFO, pre-COVID and post-COVID respectively[4]

The marine fuel of choice for many ship-owners was 'Very Low Sulfur Fuel Oil' (0.5% sulfur). Its price averaged $201/mt in April on a delivered basis at Rotterdam, half what it was before IMO 2020, despite the main fuel one year ago containing more sulfur. The prevalent marine fuel last year, high sulfur fuel oil (3.5% sulfur), averaged $421/mt in April 2019 at Rotterdam, S&P Global Platts data shows.[4]

The fuel prices were expected to shoot up due to the change-over of fuel but it did not take the projected trajectory but took a steep fall. This can be attributed to the present COVID-19 pandemic, which has shaken even the strongest of economies. Thus the impact of IMO 2020 is yet to hit the shipping industry and its repercussions are yet to trickle down to the end customer.

Alternative in Ammonia

Ammonia's potential as a transport fuel has been demonstrated by NASA in its deployment in rockets. NASA in its paper 'Theoretical Performance of Liquid Ammonia and Liquid Fluorine as a Rocket Propellant' has highlighted the use of ammonia along with fluorine in its liquid form as a fuel which is very much capable of an expansive thrust. Theoretical values of performance parameters for liquid

ammonia and liquid fluorine as a rocket propellant were calculated on the assumption of equilibrium composition during the expansion process for a wide range of fuel-oxidant and expansion ratios [6]. This report was submitted on March 16, 1953 and classified. It was made available only to the public on August 29, 2013.

Advantages of Liquid Ammonia as a Fuel

Apart from electric propulsion we have two main alternative fuels, hydrogen and ammonia. Ammonia is less dense in energy, when compared to hydrogen. However in the ease of transportation and storage, the properties of ammonia more than exceed those of hydrogen.

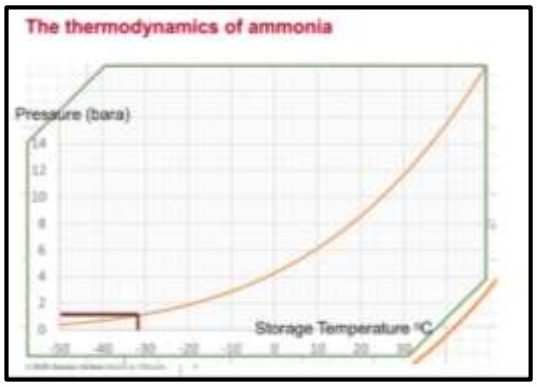


Figure 2: Thermodynamics of Ammonia

- The thermodynamics of ammonia (Fig 2) shows us that Ammonia at atmospheric pressure is liquefied at -33ºC and the same liquefaction point is increased to room temperatures when it is stored under a pressure of 11 bar.[6] Thus it is mildly cryogenic in nature.

- The flammability of ammonia is between 15-28%. The Lower Explosive Limit (LEL) being 15% and Upper Explosive Limit (UEL) being 28% respectively [7] this makes it harder to ignite and thus reduces the chances of an explosion.

- Ammonia has a molecular formula of NH_3 , and it made up by 3 atoms of hydrogen and one atom of nitrogen. As it contains no carbon, the fear of carbon oxide emissions can be safely rested. Thus, the fuel is ready to comply theoretically with the IMO's vision of 2050.

- It is more energy dense than hydrogen and is the most energy dense, zero carbon emission fuel (Fig 2)[8]

Limitation of Ammonia as a Fuel

- Ammonia is very hard to burn and needs a pilot fuel to burn if used on a Liquid Gas Ignition (LGI) Engine. Thus upto 15% pilot fuel is required to burn it on a LGI engine, eliminating the entire concept of zero-carbon based-emission free fuel.

- It it less energy dense than most of the fossil fuels that are used today. Energy density of ammonia is only 38% of what was obtained from burning of diesel fuels. Thus for the same power generation we would need thrice the storage capacity. This would have to be done by compromising precious cargo space, thus reducing the cargo carrying capacity.

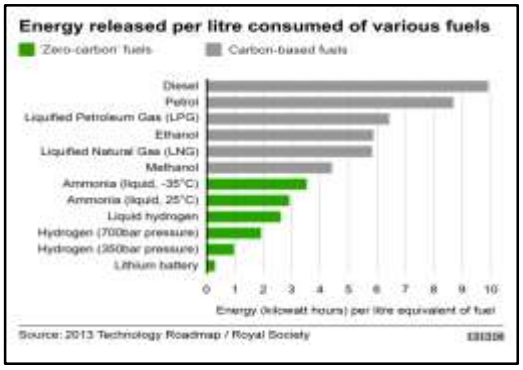


Figure 3: Comparison of Various Fuels with respect to their energy density/litre of equivalent fuel

- The amount of NOx emissions would increase substantially. Thus, to confer with the Tier III regulation of Annex VI, of Marpol, a Selective Catalytic Reduction (SCR) would need to be installed. This would increase the Capital Expenditure (CAPEX) by the owner in terms of installation, maintenance and upskilling of manpower.

Reduction of NOx Emissions

NH_3 has been drawing attention recently as a carbon-free alternative fuel. NH_3 is a combustible gas that can be widely used in thermal power generation and industrial furnaces as an alternative to gasoline and light oil. However, it is difficult to burn (high ignition temperature) and generates harmful nitrogen oxides (NOx) during combustion.

Catalytic Combustion Method

Researchers at the International Research Organization for Advanced Science and Technology (IROAST) in Kumamoto University, Japan focused on a "catalytic combustion method" to solve the NOx emission issue. This method adds substances that promote or suppress chemical reactions during fuel combustion. Recently, they succeeded in developing a new catalyst which improves NH_3 combustibility and suppresses the generation of NOx. The novel catalyst (CuOx/3A2S) is a mullite-type crystal structure $3Al_2O_3{\cdot}2SiO_2$ (3A2S) carrying copper oxide (CuOx). When NH_3 was burned with this catalyst, researchers found that it stayed highly active in the selective production of N_2, meaning that it suppressed NOx formation, and the catalyst itself did not change even at high temperatures.[9]

Selective Catalytic Reduction

A Selective Catalytic Reduction (SCR) system uses a metallic or ceramic wash-coated catalyzed substrate, or a homogeneously extruded catalyst and a chemical reductant to convert nitrogen oxides to molecular nitrogen and oxygen in oxygen-rich exhaust streams. . As exhaust and reductant pass over the SCR catalyst, chemical reactions occur that reduce NOx emissions to nitrogen and water. SCR catalysts can be combined with a particulate filter for combined reductions of both PM and NOx. Open loop SCR systems can reduce NOx emissions by 75 to 90 percent. Closed loop systems on stationary engines can achieve NOx reductions of greater than 95 percent. SCR systems are also effective in reducing HC emissions up to 80 percent and PM emissions 20 to 30 percent.

Case Study

The properties of ammonia have been considered in detail and its merits and its limitations having being addressed, one might begin to wonder about whether this

idea of ammonia as an alternative fuel is just limited to the papers or has any of the players of the maritime industry shown serious commitment to the use of ammonia as a fuel.

Wärtsilä

The technology group Wärtsilä, in close customer cooperation with Knutsen OAS Shipping AS and Repsol, as well as with the Sustainable Energy Catapult Centre, will commence the world's first long term, full-scale, testing of ammonia as a fuel in a marine four-stroke combustion engine. The testing is made possible by a 20 Million NOK grant from the Norwegian Research Council through the DEMO 2000 programme.

Figure 4: Ammonia Engine being testing at Wärtsilä R&D

Meanwhile, Wärtsilä is working on four-stroke engine designs, hoping to reach the stage of field tests as soon as 2022. Fig 4, shows the testing of one such engine at its R&D facility.

MAN Energy Solutions

Man Energy Solutions is expecting to have a two-stroke ammonia engine ready to deliver by early 2024. The project aims to demonstrate – at full-scale – a large marine engine running on ammonia at MAN Energy Solutions' test facility, Research Centre Copenhagen. The project comprises three main stages

1. Concept development and initial design of an ammonia engine.
2. Design of an ammonia fuel-supply system.
3. Full-scale testing.

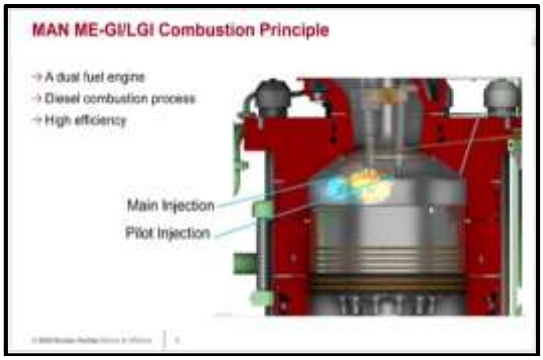


Figure 5: Testing of Ammonia as a fuel by MAN Energy Solutions on their LGI engine

MAN is also looking to burn ammonia in their LGI engines. They have burned LPG and they currently plan to have an evolution of that engine with ammonia as a fuel. The company aims to offer retrofit conversions to allow existing two-stroke engines to use ammonia.

Conclusion

The marine industry is cornered and bombarded with regulations from IMO, which in turn wants to bring about revolutionary changes to counter climate changes. It is said that adversity is the mother of all innovations, thus it is now the time to think outside the box or rather expand the box to accommodate the alternative fuels. The fuel is still in its initial stages of testing, with various players testing the fuel capabilities of ammonia in various kinds of engines. Ammonia can be also used as a energy source from fuel cells with the

combination of nitrogen and hydrogen release energy which can be used to run a motor. It is still not a proven technology and is still in its initial stage of testing but since we are backed into a corner, ammonia deserves to be given a shot.

References

[1] https://www.imo.org/en/MediaCentre/HotTopics/Pages/Reducing-greenhouse-gas-emissions-from-ships.

[2] https://safety4sea.com/list-of-countries-that-restrict-the-use-of-open-loop-scrubbers/

[3] https://ntrs.nasa.gov/citations/19930087555
https://safety4sea.com/cm-the-case-of-ammonia-as-a-marine-fuel/
[4] http://www.wermac.org/safety/safety_what_is_lel_and_uel.html
[5] https://www.bbc.com/news/business-54511743

[6] https://scienceblog.com/500593/new-catalyst-turns-ammonia-into-an-innovative-clean-fuel/

[7]http://www.meca.org/technology/technology-

[8]https://www.greentechmedia.com/articles/read/marine-sector-looks-to-ammonia-to-decarbonize-shipping

[9]https://man-es.com/docs/default-source/press-releases-new/20201021_man_es_pr-aengine-mes_en.pdf

ALTERNATIVE FUEL – ANTICIPATED ISSUES & PROPOSED SOLUTIONS

Menon Ashwin Pramod
Tolani Maritime Institute
pramodashwin5@gmail.com

Prof. Anirudh Kumar
Tolani Maritime Institute
anirudhk.1234@gmail.com

ABSTRACT

The Maritime Industry, despite being conservative to changes, has recently been looking into alternative fuels for running their ships. This newfound interest in alternative fuels can be primarily attributed to the emission standards of harmful gases like sulphur oxides and nitrogen oxides being progressively tightened by the IMO under Annex VI of MARPOL. These fuels come with several benefits for both the environment and companies alike. They will positively impact the environment with significant reductions in greenhouse gas emissions, which will help decarbonize the environment and curb climate change.
Although many alternate fuel sources are available, only a few are practically viable for the propulsion of ships. Some of the fuels under review are LNG, Biofuels, Hydrogen and Ammonia. Currently, LNG leads the race due to their attractive prices and abundant supply. Even though the companies have shown considerable interest in using alternate fuels, there are several barriers like limited availability, compatibility issues, high production costs, increased storage space and regulation issues that need to be broken before such fuels are introduced on a large scale. Considering the promising studies and proposed solutions, Alternate Fuels are set to be game-changers in the maritime industry.

Keywords

Alternate fuels, LNG, Biofuels, Barriers, Solutions

Introduction

Alternative fuels are fuels that can serve as a substitute for fossil fuels wholly or partly and help reduce the pollution caused by the transport sector. The Maritime Industry has been a consumer of fossil fuels for propulsion and power generation and although it's a clean and efficient mode of transportation requiring only 2-3 grams of fuel per ton*km, it has been one of the largest contributors to Nitrogen oxide and Sulphur oxide emissions with a share of 13% and 12% of the global emissions, respectively. It is also responsible for around 2.2% of global CO2 emissions due to fossil fuel use [1][2]. Another significant issue is the amount of particulate matter spewed out by the ships (1.2-1.6 million metric tons), resulting in around 60000 deaths due to cardiopulmonary and lung cancer annually [2]. With these emissions continuing to rise and the reserves of traditional fossil fuels depleting rapidly, alternate fuels will play a significant role in creating an

environmentally friendly and sustainable shipping industry.

This paper scrutinizes some of the alternate fuels considered as viable replacements to the current marine fuels. We will discuss the potential challenges we face in shifting to such cleaner fuels and proposed solutions to overcome these challenges.

Alternate Fuels Under Review

Some alternative fuels with the potential to be used as a marine fuel are LNG, Hydrogen, Ammonia, Biofuels, and renewable energy sources like wind and solar energy. But at the moment, all other fuels except LNG and Biofuels are not feasible enough. The biggest hurdle preventing the use of most alternative fuels are their Physico-chemical characteristics such as low flashpoints, higher volatilities, different energy content and toxicity. Another problem faced is that the IGF Code, a mandatory safety code for gas-powered ships does not recognize most of the proposed alternate fuels which limits the use of these fuels. Ammonia has a very low energy density and is highly toxic and corrosive [3]. Similarly, Hydrogen also requires a lot of space and needs to be cooled to -253^{o}C to be stored as a liquid [10]. It is also very flammable and very costly to produce. The space of renewable energies as marine fuels has seen several technological advancements like Rotor Sails, Solar Panels, Kites, and Wind Sails which harness wind and solar energy to propel the ship. But at the moment, it is not a feasible solution for deep-sea shipping and can only be used to assist in propulsion partially. Considering these points, LNG and Biofuels can be looked at as the most feasible solutions in the current scenario.

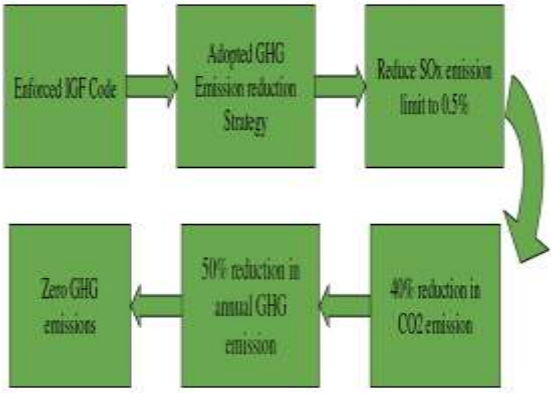


Figure 1: IMO DE carbonization Strategy

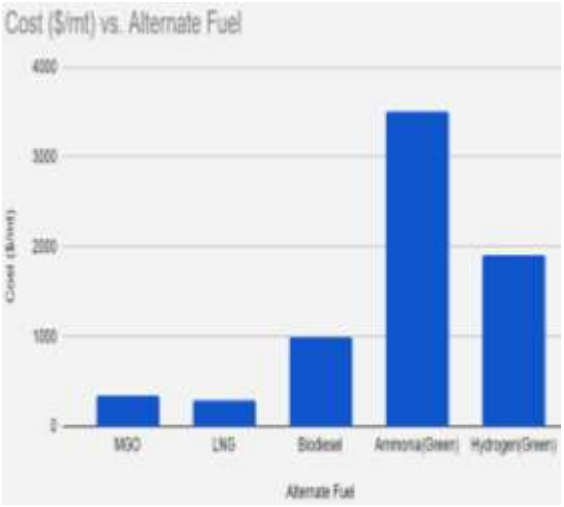


Figure 2: Comparison of Cost of Different Fuels

A) Liquefied Natural Gas

Liquefied Natural Gas or LNG has been widely accepted as the most mature and viable alternate fuel currently available. Over the past decade, new technological innovations like hydraulic fracking have led to LNG being readily available, making it competitive in costs with distillate fuels. An LNG powered ship is future-proof to new emission regulations

and will yield a higher return on investment than scrubber systems and LSFO. From an environmental perspective, LNG is an excellent alternative fuel as it eliminates SOx and particulate matter emissions by almost 100%, NOx emissions by 85%, and CO2 emissions by around 21% [4].

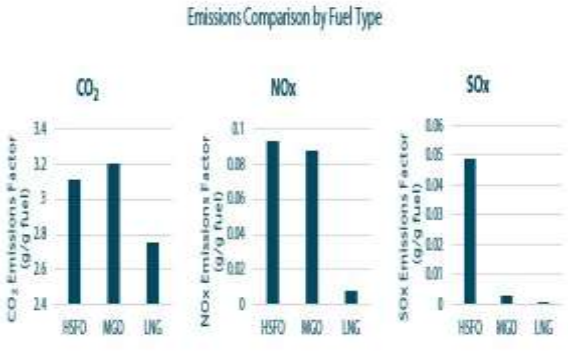


Figure 3: Comparison of Emissions by Fuel Type (Source: breakthroughfuel.com)

These advantages have led to a significant annual growth of 20-40% in the number of LNG powered ships over the last decade [5]. We have also seen the market for LNG powered vessels from the short-sea to deep-sea shipping space with over 400 vessels either in operation or under construction. The number of LNG bunkering facilities has also increased in recent years, with them being either operational or under construction in 9 out of 10 major bunkering locations worldwide and around 20 bunker vessels are also either in use or under construction for remote bunkering [5].

Figure 4: Global LNG Bunkering Infrastructure (Source: safety4sea.com)

Some of the challenges preventing shipping companies from using LNG-powered ships are:

- **High Capital Cost:** LNG being a Non Drop-in fuel is not compatible with the existing engines and fuel systems and hence the ships have to be retrofitted with Gas Engines and fuel systems or new vessels have to be constructed. Additional crew training is also required to handle these ships. These require large amounts of capital, which prevents companies from adopting LNG as a marine fuel.
- **Large Fuel Storage Volume:** LNG has a considerably low energy density and requires twice as much fuel storage space as a liquid fossil fuel for the same amount of endurance [2].
- **Need for De-Bunkering**: Fuel tanks have to be emptied with the help of de-bunkering facilities

when the vessel is kept in anchorage for a long time. Otherwise, the natural gas will boil-off, causing large amounts of methane losses to the atmosphere [2].

- **Methane Slip:** It is the emissions of unburnt methane caused by the scavenging in the cylinder and the ventilation from the crankcase. This is considered as greenhouse gas emissions and is extremely dangerous for the environment.

Some of the solutions to these challenges that have been either proposed or put into action are:

- Governments and other organisations can grant fundings for further research and as an incentive to make companies add LNG-powered vessels to their fleet. Some of these funds that have already been granted are the Norwegian NOx fund, Ocean Fund, and TEN-T program. Companies have also upgraded their training facilities for providing their crew with LNG handling training.
- In order to combat the storage issue, several companies are developing storage tanks that can be placed anywhere on the vessel like astern of the ship, in superstructures, or under cargo space [6]. One such solution is the GTT Membrane tank, which optimizes fuel holding capacity with the help of adaptable geometry, lightweight structure, etc [7].
- The challenge of bunkering and de-bunkering is diminishing with time as LNG continues to gain popularity, and the number of bunkering facilities, bunker vessels, and bunker barges increases.
- Over the past decade, the methane slip of Otto engines has reduced significantly and can be reduced further by using Exhaust Gas Recirculation or by using catalysts like palladium for exhaust gas after-treatment [2][8].

B) Biofuels

Some of the biofuels with the potential to be used as marine fuels are Pyrolysis oil, Ethanol, Algae Fuels, and biodiesels like FAME. Some other options are Bio-LNG and Bio-Methanol. These biofuels are Drop-in fuels to a certain extent, meaning they are compatible with the current diesel engines and fuel systems. They are practically sulphur-free and also help in reducing greenhouse gas emissions significantly more than LNG. They are also safe for the marine environment as they degrade very quickly [2].

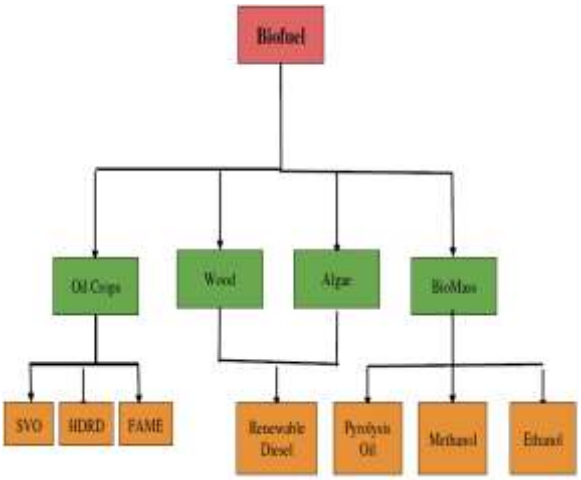


Figure 5: Types of Biofuel and Their Sources

Even though some Biofuels have shown promising results, several challenges stop them from being seen as an alternative for the current marine fuels. They are:

- **Availability:** Securing necessary volumes of biomass for commercial production is a challenge.
- **Storage and Oxidation Stability:** Biofuels, especially biodiesel, degrade over time and form contaminants of peroxides, acids, etc [2]. They also tend to oxidize quickly and hence can cause corrosion of tanks.
- **Price:** Currently, they are not competitive in pricing with fossil fuels and hence are not attractive enough for commercial shipping.
- **Lack of applicable regulations:** Current Regulations don't cover the use of Biofuels.

Although Biofuels are not a viable solution due to these challenges, some proposed solutions can help them become an attractive solution in the next decade. They are:

- Fundings can be granted for projects for mass production of biofuels sustainably. One such fund is the European Commission fund for the production of FAME. The US Navy has also given orders for several Biofuels like algae fuel and FAME [2]. This will also help in reducing the price of such biofuels.
- The storage issue can be combated by avoiding storage periods of over six months and by using a fuel monitoring program. Antioxidants can also be used to increase storage life [9].
- Research has to be done on how to produce biomass at a large-scale and more focus should be given to find suitable algae strains for large-scale production [10].
- IMO is working on introducing regulations for use of Biofuels under the IGF Code with the formal approval expected in the coming years.

Conclusion

The biggest topic of discussion in the Maritime world for the last decade has been alternate fuels and emission reductions. Although IMO 2020 brought significant reductions in emissions, there are still a lot of issues and alternate fuel is the solution to all these problems. At the moment, there is no silver bullet but LNG is the most mature solution. But it should be looked at only as a bridge towards better solutions as it's not sustainable due to its method of production and GHG emissions. As we look for a carbon-free economy, fuels like Hydrogen, Ammonia and Biofuels will play very important roles

provided they can be produced in a large and feasible manner. Renewable energies like wind and solar energy will also have a role to play, but the extent of their impact can only be understood with further research.

The Earth, as we know it is in grave danger and in order to hand over a hospitable planet to the future generations we have to shift to alternate fuels and for this to happen governments, maritime agencies, ship-owners and classification societies have to come together and show an active interest in carrying out studies, creating safety standards and regulations and most importantly accepting the solutions put forward.

References

[1] https://link.springer.com/article/10.1186/s41072-019-0051-8, accessed on 3/11/2020

[2] http://www.methanol.org/wp-content/uploads/2016/07/inland-and-marine-waterways-exploratory-work-on-alternative-fuels_kamaljit-moirangthem_final.pdf, Page 6, 13, 17, 18, 20, 21, accessed on 3/11/2020, 4/11/2020, 5/11/2020

[3] https://safety4sea.com/cm-the-case-of-ammonia-as-a-marine-fuel/, accessed on 4/11/2020

[4] https://www.fortisbc.com/est/marine /environmental-benefits-of-lng-fuelled-marine-vessel, accessed on 4/11/2020

[5] https://safety4sea.com/cm-lng-as-a-marine-fuel-key-considerations/, accessed on 4/11/2020

[6] https://www.marineinsight.com/tech/properties-of-membrane-tanks-for-transportation-of-lng-cargo-on-ships/, accessed on 4/11/2020

[7] https://www.gtt.fr/en/applications/lng-as-a-fuel, accessed on 4/11/2020

[8] https://safety4sea.com/methane-slip-from-lng-fueled-engines/, accessed on 4/11/2020

[9] https://www.cimac.com/cms/upload/workinggroups/WG7/CIMAC_WG7_Guideline_for_Ship_Owners_and_Operators_on_Managing_Distillate_Fuels_May_2013.pdf, Page 5, accessed on 5/11/2020

[10] https://transportemaritimoglobal.files.wordpress.com/2014/01/dnv-gl-alternative-fuel-2014-positionpaper.pdf, Page12,13, accessed on 4/11/2020

[11] https://shipandbunker.com/news/world/643434-blue-insight-sets-out-current-cost-of-alternative-fuels, accessed on 4/11/2020

[12] https://www.breakthroughfuel.com/blog /lng-opportunities-and-challenges-diversifying-shippers-marine-fuel-portfolio/, accessed on 4/11/2020

[13] https://safety4sea.com/lng-bunkering-infrastructure-around-the-world-2/, accessed on 4/11/2020

WIND-AIDED PROPULSION IN THE FORM OF ROTOR SAILS

Vibha Dinesh Sharma[a]
School of Naval Architecture and Ocean Engineering, IMU Visakhapatnam.
vibha8101@gmail.com

Shweta Jodha[b]
School of Naval Architecture and Ocean Engineering, IMU Visakhapatnam.

P. Sirisha[c]
School of Naval Architecture, IMU Visakhapatnam.

ABSTRACT

Ships were indeed one of the greatest applications of mankind's scientific knowledge. As time passed by, their strategic importance grew and today these ships have become lifelines of World trade. Since their invention, water transportation became irreplaceable and countries allotted huge amounts of its available energy resources to keep them functioning. We have used several energy resources to power these mega-machines. It all began with wind sails, but with the advent of fossil fuels, ships began using pollution-emitting oils as its fuel. It was a smooth ride until the world realized that we are running out of oil supplies and the pollution caused due to it in the past decades is taking a toll on the environmental balance. As threat to our planet increased, the quest for cleaner fuels began. Many of the environment friendly options were not really "economy-friendly", so their implementation was avoided. Now ship-makers are going back in time and once again analyzing the possibilities to power the ships using winds. Once such technology that could enable wind-aided propulsion could be of ROTOR SAILS or the FLETTNER SAILS. This paper explains the working principle of rotor sails (the magnus effect), its possible application on the existing as well as new ships and also discusses its contribution in cutting annual Carbon emissions caused by shipping industry.

Keywords

Wind, Renewable, Magnus effect, Rotor, Alternative fuel.

Introduction

Ships are world's most efficient transportation agents today, but are also acting as massive contributors to the air-borne emissions posing threatening implications such as global climate change, ocean warming, sea-level rise and also acidification of the seas. The global community now has to think of a comprehensive solution that helps retain profitability of ships and also strides in the environment-friendly direction. Initializing a change towards avoiding more pollution is to opt for Hybrid applications, or using two or more technologies for power-generation. It can be a combination of a fossil-fuel and an alternative renewable source.[1] One such alternative, a greener solution, which can help in cutting down a ship's carbon emission is of the Rotor sails. The origin of shipping came from wind-assisted propulsion, albeit at lower scale before it was taken over by the fossil fuels, beginning with coal and then oil-based technologies such as Marine Diesel oil

(MDO) or Heavy Fuel Oil (HFO) which are currently exercising their monopoly over the ships. The rotor sail's technology was previously proposed in early 20th century by a German engineer, Anton Flettner. He described it as "Blue-Coal". But it was the time when the shipping industry hadn't gained momentum, fuel prices were extremely low and ship-makers absolutely had no environmental concerns. So, this technology was never taken into consideration. But its need is felt massively in today's time, with oceans carrying 90% of the total transported goods. The effects of its environmental damage are now becoming evident as the Sulphur and soot emitting fuels are giving their major contribution to global threats. The industry now feels obliged to incorporate ways to reduce the pollution.[2]

Magnus Effect

The working of Rotor sails is governed by a scientific phenomenon called the Magnus Effect. It was discovered by a German physicist Heinrich Gustav Magnus. In this effect, whenever a cylindrical/spherical spinning object is bought in contact with relative motion of fluid it produces a sidewise force. Consider a ball spinning amongst the air flow-

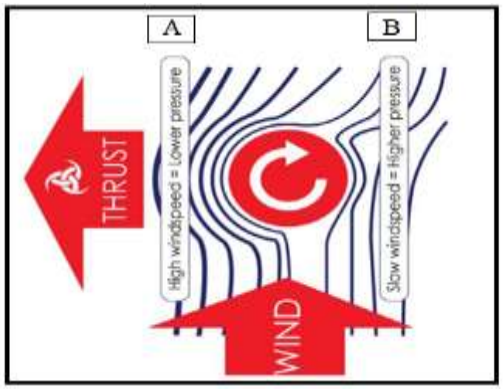


Figure 1: Explaining Magnus Effect.
© Norsepower

If we focus on PART A particularly, this half of the ball is spinning with the direction of wind flow. Thus, velocity of the air flow increases and the pressure in this area decreases. Now if we see PART B, this half of the ball is opposing the motion of airflow. Thus, the velocity of air flow is retarded due to opposition imposed by the ball and pressure in this area increases. It is an extended application of the Bernoulli's principle, where velocity increases when pressure decreases and vice versa. We see that a pressure difference is generated. So, the ball experiences a force from the higher-pressure side (B) to the lower-pressure side (A). Another approach to it suggests that, in PART A, due to the frictional surface of the ball the air is dragged in the downward direction. In PART B, due to the opposition faced by the air, it is not deflected upwards. So, if we consider the net impact on the airflow due to its interaction with the ball it is clear that the airflow experiences a net downward deflection, i.e. the ball exerts a net downward force on the airflow. Now, as per the Newton's Third Law of motion- every action has an equal and opposite reaction.[3] So, in the form of a Reaction force, the airflow exerts an upward force on the ball, which is termed as the Magnus force. In practical scenarios, the net results of this air-ball interaction are-

- A Lift force- "Magnus Force" generated in the direction perpendicular to the wind flow.
- A Drag force- Frictional force opposing the relative motion between ball and the wind, generated in a direction opposite to that of the wind flow.

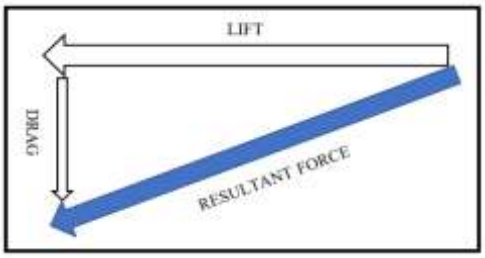
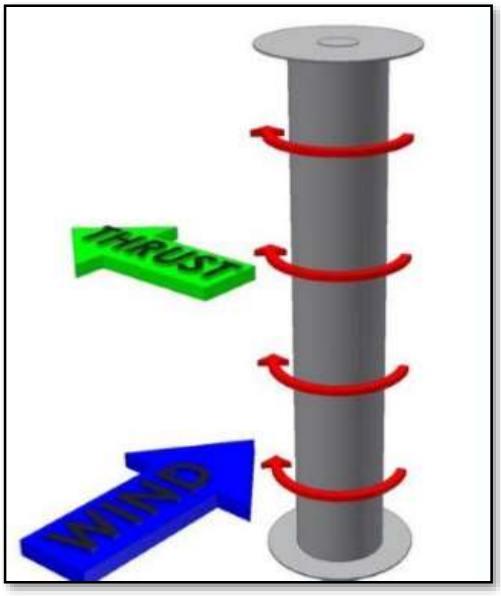


Figure 2: Direction of Resultant Force.

The mathematical computation of lift force is done in the following way-
Lift= ρ A V^2 C_L
Where,
ρ= Density of air
A= Surface area of rotor
V^2 = apparent velocity (vector addition of wind speed and ship's speed
C_L= coefficient of lift.

Working and Installation

The Rotor Sail installed on the ships will also use this principle to harness the wind energy and generate supplemental thrust to propel the ship. It is a relatively simpler technology to extract energy from renewable sources in terms of construction and operation. Rotor Sails are tall cylinders (range of 18-30m) with an approximate diameter of 5m rotating continuously at an expense of low voltage electrical power supply given to each sail Height of the sail is generally taken from the weather deck to the tallest mast of the ship to avoid any increment in the air draft. It is constituted by a cylindrical-shape, it implies we don't have to adjust the angle of attack, or the stall angle every time the wind changes its direction even slightly to maximize the output.[4] The sails have a disc fitted on the top which serves dual purpose. First one being, maintaining the pressure difference generated by the wind flow. Secondly, it is known that a part of induced drag is due to formation of permanent tip vortex, a similar phenomenon which occurs in the wings of an air-craft. This drag is reduced by a higher aspect ratio (ratio of length of disc to its chord) wings or tip fins. This was the reason Flettner installed discs over the sails.



©Norsepower
Figure 3: Working of a Rotor Sail.

Number of sails required by a vessel depends on various factors, like speed and size of the ship, its working conditions, etc. In favorable wind conditions, it will generate a forward thrust and allow the main engine to throttle back, resulting in lesser consumption of fuel. Some technological advances have been made in this simple technology. Now the Rotor sails are also equipped with an automatic control system. The sails can be operated from the bridge and the crew just has to initiate the power supply. It will sense when the wind speed is sufficient to produce fuel savings and the sails will automatically begin their operation. No extra crew or attention is required. It is a technology that can be constructed in new ships, but can also be retrofitted in existing ships which satisfy certain criteria. Its installation is possible on the vessels having free-deck space. The deck shouldn't have any considerably large superstructure which will obstruct the air-flow through the sail. The deck should also have a strong mounting point on which the large cylinders can be mounted. The mounting sites require a careful analysis to make sure that the sail placed in that location will

generate thrust in such a way that the force will be transferred to the ship structure without disturbing its other operations. First option for suitable mounting sites is usually deck reinforcements for cranes or capstan. It is made sure that the rotors are definitely not mounted directly above the bulkheads which can cause extra stiffening. It can be proven efficient for tankers, Ro-Ro vessels, Gen. Cargo, Bulk carriers as well as cruises and ferries. It is indeed an old technology, but it has been improved with some fundamental changes. The rotor cylinder is constructed using modern materials like Carbon and Glass Fibers that cut the weight by a factor of 3, making it light-weight and more efficient. The two most commonly used materials are GFRC and CFRP. GFRC or Glass Fiber Reinforced Concrete is an amalgamation of Portland cement, aggregates, acrylic, copolymer and Glass fiber reinforcement. Appreciated qualities of GFRC include high tensile strength compared to any concrete counterpart, lightweight, durability and ease of molding it in desired shapes.[5] The other one is Carbon Fiber Reinforced Polymer Composites, CFRP. It contains carbon fibers for strength and a binding polymer like Epoxy to keep the fiber together, maintaining its light weight nature. In most sails, CFRP is sandwiched between GFRC to get a light and strong structure. For the technology to benefit the propulsion, it should encounter favorable wind conditions.

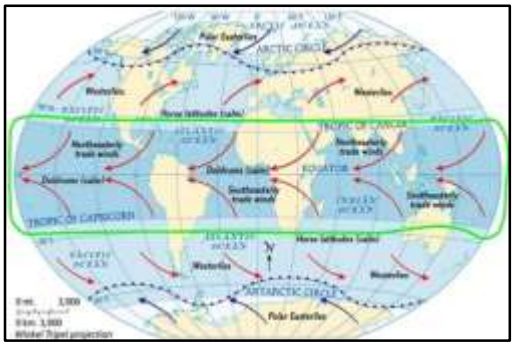


Figure 4: Wind Zones of the Globe.

The wind should be flowing at least with a speed of 18 km/hr. (approximately 10 knots) and it should be flowing across the bow at an angle of at least 20^0.

Figure 5: Most Frequent Shipping Routes.

Ships are likely to encounter such wind conditions in the north Pacific and northern Atlantic shipping routes. So, if we judiciously coordinate with the wind cycle of the nature, we can harness the benefits of wind energy. In a storm-like scenario, where the wind speed causes excess heeling of the ship in the transverse direction, the presence of rotor sail can prove to be beneficial to counter the heeling force caused by the wind. As the wind speed increases, the drag force which is produced on the rotor surface also increases proportionally which acts in the direction opposite to the direction of the wind flow and hence reducing the net transverse force which is responsible for excess heeling. So, the ship+rotor system can be termed as a virtually "storm-proof" system.[6]

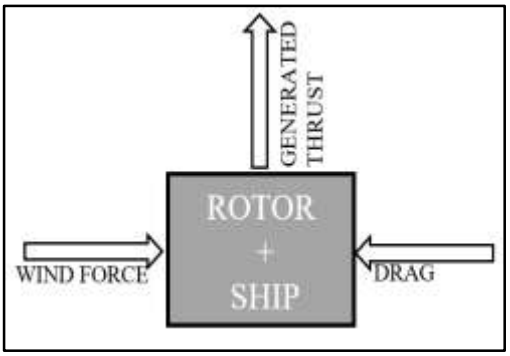


Figure 6: Ship-Rotor System.

Testing the Technology

A Finnish company, registered in the name of NORSEPOWER, is now heading on to industrialize Rotor sails. To further verify its capabilities, it installed Rotor Sails on 3 commercial vessels of different types which includes-

1. Bore's Estraden (It was fitted with one more rotor sail) a 9700 dwt Ro-Ro carrier.
2. Viking Line Viking Grace, an LNG fueled cruise ferry.
3. Maersk Pelican, a 109,647 dwt Product Tanker.

The most interesting collaboration is the Norsepower- Maersk for the tanker Pelican. The tanker was fitted with the largest Rotor sail ever made, 30m tall and 5m in diameter, and was installed on the port of Rotterdam. It aimed cutting down fuel consumption by 10%. The tanker's performance was analyzed between a 12-month period, from September 2018 to September 2019. To generate an impartial data about its efficiency, a team from the Lloyd's Register (LR) is been appointed to scrutinize its performance aspects. The vessel delivered expected results, saving 8.2% of overall fuel consumption under normal wind conditions. Estimations show that this has avoided emission of 1400 tons of Carbon Dioxide. The Rotor sail added one more feather in its cap in February 2019 when it received first-ever type approval design certificate granted to an auxiliary wind propulsion system onboard a commercial ship by the classification society DNV GL after it assessed rotor sails functioning on Pelican. This signifies that any ship having Rotor sails is technically capable of safely navigating all operational and environmental situations.

Conclusions

Today shipping finds itself in turmoil while balancing between maintenance of its economic efficiency and the share of pollution that it has been creating. The job in hand is to bring up solutions which will maintain the "low-cost" identity of shipping and also reduce the environmental torture caused by maritime industry. Rotor sails can be a technology contributing towards cutting down fuel consumption by a fraction. All it is going to require is the willingness of this community to give environmental protection priority status.

References

[1]Technology presentation: Norsepower Rotor Sail Solution Project presentation: Flettner project.

[2] The magnus effect and Flettner rotor; potential application for future oceanic shipping by Peter Nuttall and John Kaltu.

[3] International Council of Clean transportation- GHS Emission from International Shipping report of 2103-2015.

[4] International Council of Clean transportation- working paper by Bryan Comer- Rotors and Bubbles

[5] Use of Flettner Rotor in Efficient ship Design by D R Pearson

[6] Studies Of Glass Fiber Reinforced Concrete Composites By Komal Chawla And Bharti Tekwani.

[7] https://gcaptain.com/ norsepower-rotor-sails-issued-design-type-approval/

[8] https:/ /theconversation.com / spinning -sail-technology-is-poised-to-bring-back-wind-powered-ships-74872

[9] http://www.ces.fau.edu/nasa/ content /resources/global-wind-patterns.php

[10] https://worldmaritimenews.com / archives/285275/norsepower-rotor-sails-achieve-8-2-of-fuel-savings-on-maersk-pelican/

[11] https://www.seatrademaritime.com / news/europe/big-oil-firms-back-norsepowers-rotor-sail-solution-for-ships/

[12] https://mobile.worldmaritimenews .com/archives/259777/rotor-sails-fitted-on-board-maersks-tanker-in-a-worlds-1st/

[13] https://www.sciencemag.org/news /2017/09/spinning-metal-sails-could-slash-fuel-consumption-emissions-cargo-ships

[14] https://www.forbes.com/sites/ oliversmith/2018/03/12/norsepower-why-european-ships-are-switching-back-to-sails/#49df5ec926a0

[15] https://maersktankers.com/media/ testing-begins-on-first-product-tanker-vessel-utilising-wind-propulsion-technology

[16] https://en.wikipedia.org/wiki/ Carbon_fiber_reinforced_polymer

WASTE HEAT RECOVERY TECHNOLOGIES IN DIESEL ENGINES FOR ENERGY CONSERVATION

Prof. Jigar Trivedi
CME, Pune
jigar38@gmail.com

ABSTRACT

Waste heat is the energy that is generated in various engineering processes which is not put into any practical use and is lost, wasted and dumped into the environment, which is an infinite sink. Recovering the waste heat can be conducted through various waste heat recovery technologies to provide valuable energy sources and reduce the overall energy consumption. In this review paper, a wide-ranging evaluation is made of waste heat recovery technologies in engines, in general and for exhaust waste heat recovery processes, in particular. By considering inputs from various review papers in the domain of waste heat recovery, a revision of the current practices and procedures is evaluated. The review is conducted on the operation and performance of the commonly used technologies in exhaust gas waste heat recovery. Though most of the topics covered in this review paper are available in open domain, in order to maintain the uniqueness, the latest trends and researches in the spectrum of waste heat recovery has also been discussed in this paper.

Keywords

Heat, Diesel Engine, Energy, Technology, Turbo Charging

Introduction

Currently, diesel engines are widely used due to their abilities and advantages in residential, commercial and industrial domain for producing energy, electricity, transportation, etc., but a large amount of their fuel energy is wasted through the exhaust. Researchers confirm that more than 30–40% of fuel energy gets wasted from the exhaust and just 12–25% of the fuel energy converts to useful work [1,2]. On the other hand, statistics show that the production of a large number of internal combustion engines increases the presence of harmful greenhouse gases (GHG) which is a cause of concern. So, researchers are motivated to recover the heat from the waste sources in engines by using applicable ways. Heat recovery not only reduces the demand of fossil fuels, but also reduces the GHG and helps to save energy. Rakopoulos [3] mentioned that one of the main aims of the second law of thermodynamic, in engines, is identifying the source of destruction and suggesting ways to convert these destructions to useful work or to use them. Exhaust of the engines is one such source from which a large amount of energy gets wasted through it. This energy can be recovered by using the heat exchanger in exhaust and this recovered heat can be then used in the cycles such as Organic Rankine Cycle (ORC), combined heating and power (CHP), combined cooling, heating and power (CCHP), etc. M. Hatami et al. [4] carried out an exhaustive review of

different heat exchangers designs for increasing the diesel exhaust waste heat recovery. In all these applications, requirement of a heat exchanger is necessary to transmit the heat from hot gases to working fluid at excellent efficiency. The current paper aims to introduce the ways to recover heat from engines. The experimental set up for testing and evaluation of one such waste heat recovery system has also being undertaken as a project.

Waste Heat Recovery Technologies In Engines

A review of the technologies for heat transfer from engines is presented in this section. In the current status of the world, the requirement of energy is increasing, especially for transportation applications, so the usage of fossil fuels and consequently harmful greenhouse gases (GHG) will also increase. Researchers have attempted to reduce the need of fossils fuels by using the waste heat recovery from engines. As of now, six technologies are presented for engines waste heat recovery of which Saidur et al. [5] have performed a complete review of four of them. These six technologies are thermoelectric generators (TEG), Organic Rankine Cycle (ORC), six stroke engines, turbocharging, exhaust gas recirculation (EGR) and exhaust heat exchangers (EHXs). A brief introduction to each of them is given below.

Thermoelectric Generators

Thermoelectric generators (TEG) or Seebeck generators are devices which directly convert waste heat energy into electrical energy. These devices work on Seebeck effect which was discovered by Thomas Johann Seebeck in 1821 [6]. Recently, for increasing the efficiency of these devices, semiconductor p–n junctions were added (Fig. 1) that are made up of new materials such as BiTe (bismuth telluride), CeFeSb (skutterudite), ZnBe (zinc–beryllium), SiGe (silicon–germanium), SnTe (tin telluride) and new nano-crystalline or nano-wire thermoelectric which increase their efficiency to around 5–8% [5].

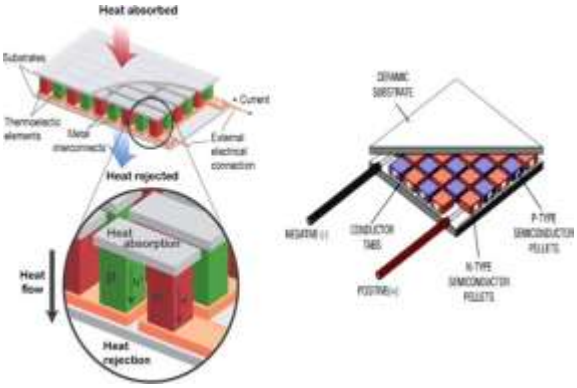


Figure 1: Schematic view of p-n junctions in TEG devices

Although TEG devices have many advantages such as clean energy, without sound, without movable component and lesser maintenance costs, they are however only economical when used at high temperatures (4200°C) and when only small amounts of the power (a few milliwatts) are needed. TEG's advantages motivated many of the researchers to use it in automobile waste heat recoveries which can be seen in [5]. For instance, Karri et al. [7] studied two cases of exhaust waste heat recovery using TEGs. Also, Zhang and Chau [8] reported that using TEG has low effect on engine performance and it can improve the engine power up to 17.9%.

Organic Rankine Cycle

A number of thermodynamic cycles such as Kalina, trilateral flash, Goswami and Rankine are presented in the literature for exhaust waste heat recovery from engines [5]. Among these cycles, Organic Rankine Cycle (ORC) can be introduced as the most efficient cycle for low temperature sources such as engine exhaust. A schematic of the ORC is shown in Fig. 2 which contains boiler, expander, condenser, pump and working fluid [9]. Many works are performed in this field and complete reviews of them are presented by Sprouse et al. [10], Chen et al. [11] and Wang et al. [12]. Most of these works are based on the effect of working fluid type on the ORC performance.

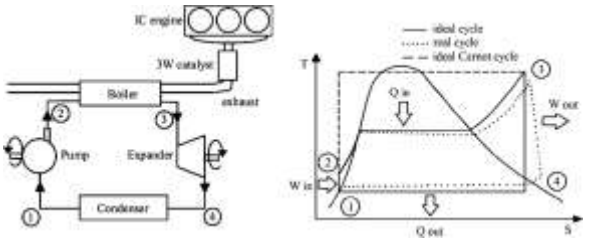


Figure 2: Schematic of Organic Rankine Cycle (ORC)

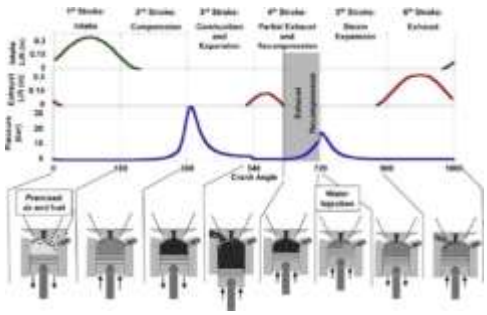


Figure 3: Six stroke engine operation

Six Stroke Engines

The six-stroke engine is a type of internal combustion engine based on the four-stroke engine but with additional complexity intended to make it more efficient and reduce emissions. Three types of six-stroke engines have been developed since the 1890s [5], but in one of them proposed by Conklin and Szybist [13], the engine captures the heat lost from the four-stroke diesel engine and uses it to generate an additional power without more fuel consumption. A schematic of the operation of this engine is shown in Fig. 3. As seen, there are two power strokes: one with fuel, the other with water injection by using the waste heat of burned gases in the previous stroke. Water injection is occurred after compressing the burned gases from first stroke when the crank shaft angle is 720°.

Turbo charging

The first idea of turbochargers was proposed by Dr. Alferd J. Buchi in 1915 which he developed it on a diesel engine [5]. Actually, a turbocharger is a supercharger driven with exhaust gases energy and increases the engine power by compressing the inlet air to engine. Fig. 4 shows a turbocharger with its appurtenances. A turbocharged engine is more powerful and efficient than a naturally aspirated engine because the turbine forces more air and proportionately more fuel into the combustion chamber than atmospheric pressure alone, but it has some shortcomings.

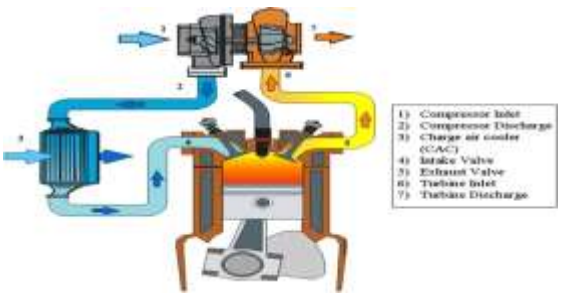


Figure 4: Schematic view of turbo-charging

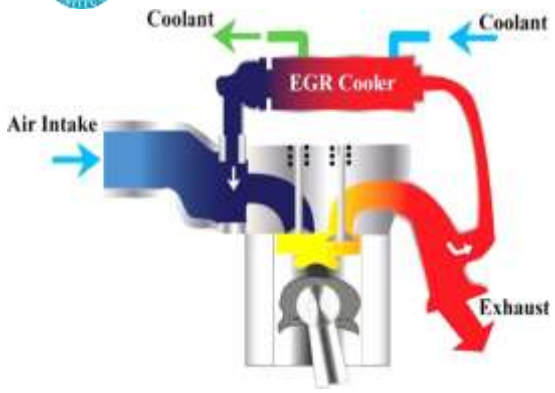


Figure 5 : EGR principle

A novel exhaust steam recovery called steam turbocharging is presented by Fu et al. [14]. They set a Rankine steam cycle system coupled on engine exhaust pipe which utilizes the exhaust energy of engine in order to generate steam and then drive the turbine. Their results show that IC engine power can theoretically be improved by 7.2% at most and thermal efficiencies can be raised up to 2 % or more.

Exhaust Gas Recirculation

Recirculation of the exhaust gases into cylinder or EGR is one of the efficient methods to decrease the NOx level. EGR can be applied internally or externally in the engines. EGR is widely used in both gasoline and diesel engines reviewed by Wei et al. [15] and Zheng et al. [16], respectively. In a diesel engine, the exhaust gas replaces some of the excess oxygen in the pre-combustion mixture. Since NOx is formed primarily when a mixture of nitrogen and oxygen is injected into high temperature circumstances, the lower temperatures of combustion chamber caused by EGR reduce the amount of the NOx. Furthermore in modern diesel engines, the EGR gases are cooled with a heat exchanger in order to enter a greater mass of recirculated gases (Fig. 5).

Engine Heat Exchangers (Hxs)

One of the most common ways to recover heat from engines is using the heat exchangers. Although heat exchangers are used in ORC cycles, they can separately be used for obtaining the heat from the exhaust for other applications such as hot water for domestic uses or utilizing as injection in cylinder, turbocharger, EGR, etc. Due to the high applications of heat exchangers, researchers have tried to improve heat transfer through special design of heat exchangers.

HXs in Cylinder

Cylinder is the highest temperature source for heat recovery in engines. Although cylinders were commonly cooled by radiators, but Ghazikhani et al. [17] considered a separate circuit for cylinder cooling to reduce the brake specific fuel consumption (BSFC) in a two stroke SI engine. They reported the effect of engine speed and torque on exergy balance and irreversibility. Their outcomes reveal that when torque or speed increases, the pressure and temperature in the cylinder will rise and makes an increase in exhaust gas availability and as a result the internal irreversibility decreases. So, more exergy will be recovered in higher load and speeds.

HXs in Radiator

Another main application of HXs in engines is radiators constructed of a pair of header tanks, linked by a core with many narrow passageways, giving a high surface area relative to volume. Engines are often cooled by circulating a liquid called engine coolant through the engine block. Engine coolant is usually water- based, but may

also be oil or nanofluid for increasing the heat transfer rate.

HXs in Exhaust

Some researchers attempt to enhance the rate of heat transfer by a special design of HXs in the exhaust of diesel engines due to their high applications. Zadsar and Gorji-Bandpy [18] used a twisted tape in the exhaust of an OM314 diesel engine in order to increase the recovered heat and their usage in a refrigeration cycle experimentally. Pandiyarajan et al. [19] designed a finned-tube heat exchanger as shown in Fig. 6. They used a thermal energy storage using cylindrical phase change material (PCM) capsules and found that nearly 10–15% of fuel power is stored as heat in the combined storage system in different loads as seen in Fig. 7.

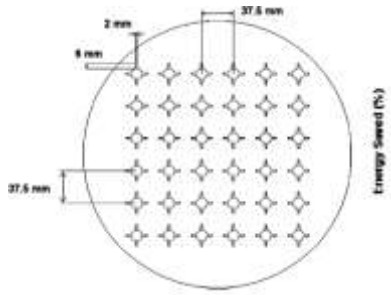


Figure 6: Heat exchanger designed by [19]

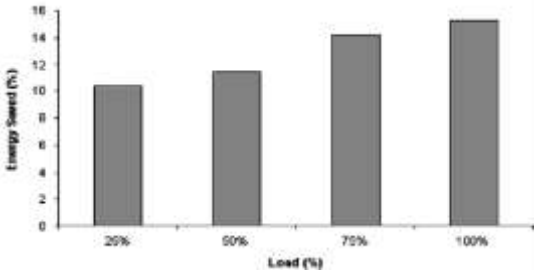


Figure 7: Heat recovery rate

Furthermore, Lee and Bae [20] made a small heat exchanger with fins in the exhaust by design of experiment (DOE) technique. They reported that fins should be in the exhaust gases passage for more heat transfer (Fig. 8) and designed 18 cases with different fin numbers and thicknesses and found the most effective cases as shown in Fig. 8. Zhang et al. [21] modeled a finned tube evaporator heat exchanger for an ORC cycle as shown in Fig. 9. They concluded that waste heat recovery efficiency is between 60% and 70% for most of the engine's operating region and also they mentioned that heat transfer area for a finned tube evaporator should be selected carefully based on the engine's most typical operating region.

Ghazikhani et al. [22] used a simple double pipe heat exchanger in a diesel engine and performed an exergy analysis for finding the relation between irreversibility and exhaust sound level. Recently, they [23] estimated an experimental work that BSFC could be improved approximately up to 12% in different loads and speeds of an OM314 diesel engine by utilizing the recovered exergy from a simple double pipe heat exchanger in exhaust (Fig. 10). Also, they showed that exergy recovery will be enhanced by increasing the engine loads and speeds especially in high speeds.

The thermoelectric modules for heat recovery need two heat sources, cold and hot. So, HXs can be a suitable device for providing these sources which can simultaneously produce electricity and hot water. Weng and Huang [24] designed a heat exchanger with radial fins and TEG device as illustrated in Fig. 11 and studied

the effect of HX length and TEG number on heat recovery. Lu et al. [25] designed a heat exchanger on exhaust automobile as

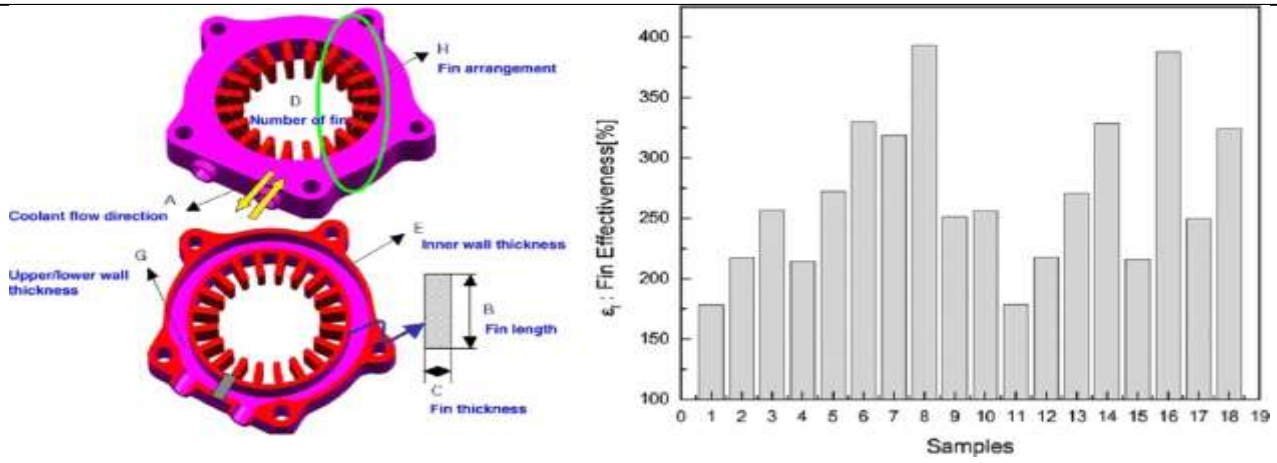


Figure 8: Heat exchanger designed in Ref [20]

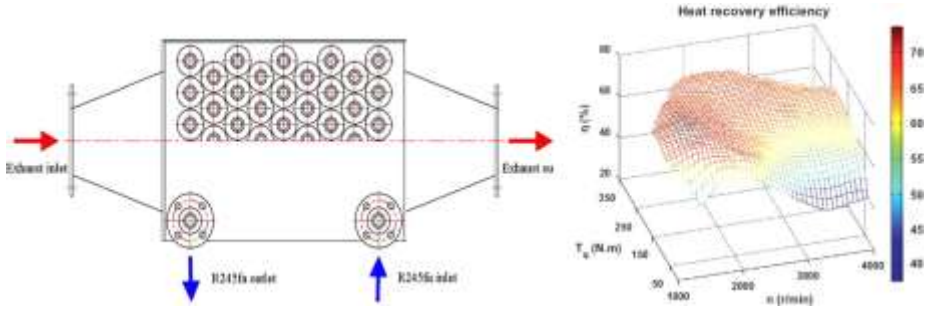


Figure 9: Finned tube heat exchanger designed by Zhang et al. [21] for ORC application

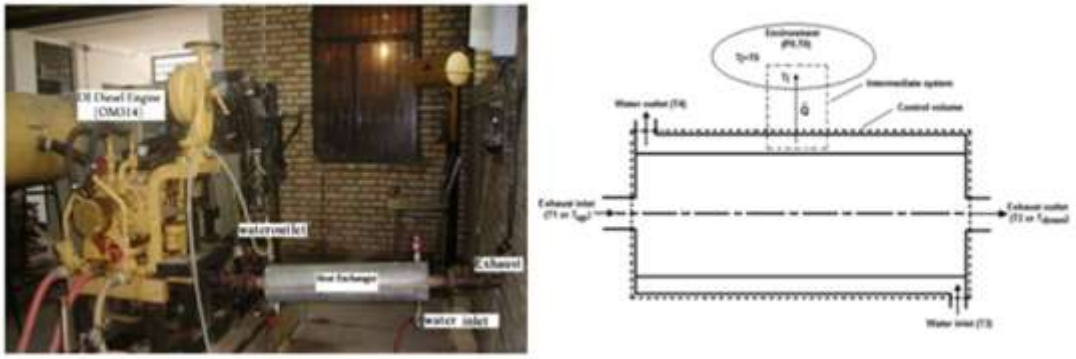


Figure 10: Double pipe heat Exchanger used in Ref. [23]

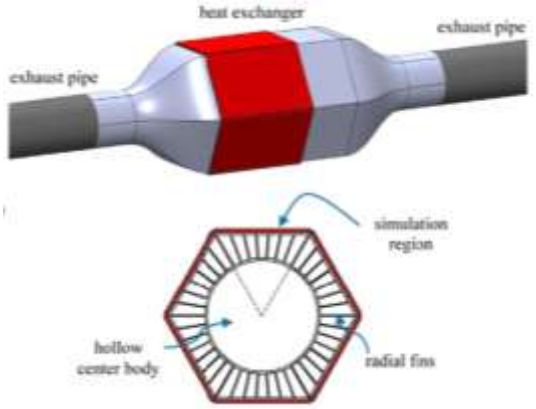


Figure 11: HX designed with thermoelectric and radial fins [24]

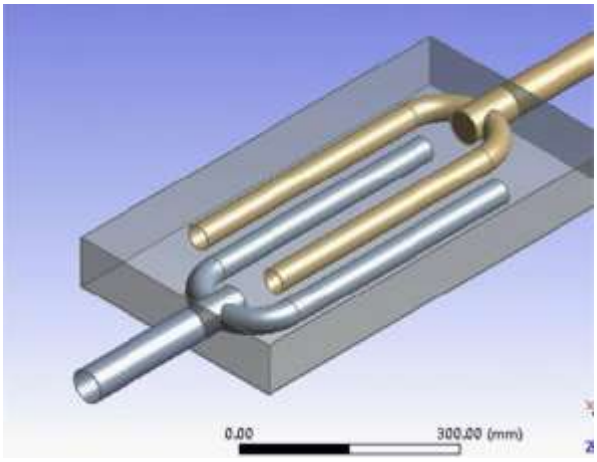


Figure 12: TEG heat exchanger designed by Lu et al.[25]

Fig. 12 in different outlet and inlet pipe numbers. Furthermore, Yang et al. [26] invent a heat pipe for cooling the exhaust of a large bus and modeled it numerically and finally obtained a good agreement between numerical and experimental outcomes. Wang et al. [27] suggested a heat exchanger as shown in Fig. 13, it seems that this kind of HX has high back pressure, but in their study the total fuel saving of the engine reached up to 34% under some of the operating conditions. Recently, Hossain and Bari [28,29] applied a new HX for a diesel engine presented in Fig. 14 experimentally and numerically. After that they optimized the working fluid pressure and the orientation of heat exchangers and found the additional power increased from 16% to 23.7%. Also, they investigated the parallel and series configurations of HXs and as a result obtained additional power are shown in Fig. 14. Mavridou et al. [30] examined two groups of configurations: (a) a classical shell with a tube heat exchanger using staggered cross-flow and (b) a cross-flow plate heat exchanger which is initially placed with finned surfaces on the exhaust gas and then is covered with metal foam instead of the fins. They attempt to minimize the volume and weight of the arrangement and simultaneously keep the heat transfer from the gas side at a maximum range. Kauranen et al. [31] used phase change materials (PCM) and latent heat accumulator (LHA) for diesel exhaust waste heat recovery which help to decrease the fuel consumption and also its emission reduction. In a different study, Baker et al. [32] designed a multi pass duct shape heat exchanger (Fig. 15) for a diesel engine by numerical finite difference method (FDM) and examined the effects of TEG, porous structure and fins for the amount of heat recovery. Then, they found that 1.06 kW is the maximum net electrical power which can be achieved for the three parallel flow paths in a counter-flow arrangement. A

Figure 13: Exhaust HX used in Love et al. [27]

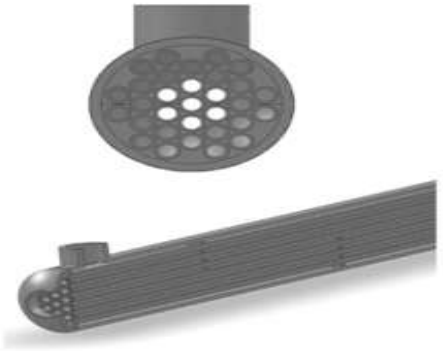


Figure 14: HX used by Hossain and Bari [28]

So, Deng et al. [33] designed two thermoelectric HXs models by CFD simulation and used Wilcox k-ω model to discuss on different internal structures, lengths and materials on the HX performance.

The same study has been performed by Kumar et al. [34] which modeled three HXs (rectangular, triangular and hexagonal) by CFD FLUENT software and experimentally produced and tested the best model.

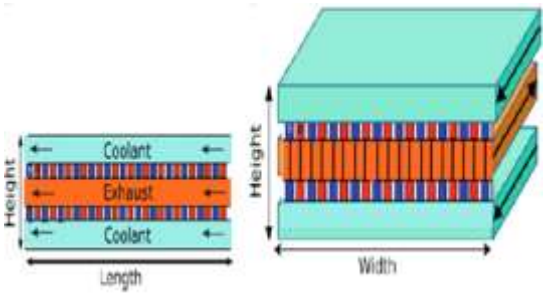


Figure 15: Duct shaped HX designed by Baker et al. [32] for studying TEG

Latest Trend

Two of the recent researches in the field of waste heat recovery are given below. These researches will be forerunner for efficient conversion of the waste heat into more useful form of energy.

Generator to convert waste heat into clean electricity

University of Texas at Dallas researchers have developed a generator prototype in Oct 2019 that uses liquid metal to convert waste heat from sources such as electric cars or data-centres into clean electricity. Data centres, electric car batteries and appliances such as air conditioners generate a largely untapped potential energy source. This project zeroes in on sources that generate lower temperature heat, between 80 and 115°F, which have been more challenging to convert to electricity. The researchers started with a magneto-hydrodynamic power (MHD) generator, a device that generates electricity by moving fluid through a magnetic field. The technology has many potential applications. The technology also could improve the efficiency of electric vehicles by converting heat from the car batteries and exhaust into electricity.

Photo 1: Researchers at University of Texas, Dallas

Latest Trend: Aqua ammonia based thermally activated combined power and cooling system

According to research published in Sep 2019 in Progress in Industrial Ecology, An International Journal, it should be possible

to generate electricity and refrigerate simultaneously using low-grade waste heat from industry. The key is a system based on an ammonia-water mixture. Mechanical engineer Kolar Deepak of Vardhaman College of Engineering, in Hyderabad, India, has proposed a system that exploits thermodynamic phenomena encapsulated in the Kalina cycle to generate power and cool a system at the same time using evaporation and condensation of an ammonia-water working fluid.

The system does mechanical work, which can drive a dynamo type device to generate electricity, while the refrigeration effect is produced by the working fluid from the turbine exit. A thermal efficiency of almost 20% at an operating temperature of 135°C was achieved which is the sort of temperature for "waste" heat streams from industrial plants and gas turbine exhaust, as well as municipal incinerators, or renewable energy sources, including geothermal brine.

Conclusions

In this paper, a brief review of heat recovery technologies in engines and heat exchangers has been presented. It seems that in most of these technologies (ORC, TEG, EGR, HXs and turbo- charging), heat exchangers have an important role to transfer heat should be applied in accordance with this fact that heat transfer increases when pressure drop is in the allowable limit. Rising focus of the regulatory regime toward sustainable development and long-term benefits of decarbonisation, have significantly boosted the demand for waste heat recovery systems. On-going initiatives toward reducing carbon dioxide emissions along with favourable government policies toward adoption of energy efficient systems and solutions will further enhance the industry growth. Global Waste Heat Recovery System Market is expected to surpass USD 80 Billion by 2025, as reported in the latest study by Global Market Insights, Inc. Shifting focus toward emission control coupled with stringent government regulations will stimulate the adoption heat recovery systems. Technology advancement, greater operational flexibility and subsequent cost reduction are few prominent features that will significantly contribute toward expansion of global waste heat recovery market size.

References

[1] Saidur R Rahim NA, Ping HW JahirulMI, Mekhilef S Masjuki HH. Energy and emission analysis for industrial motors in Malaysia. Energy Policy 2009;37 (9):3650–8.

[2] Hasanuzzaman M Rahim NA, Saidur R Kazi SN. Energy savings and emissions reductions for rewinding and replacement of industrial motor. Energy 2011; 36 (1) :233–40.

[3] Rakopoulos CD, Giakoumis EG. Second law analyses applied to internal combustion engines operation. Prog Energy Combust Sci 2006; 32:2–47.

[4] M. Hatami, D.D. Ganji, M. Gorji-Bandpy, A review of different heat exchangers designs for increasing the diesel exhaust waste heat recovery, Renewable and Sustainable Energy Reviews 37 (2014)

[5] Saidur R, Rezaei M, Muzammil WK, Hassan MH, Paria S, Hasanuzzaman M.

Technologies to recover exhaust heat from internal combustion engines. Renew Sustain Energy Rev 2012;16:5649–59.

[6] Riffat SB, Ma X. Thermoelectrics: a review of present and potential applications. Appl Thermal Eng 2003;23(8):913–35.

[7] Karri MA, Thacher EF, Helenbrook BT. Exhaust energy conversion by thermo-electric generator: two case studies. Energy Convers Manage 2011; 52(3): 1596–611.

[8] Zhang X, Chau KT. An automobile thermoelectric–photovoltaic hybrid energy system using maximum power point tracking. Energy Convers Manage 2011; 52(1):641–7.

[9] Duparchy A Leduc P, Bourhis G Ternel C. Heat recovery for next generation of hybrid vehicles: simulation and design of a Rankine cycle system.

[10] SprouseIII C, Depcik C. Review of Organic Rankine Cycles for internal combustion engine exhaust waste heat recovery. Appl Thermal Eng 2013; 51: 711–22.

[11] Chen H, Goswami DY, Stefanakos EK. A review of thermodynamic cycle and working fluids for the conversion of low-grade heat. Renew Sustain Energy Rev 2010;14:3059–67.

[12] Wang Tianyou, Zhang Yajun, Peng Zhijun, Shu Gequn. A review of researches on thermal exhaust heat recovery with Rankine cycle. Renew Sustain Energy Rev 2011;15:2862–71.

[13] Conklin JC, Szybist JP. A highly efficient six stroke internal combustion engine cycle with water injection for in-cylinder exhaust heat recovery. Energy 2010;35:1658–64.

[14] Fu J, Liu J, Yang Y, Ren C, Zhu G. A new approach for exhaust energy recovery of internal combustion engine: Steam turbocharging. Appl Thermal Eng 2013;52:150–9.

[15] Wei H, Zhu T, Shu G, Tan L, Wang Y. Gasoline engine exhaust gas recirculation - a review. Appl Energy 2012;99:534–44.

[16] Zheng M, Reader G T, Hawley JG. Diesel engine exhaust gas recirculation—a review on advanced and novel concepts. Energy Convers Manage 2004;45: 883–900.

[17] Ghazikhani M, Hatami M, Safari B. Effect of speed and load on exergy recovery in a water-cooled two stroke gasoline–ethanol engine for the BSFC reduction purposes. Sci Iran 2014;21(1):171–80.

[18] M.Zadsar, M.Gorji-Bandpy, An investigation of engine exhaust gases as an energy source with the exergy analysis. In: Proceedings of ISTP-22 conference, Aula Contre, Delft, The Netherlands, 2011.

[19] Pandiyarajan V, Chinna Pandian M, Malan E, Velraj R, Seeniraj RV. Experimental investigation on heat recovery from diesel engine exhaust using finned shell and tube heat exchanger and thermal storage system. Appl Energy 2011;88:77–87.

[20] Lee S, Bae C. Design of a heat exchanger to reduce the exhaust temperature in a spark-ignition engine. Int J Thermal Sci 2008;47:468–78.

[21] Zhang HG, Wang EH, Fan BY. Heat transfer analysis of a finned tube evaporator for engine exhaust heat recovery. Energy Convers Manage 2013;65:438–47.

[22] Ghazikhani M, Hatami M, Shahi Gh, Behravan A. Exergy analysis and experimental investigation on exhaust sound level in a DI diesel engine.In: Proceedings of the 7th international conference of internal combustion engine, Olympic International Hotel, Tehran, Iran, 2011.

[23] Ghazikhani M, Hatami M, Ganji DD, Gorji-Bandpy M. Gh.Shahi, A.Behravan, Exergy recovery from the exhaust cooling in a DI diesel engine for BSFC reduction purposes. Energy 2014;65:44–51.

[24] Weng CC, Huang MJ. A simulation study of automotive waste heat recovery using a thermoelectric power generator. Int J Thermal Sci 2013; 71:302–9.

[25] Lu H, Wu T, Bai S, Xu K, Huang Y, Gao W, Yin X, Chen L. Experiment on thermal uniformity and pressure drop of exhaust heat exchanger for automotive thermoelectric generator. Energy 2013; 54:372–7.

[26] Yang F, Yuan X, Lin G. Waste heat recovery using heat pipe heat exchanger for heating automobile using exhaust gas. Appl Thermal Eng 2003;23:367–72.

[27] Tianyou Wang Yajun Zhang, Zhang Jie, Shu Gequn, Peng Zhijun. Analysis of recoverable exhaust energy from a light-duty gasoline engine. Appl Thermal Eng 2013;53:414–9.

[28] Nisar Hossain Shekh, Bari Saiful. Waste heat recovery from the exhaust of a diesel generator using Rankine cycle. Energy Convers Manage75 2013:141–51.

[29] Saiful Bari Shekh Nisar Hossain. Waste heat recovery from a diesel engine using shell and tube heat exchanger. Appl Thermal Eng 2013; 61:355–63.

[30] Mavridou S, Mavropoulos GC, Bouris D, Hountalas DT, Bergeles G. Comparative design study of a diesel exhaust gas heat exchanger for truck applications with conventional and state of the art heat transfer enhancements. Appl Thermal Eng 2010; 30:935–47.

[31] Kauranen Pertti, Elonen Tuomo, Wikstrm Lisa, Heikkinen Jorma, Laurikko Juhani. Temperature optimization of a diesel engine using exhaust gas heat recovery and thermal energy storage (diesel engine with thermal energy storage). Appl Thermal Eng 2010;30:631–8.

[32] Baker Chad, Vuppuluri Prem, Shi Li, Hall Matthew. Model of heat exchangers for waste heat recovery from diesel engine exhaust for thermoelectric power generation. JElectron Mater 2012;41:6.

[33] Deng YD, Liu X, Chen S, Tong NQ. Thermal optimization of the heat exchanger in an automotive exhaust-based thermoelectric generator. J Electron Mater 2013;42:7.

[34] Ramesh Kumar C, Ankit Sonthalia Rahul Goel. Experimental study on waste heat recovery from an internal combustion engine using thermoelectric technology. Thermal Sci 2011;15(4):1011–22.

APPLICATION OF DRONES IN MARITIME INDUSTRY (FIRE FIGHTING)

Anmol Gupta
Tolani Maritime Institute.
anmoltg8@gmail.com

Ansh Bhatnagar
Tolani Maritime Institute.
kritagyaansh@gmail.com

Ansh Mehta
Tolani Maritime Institute.
anshmehta600@gmail.com

ABSTRACT

Fire is a major hazard to life, be it at-sea or ashore. In order to tackle the fire induced situations and ensure the safety of the crew on-board as well as on-shore, the following propositions are encompassed in this paper:

Dynamic Firefighting Drone (Octocopter): A drone used for autonomous firefighting applications on Manned and Unmanned Ships, and even on ports, using Artificial Intelligence System (AIS) and IoT (Internet of Things). The fire is tackled by automatically releasing DCP (Dry Chemical Powder) or by the Wave Extinguisher System (consisting of Sonic waves), in accordance to the situation presented and in conjunction with the AIS. On that account, it can autonomously fight or limit the fire, till a crew member arrives at the sight. Furthermore, it works as a guidance mechanism for seafarers in close vicinity of the fire or at risk in general and allows them to follow the drone to the nearest safe exit, avoiding obstacles on the selected path. Artificial Intelligence System: The entire set up utilizes Artificial Intelligence in the Octocopter and furthers the development through Neural Network Learning. Smart Rescue Equipment: The equipment works in tandem with the Drone and AIS. Vitality Band is the proposed arm band with a vitals sensor, a fall sensor and a positioning sensor, used in order to send immediate help to crew

members using IoT.Clothing/Shoe Transponder is also proposed, which is a transponder attached in clothing or shoes which can be used to send automated distress signals to rest of the crew for immediate help.

Keywords

Drones, Artificial Intelligence, Fire Fighting Technology, Internet of Technology, Automated Firefighting Equipment, Smart Rescue Equipment, Neural Net

Introduction

Fire has always been an unwelcome visitor onboard ship. Despite the ever-increasing norms and precautions on fire-related accidents, the accidents do occur and are responsible for the loss of billions of dollars' worth of cargo and many lives at sea[2]. Since the process of fighting the fire onboard ship is manual, the response time as well the probability of the fire to acquire a dangerous intensity is increased. Therefore to be better equipped to fight a fire, Artificial Intelligence can be used in tandem with the Internet of Things to make the process automated. In the event of a fire, the AI will be the first one to detect it and take necessary action, thus decreasing the role and the subsequent damage to a human during fire-fighting.

Drones

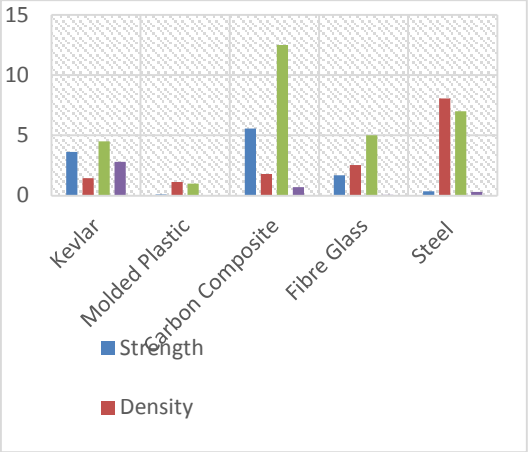


Figure 1: Comparison of Materials for the body of the Drone (Source: MDPI Journal)

A drone is an aircraft of the unman

ned variety and is made of light composite materials to reduce the operational weight and increase maneuverability. The said drones are equipped with different state of the art technology such as infra-red sensors, Self-Learning Artificial Intelligence, 3-D Mapping Technology and location transponders to accommodate for dynamic rolling and pitching[1]. The drones only work when automatic alarms are activated and are otherwise placed on charging stations and hencecause negligible distraction to the crew. Due to flight accessibility the drone works anywhere in the engine room including staircases, enclosed spaces and places which aren't easily accessible.

Construction[3]

The chassis of the drone needs to be made of a lightweight, heat resistant and sturdy material while also being economical. With an inclusion of metal compounds, thermosetting plastics, the most viable recommendation is Carbon Fiber Composites. Carbon fiber composites are comparatively heat resistant, lightweight while being resilient to physical trauma. Carbon fibers are usually combined with other materials to form a composite. When infused with a plastic resin and baked at a certain temperature, it forms carbon-fiber-reinforced polymer which has a very high strength-to-weight ratio, and is extremely rigid.

Frame: The least possible frame diameter to lift the necessary payload weight would be 1250mm.For optimum utility these are paired with 165 mm Rail Mount and foldable legs. The said frame is made from Carbon Fiber.

Motor: An Octocopter requires eight motors to fly. The drone uses brushless motors since they are lighter on the battery. Recommendation: Tarot 5008/340kv motors as they are economical and reliable.

ESCs or electronic speed control: These are essential pieces of your drone as they are in charge of delivering power to the motors. Recommendation: Hobbywing XRotor 40A-OPTO.

Propellers: In order to allow flight to the drone, propellers are used to provide aerodynamic ability. Recommendations: Arms Diameter: 25mm, Motor to motor diameter: 1200m, Height: 380cm, Body size: 250 x 240mm.

Connectors: You will need 3.5 mm connectors to weld the motors and ESCs, and 4.5 mm connectors for the power distribution board and the power distribution board.

Batteries: Recommendation: 2 x 22.4V x 12000mAh Li-ion batteries.One battery is primary whereas the other one is auxiliary.

These are also capable of being wirelessly charged. These batteries provide 40 minutes(with allowance of 5 minutes) of flying time with all the functionalities.

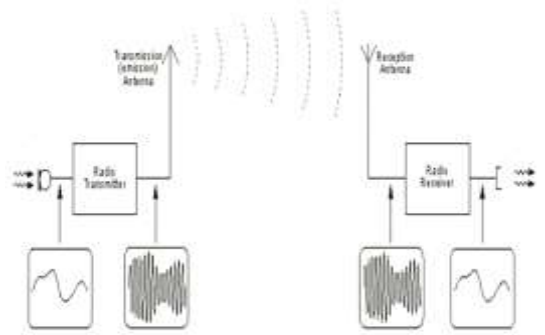


Figure 2 : Diagrammatical Representation of a Radio

Gyro System: The gyroscope system should work almost instantly to the forces moving against the drone(gravity, wind etc.) to keep it stabilized. Apart from that, the system provides navigational information to the flight control systems. Recommendation: DJI A2 multi-rotors

Thermal Imaging Camera: A Thermal Imaging Camera will aid in better identification of fire, humans and machinery at risk of catching fire.Recommendation: Seek Compact Thermal Imager

Autopilot System: This will be required to aid the AI during flight time. Recommendation: PixHawk Flight Controller System.

Activation

The ship's pre-existing fire alarm system is used to activate the drone into action. Whenever a fire in a particular section of the engine room is ignited, it is detected by the appropriate fire detecting system as per SOLAS, which might vary from ship to ship [4]**.** These include:

a. Flame detectors: Detects flicker frequency of flame (25 Hz)

b. Heat Detectors: Uses bi-metallic type detecting elements

c. Smoke Detectors: 1. Light obstruction type, 2. Ionization type.

{5})

This information is fed through pre-existing system for transferring it to the engine control room i.e. electrical signals. Using an Ultra High Frequency Emitter(ranging between 300MHz to 3GHz) located near the drone base; the information can be wirelessly transmitted to the drones which act as the receivers. The Artificial Intelligence System then decides how the drone should engage the fire.

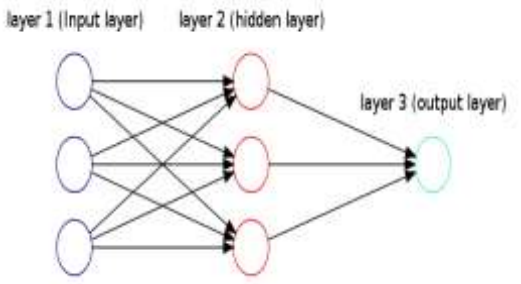


Figure 3 : Diagrammatical Representation of a Neural Net (Credits: www.astroml.org)

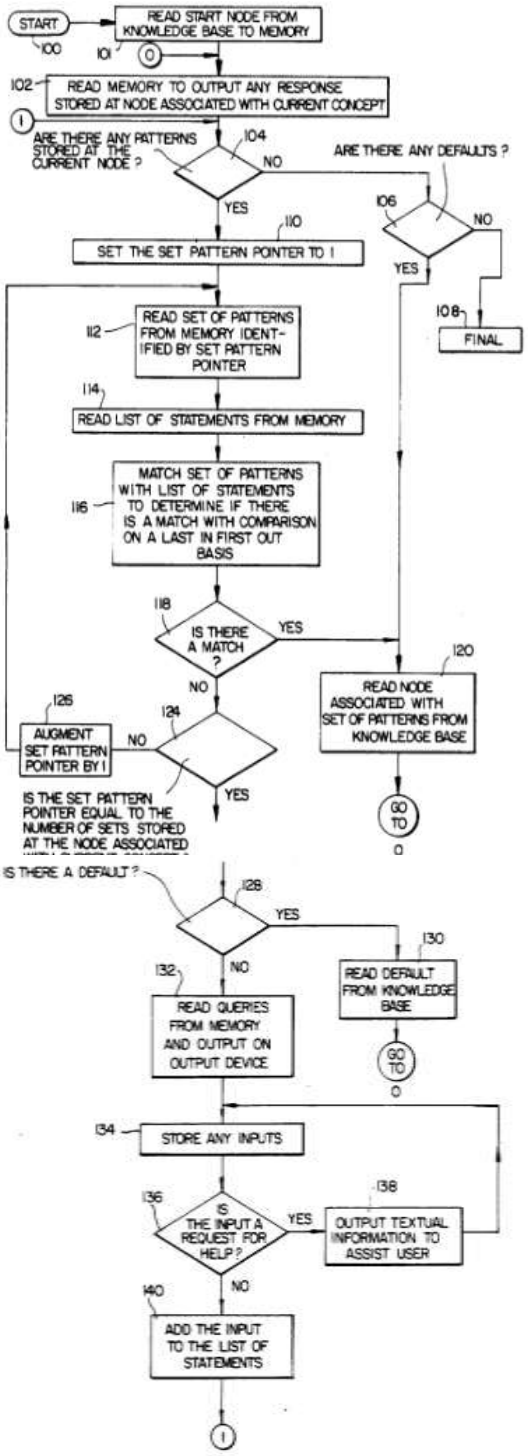


Figure 4: A Flowchart depicting the working of AIS

Artificial Intelligence System (AIS)[5]

It's a system that accepts an invocation for information/action and provides an appropriate response/action, which is based upon understanding of the request, which will be a radially transmitted signal.At its very core, Artificial Intelligence refers to giving decision-making capabilities to a machine to give it autonomy. This AI system focuses on the specific goal of Natural Language Processing. It alters a machine in terms of perception and reasoning and develops intelligence.

Working

In reference with Figure 3, the AIS first establishes the central concept of the initial signal. It interacts with the user to resolve any information gaps, contradictions and ambiguities. It does so by providing inquiries which are to be answered by the user in the form of additional information. This additional information is added to the initial statement. Later, the AIS may provide responses which are in accordance to the request made and are based upon the understanding of the meaning of the input statements which are derived through constantly providing inquires. As the initial input statement becomes more understood, the response time reduces.

Artificial Neutral Net (Self-learning)[6,7,8]

The AIS heavily relies on Neural Networks in order to Self-Learn and adapt to situations through prior experience. It's a system which is inspired by the biological neural networks; example - brains of animals. The neural net will help the AIS "learn" to perform tasks by taking into consideration day-to-day examples. For example, in image recognition, it might learn to identify images that contain a certain type of fire by analyzing example images that have been manually labeled as "electrical fire" or "no electrical fire"andusing the results to identify fires in other images, without having prior knowledge about fires.

Types of Neural Networks suitable for onboard applications

Convolutional Neural Network: It is a deep, feed-forward networks, composed of one (or more) convolutional layers where the layers are fully connected. The architecture which comprises of tied weights and pooling layers allows CNNs to take advantage of the 2D structure of the data.CNNs show superior results in applications such as image and speech. These can be trained with standard backpropagation(a method used to calculate a gradient that is needed in the calculation of the weights to be used in the network). CNNs can be trained easily than other feed-forward neural networks and estimation of parameters is easier. Deep-Dreamand Robot Navigation are one of the many applications of the same.

Deep Belief Net:A deep belief network (DBN) is a generative model made up of multiple layers of hidden units. A DBN can be used to generatively pre-train an ANN by using the learned DBN weights as the initial DNN weights. This is particularly helpful when training data are limited, because poorly initialized weights can significantly hinder model performance.

Projection Mapping

A pre-requisite for the AIS to function is a projection map of the ship which will help the drone to perceive obstacles and the ship environment better. The complexity within the ship can be easily programmed to its spatial dimensioning and thus, allow greater flexibility for the drone in aspect of navigating and traversing. It'll help the AIS to calculate the shortest possible route for reaching the desired location and also help in rescue operation of the crew, if need be.

Blockchain Technology :

Figure 5: Depiction of the Block chain Technology (Source: What is Block chain Technology?, a CBINSIGHTS newsletter)

"The block chain is an incorruptible digital ledger of economic transactions that can be programmed to record, not just financial transactions but virtually everything of value."

It's like an internet with robustness, built-in. The AIS can learn about numerous number of situations by simply accessing the blocks in which this technology stores information. At the same time, this information is also available to the AIS working on ships across the globe and any new update made to the information by one, is read-able by the other. The system lives in a state of consensus and checks itself after a given interval of time. It cannot be corrupted by altering any unit of information, despite being, by definition, "public".

Movement

The Drone is an Octocopter which is a VTOL ("Vertical Take-Off and Landing") type. In order to move, the drone is embedded with a drone vision system which uses obstacle detection sensors to scan the surroundings, while software algorithms and SLAM technology produce the images into 3D maps allowing the flight controller to sense and avoid the object.

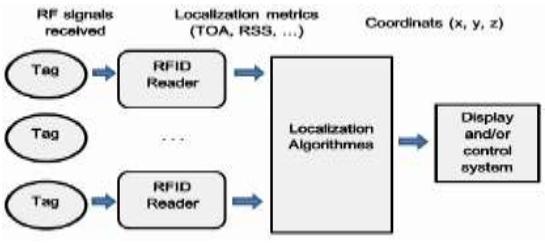


Figure 6: Working of RFID tags

Obstacle Detection and Avoidance Technology

RFID Tags[9, 10]:To accommodate for the constantly moving environment, additional Radio Frequency Identification emitters are installed onboard that operate at very vast band of frequencies (433Hz - 2.45GHz) with a readability range of 2.25 meters. These tags, being the size of a chocolate bar, can be glued to the walls easily. The emitters can withstand a temperature of upto 200°C and can absorb vibrational shocks as well. When the ship rolls or pitches, the inside environment in which the drone flies constantly change. The numerous RFID tags form a Cartesian system, that accordingly changes and the AI of the shift in the pre-programmed 3-D Map.

Others: Systems are fusing one or more of the following sensors to sense and avoid obstacles:

a. Vision Sensor: The Vision Sensor works by perceiving oncoming objects through the camera feed.

b. LiDAR:The LiDAR measures obstacle distance to target by illuminating it with multiple laser pulses and measuring the reflected ones.[11]

Real-time operations

When the fire alarm goes off in a particular section, a drone is automatically deployed to the location. Upon reaching the zone, the thermal imaging camera activates for better accuracy and assesses the degree of the fire. Thermal Imaging works on the principle of measuring infra-red radiation that radiates off a body. When the number of quanta is larger, the body under observation is hotter. This perception of hotness aids in locating through temperature. The AIS checks for the required number of additional dronesto deal with the fire and transmits the request for the same. The thermal camera and other systems transmit a live video feed through a LAN Wi-Fi Network with repeaters, placed strategically to create a continuous and fast network, to the control rooms (Engine Control Room and Bridge). Initial firefighting measures, depending on the type of fire and its degree – DCP Release or Sonic Extinguisher -are immediately deployed. In case of any Humans trapped in the area, the Drone clears a pathway by extinguishing fire and leading them to the safest possible exit. While fighting fire, the Drone's primary purpose is to completely extinguish the flames.[13]

Fire Fighting

Dry Chemical Powder: Dry Chemical is a powder composed of very small particles. The current system uses ABE Dry Chemical Powder –Mono-ammonium phosphate. Added to this, is the particulate material which is given a special treatment to provide proper flow capabilities, resistance to caking and provide resistance to packing. It stops combustion by interrupting the chain reaction sequence and absorbs the heat; thus smothering the fire by blanketing it. Dry chemicals are less contaminative and extremely economical. However, for high-tension electric installation such as a transformer, excellent insulation to prevent any damage that the DCP may occur. The dry chemical powder is stored on the drone in limited quantity through a fire extinguishing grenade as compressed dry powder with compressed nitrogen as propellant; similar to the one used in DCP fire extinguishers.

It is dispelled through a release mechanism which covers the entire region of the flame.The design is similar to the current industry models of Fire Ball Extinguishers by Elide. Each grenade weighs 1.3kgs. These grenades are replaceable after use and can be easily deployed to completely douse a flame in a 5 meter radius without harming any crew members in that area.

Sonic Fire Extinguisher

This apparatus is also called as wave extinguisher and works by employing acoustic waves to suppress the flame. The sound waves are focused in a specific direction instead of spreading them.In reality, sound waves have the potential to control oxygen and burning material. If these two get separated, the fire dies away.The extinguisher only emits sound, making it ideal to use around equipment and personnel. The vibration separates the air from the fuel, causing a momentary lapse in the chain reaction, and then starves the flame from oxygen and hot vaporized fuel. [12]

Figure 7: Route Map followed by Sonic Wave Extinguisher during operation

The frequency used is between 30Hz to 60Hz which therein poses no risk to humans or machinery nearby.

The principle behind the extinguisher is simple: as they are mechanical pressure waves that cause vibrations in the medium in which they travel, sound waves have the potential to manipulate both burning material and the oxygen that surrounds it.
If the sound could be used to separate the two, the fire would be starved of oxygen and, accordingly, would be snuffed out. The waves move the air around them in such a way that they disrupt the rapid oxidation at the core of a fire. The process essentially separates the oxygen from the fuel source and quickly extinguishes the fire.

The AI readily transmits video feed to the control room for crew to keep track of progress. The self-learning programming paradigm also causes for auto-alignment and fighting the fire.

Internet of Things (IoT): It is a system of interrelated objects, animals or people, computing devices, mechanical and digital machines that are provided with unique identifiers and are capable of transferring data without requiring the interaction of human with the computer.It consists of the following components:
a. Sensors/Devices: In the first step, the data is collected from the environment through sensors which can be bundled together to perform separate functions.
b. Connectivity: In this step, the data is sent to the cloud (storage). This can be done by connecting the sensors to the cloud through a variety of methods including: cellular, satellite, WiFi, Bluetooth, low-power wide-area networks (LPWAN), or Ethernet.
c. Data Processing: Once the data is uploaded to the cloud, the software performs the required processes on it. It can be as complex as identifying objects on a given video.
d. User interface: The information thus acquired is made useful to the user through an interface. The vitals of a given system can be analyzed by the user through the said interface. Apart from this, the user can also perform an action to affect the system. Some actions are also performed by the interface automatically, and the output of the same is given to the user.

Smart Rescue Equipment Accessories

Vitality Band:A band which monitors vitals, including pulse rate, blood pressure which primarily helps in monitoring the location of the crew. This band can be strapped on the biceps/forearm under the clothing and is made such that it does not hinder the working ability of the user.

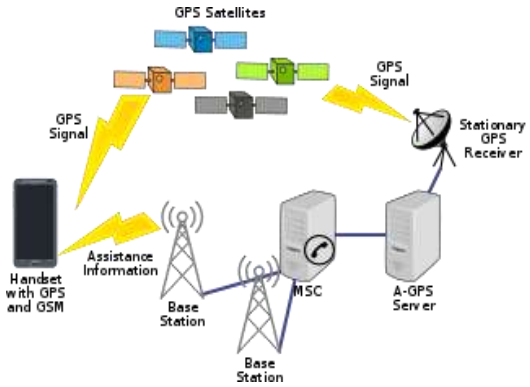


Figure 8: Working of a GPS system

The device includes a motion or fall sensor and will send an alert to the control room and the nearest drone, if a fall is detected or if there is an irregular detail of a crew's vitals. The band also has distress button that can be used to send the signal manually.The drones are first to arrive at the scene and send live video feed to control room as well as assess the situation. The AI's continual assessment also recommends actions to be taken. For example, if someone has fallen and hurt their leg – the software recommends that the rescuers carry first aid and a stretcher, if possible.[14]

a. Construction: Just like the drone, this transponder can be made of Carbon Fiber, making it light weight as well as heat resistant. A strap can be used to attach it to the biceps/arm of the crew.

b.Location: The device in its folds contains a micro GPS (Global Positioning System) tracking chip such as SKG09BL by SKYLAB. This chip is capable of sending and receiving GPS signals from the satellites. The output of the chip can be wirelessly fed to the Local Area Wi-Fi network of the ship and hence to the AIS. The AIS then alerts the drones and rescue operation is conducted automatically. The device contains an SOS button which can be tapped in case of an emergency. This information is immediately transferred to the AIS which, in turn, activates the drones to reach the said location. As the drone is already equipped with a projection mapping of the ship and the input of the position tags, it provides a relatively quicker response and the AIS decides further course of action.The same method is used when the person has to be escorted to the nearest exit in case of a smoke-filled compartment, a blackout or an engulfing fire.

c. Measurement of Vitals: An optical vital sensor by ROHM can be used for measuring pulse rate, blood pressure as well as stress due to its high-speed sampling of 1024 Hz. It has a high detection accuracy and low power consumption of 0.44 mA. It uses an integrated FIFO (First in First Out) memory to reduce power consumption. It uses supply voltages if 2.5 to 3.6 volts. It also consists of an infrared sensor for sensing as to when the device is being worn. The noise to the circuitry is reduced using optical filters. Fall detection is done with the help of sensors such as gyroscopes and accelerometers which are constantly detecting crew's movements. The sensors can detect the changes in motion as well in height as they are sampled up to 100 times per second.The output of these devices can be fed along with the tracking information.

Clothing Transponder: The same transponder device can also be attached onto the clothing. In case of uneasiness or to gain the rest of the crew's attention, the transponder can be used to send out distress signal. The drones are first to respond.

In both applications of the drone, the seafarer's lives are rescued through automation and technological advancements of the drone. In case of rescue from a fire, the drones use the rescue equipment to locate the seaman trapped in the compartment and then find the safest possible escape route, whilst fighting the fire and clearing the pathway for escape.

Maintenance

Charging[o]

The drones use wireless charging, which is a docking station on which the drone automatically sits and self-charges upon requirement. Wireless charging works on the principle of induction. The charging dock works as a primary coil that constantly traverses current. The device to be charged

Figure 9: Wireless Drone Charging Pad

contains a secondary coil that is induced and thus charges it. These pads can be kept at routine places of use such as every level of the engine room, bridge, etc.

DCP Replacement

Dry Chemical Powder grenades can be automatically replaced by the drone through a self-refilling system wherein the routine code insists that empty grenade pockets are first filled up after every charging or completion of rescue, whichever is earlier. The QR Code on every grenade is scanned just before it is placed onto the deployment pocket, and its replacement date is automatically fed to the system, along with other details such as information of grenade, manufacturer and all other requirements of any Life Saving Appliance.

Scope

The project can be used on Manned and Unmanned Ships, with usability also inclusive of cruise liners, coastal vessels and even be extended to ports.
On Completely autonomous Unmanned Vessels, the Drones will work in tandem with the AI onboard, as extensions. The drones can also be used toaid other jobs that relate in entering enclosed spaces, working aloft, etc. by keeping the control room and OOW informed of recent developments in real-time. Through remote control, these can also help in more frequent and faster inspections of a greater area onboard.

Benefits

The proposal requires no major structural changes and primarily uses the ships pre-existing systems only small installations are required. Due to greater maneuverability and speed through flight, response time is significantly reduced. It also aids in watch keeping and monitoring of systems, as well as, in quickly spotting errors and issues with machinery and working through better available video surveillance.

Conclusion

The assortment of ideas when put together creates a safer, more automated format of fire-fighting and personnel caregiving which can account for every person who is at risk and also ensure they are also brought out of the risk safely. Multiple drones, and each stationed close to a command centre (Bridge, Engine Control Room, and Accommodation) or places of

high fire risk, can aid in rescuing people and even extinguishing fire before the first responders show up. Through the Internet of Things, there is greater availability for surveillance of harm, better assessment of risk, in addition to the very quick response of efficient rescue systems. Here-in are discussed widely used systems that have already been developed and the possible modifications that can be brought in these developed systems for their application on-board. The life of the seafarers is paramount and hence, the technological advancement through augmentation in Fire Fighting techniques with Artificial Intelligence is indispensable to ensure safety of life followed by safety of property and environment.

Refrences

[1] PJ Bristeau, F Callou, D Vissiere, "N Petit Navigation and Control Technology inside a Drone", IFAC Proceedings Volume, 2011

[2] Masellis M., Gunn S., William A., "The Management of Mass Burn Casualities and Fire Disasters", Springer, pg. 7-12, 1992

[3] JSR Jang, "Self Learning Fuzzy Controllers", IEEE- Transactions on Neural Networks, 1992

[4] Tolani Maritime Institute, "Fire Fighting and Fire Prevention" course handout, 2018

[5] Farley, B.G., W.A. Clark, "Simulation of Self-Organizing Systems by Digital Computer", IRE Transactions on Information Theory, 1954

[6] Fei-Fei, Li, Fergus, Rob, "One-shot learning of object categories", IEEE Transactions on Pattern Analysis and Machine Intelligence", 1992

[7] Hiroaki Kitano, Satoshi Tadakoro, "RoboCup Rescue: A Grand Challenge for Multi-agent and Intelligent Systems", AI magazine, Vol. 22, Spring 2001

[8] Alex Kriz Hevsky, I Sutskever, GE Hinton,"Image Net Classificiation with Deep Convolutional Neural Netwroks", papers.nic.cc, 2012

[9] Trolley Scan Private Limited,www.trolleyscan.com/ecotag.html

[10] Zinhed Belhadi, "RFID TAG Indoor Localization by Fingerprinting Methods", Denmark, May 2014

[11] R. Watson, Goyer G, "The Laser And Its Application To Meteorology", Vol. 44, No. 9, September 1963

[12] Dr. S. S. Verma, "Sonic Fire Extinguisher", Scientific India, October 2017

[13] M.H. Hebert, CE Thorpe, "Intelligent Unmanned Ground Vehicles", Carnegie Mellon, 2012

[14] SWH Chuah, PA Rauchnabel, N. Krey, "Wearable Technologies–Computers in Human", Elsevier, 2016

[15] MJ Sarnowsky, "Wireless Charging Device", US Patent- 7868585, USA, 2017

[16] Don and Alex Tapscott, "Blockchain Revolution", Penguin Random House, 2016

[17] "Journal of Computer and Communications", 2015

[18] General Insight on Artificial Intelligence- https://en.m.wikipedia.org/wiki/Artifical_intelligence

[19] General Insight on IoT- https://arstechnia.com/tag/internet-of-things/

[20] General Insight on Neural Networks- https://techcrunch.com/2018/09/26/a-new-way-to-explain-neural-networks/

[21] General Insight on Sonic Extinguisher- https://physics.stackexchange.com/questions/314354/can-a-sonic-boom-put-out-a-fire

[22] Prevailing Fire Fighting systems on-board-https://marineinsight.com/ marine-safety/16-fire-fighting-appliances-and-preventive-measures-present-onboard-ship/amp/