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Air Lubrication: A Hull-slide View

The Institute of Marine Engineers (India)

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EDITORIAL

Each of us is responsible for everything and to every human being.

- Simone de Beauvoir

The container box problem is everywhere. This apart, Indian exports suffer from maladies of high freight costs and shortage of domestic options. One end of economic spectrum shows an increased FDI (though not yet as copious as pre-Covid times) and an all-time high in start-up investments. In this exuberance it will be wiser to remember that India has largely relied on tried models rather than self-spinning solutions that would fuel start-ups.

Coming to shipping, the Budget was expected to extend sops with liberal tax models (tax on fleet tonnage rather than on profits; no capital gains on vessel disposal gains), incentives to shipping lines started in India, encouraging more container manufacture, greater budget for recycling etc. But for logistics sector getting a boost, this wish-list items are yet to gain traction.

It will take every other sector like trade, commerce, finance etc., to energise our shipping at this stage. Adding up, our innovations, our strength in computing and commerce also have to give traction. The exporters to engineers, the academia to industry and possibly each of us have a part to play if we have to touch the trillion range targets.

The existential plane applies to the pandemic situation also...

Withstanding the positivity rate and the mutation...

The masks, booster jabs, the distancing... each of these matter in the endlessly extending pandemic period. On the very note, each of us has a responsibility towards every other human being.

In this issue...

The premise that reduction of hull resistance will reduce power required to move the hull prevails. Under innovating ideas, air lubrication has been a talked about technique. The efforts of Mitsubishi Air Lubrication System (MALS) are the ones to be watched for in times to come. Keeping up this conversation on air lubrication, C.P. Balaji and Dr. Sivasami discuss an air bubble generation method. The short essay posits that the 'Winged Air Induction Pipe' (WAIP) technology, covers a larger under-hull area with microbubbles, which regular compressed air applications do not. This is an easy, informative read.

Continuing with Part D of the Power Management series, Dr. Veda discusses the grounding aspects and developments in insulation monitoring. The importance of integrity monitoring of cables, their derating for multi-layered configurations etc., are discussed including the tools for quality assessment. The interest is sustained with discussions on Variable Speed Drives and optimisation. Shipboard engineers should find these talks enlightening from the electrical knowledge dimension.

We see a whale of a problem in the Spanner in the Works column. Naresh Kumar Mishra presents a case of weight addition to the hull in the form of a dead whale on the bulbous bow. The vessel behaviour, particularly the effect on the speed with the whale across the bow and after dislodgement is discussed. This can draw similar experiences from engineers for sharing and analysing.

Also seeking attention will be the Technical Notes section with a simple deliberation on merits of Miller cycle application. Though the knowledge has been well exposed, it is worth a relook from engineers for ideas.

Under obituaries, we log two departures with despondency, one of which has a private pain. I record the passing away of a good friend Venkatesan, who was undeniably one of the best Marine Engineering minds. His association with MER at the Competency Corner will be remembered for clearing the regular misconceptions. While we had planned for some more pointed topics (including power layout envelopes etc.), Nature chose otherwise.

Here is the February issue at your fingertips...

Dr Rajoo Balaji
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Cover Photo Source: **Mitsubishi Air Lubrication System [MALS]**

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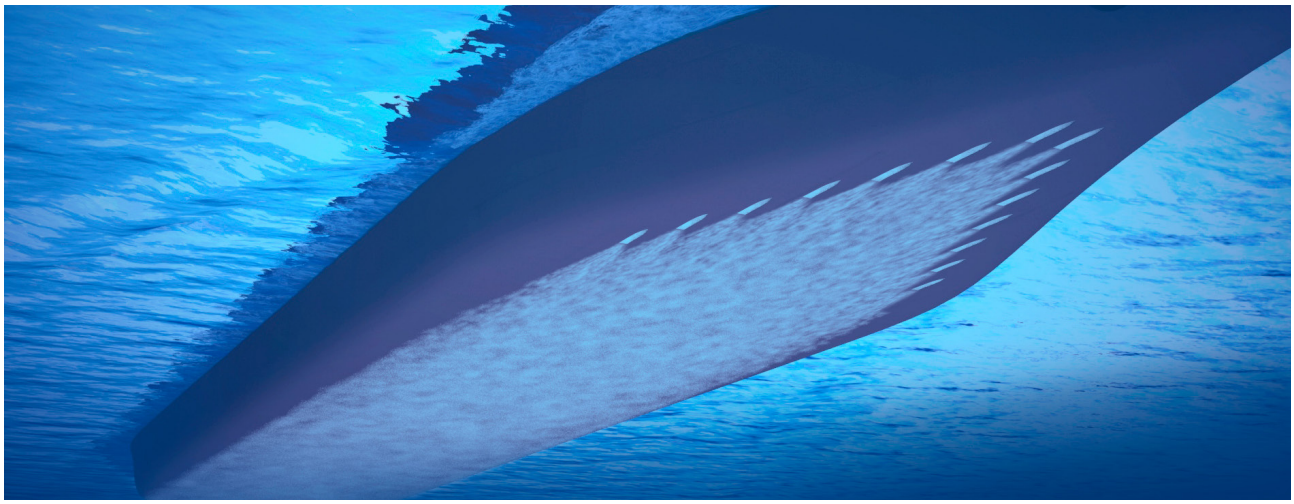
AIR BUBBLE LUBRICATION FOR HULLS



C.P. Balaji,
K. Sivasami

ABSTRACT The reduction of resistance and the increase of propulsive efficiency are the major drivers for ship designer both for economic reasons and increasingly for reducing the ship's environmental footprint. Ship hull optimisation has been utilised commonly to reduce the frictional resistance component of the ship. Reducing the frictional resistance by air injection below the ship in combination with special coatings is an active area of research. Air lubrication can be achieved by using techniques such as air-cavity, microbubbles, and air film formation. This paper reviews about the hull modification for air bubble lubrication in the improvement of ship's energy utilisation.

Keywords: *frictional resistance, air bubble lubrication*

I. INTRODUCTION

Ship is the most energy saving transporter among others. The steep rise in prices of raw materials such as crude oil is predicted to continue for the foreseeable future, in conjunction with the economic growth of developing countries. In the situation surrounding the marine transportation business, expectations for the development of energy-saving technologies for shipping are high, with the international need to address shipping costs and environmental issues such as CO_2 emissions.

The air lubrication method is a technology to reduce skin friction resistance working on a hull by sending air to the bottom of the hull to create a layer of air bubbles between the hull and sea water. Three distinct approaches are identified namely the injection of bubbles, air films, and air cavity ships. These three approaches are very useful in reducing the frictional resistance in hull. Since the proportion of skin friction resistance to total resistance is high, especially on large low-speed blunt ships, the air lubrication method has been focused on for quite some time as an effective measure to reduce skin friction resistance.

II. AIR BUBBLE LUBRICATION

A. Microbubbles using Hydrofoil air pump

A research area for drag reduction of ship with microbubbles has been active in recent years because of the energy saving potential and of the environmental safety for the marine pollution.

The injection of air microbubbles into a turbulent boundary layer over the ship hull, modifies the boundary layer and reduces skin friction

The injection of air microbubbles into a turbulent boundary layer over the ship hull, modifies the boundary layer and reduces skin friction. Although recent applications of drag reduction technology with microbubbles to the ship reduce about 10-15% of the energy regarding the skin friction in the turbulent boundary layer, the energy necessary for the injection of air bubbles by using conventional bubble generators, which is about 5-10%, is generally ignored. So a power-saving device which reduces the energy for the bubble injection has been produced. The new facility called WAIP (Winged Air Induction Pipe) which has an angled hydrofoil with an air introducer (**Figure 1**).

This device utilises a low-pressure region produced above the hydrofoil as the ship moves forward, which drives the atmospheric air into the deep water.

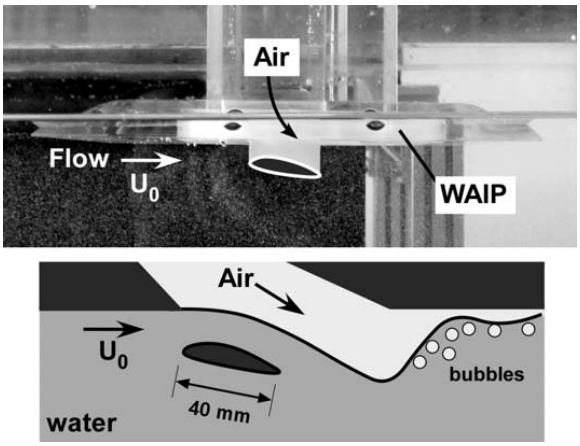


Figure. 1. Side view of WAIP

B. WAIP (Winged Air Induction Pipe) technology:

WAIP technology is proven to be highly effective in reducing the frictional resistance caused by ship's propulsion

WAIP technology is proven to be highly effective in reducing the frictional resistance caused by ship's propulsion. It was conceived for the purpose of lessening the amount of energy required for generating micro air-bubbles and also to reduce the size of generated micro-bubbles resulting in reduced buoyancy of the bubble. It turned out that the size of the ultra-fine micro-bubbles generated by WAIP was in the vicinity of 10 microns which was 1/100 of the size of the air-bubbles generated by the conventional air compressor method.

Unlike the bubbles generated by compressed air, the micro air-bubble generated by WAIP tends to stay within the water flow around the hull and effectively covers a large area of the hull surface from bow to stern. Installation of WAIP units on the hull reduces the ship's frictional resistance by around 15 % to 20%, contributing to reduction of main engine power and fuel consumption. Interestingly, the size of microbubbles does not change once ejected into the water.

Figure. 2. WAIP installation process in dry dock and Cast iron WAIP fitting

The WAIP unit is installed on the hull surface and consists of a wing-like blade attached to an air induction pipe connected to the atmospheric air intake (**Figure 2**). When underway, the vessel's forward movement through the water generates a suction force under the WAIP unit, thus the micro-bubbles are continuously pulled out of the WAIP unit.

This air-bubble generating sequence occurs when the ship's draught is below a certain level and is sailing above a certain speed.

When the air and water boundary is located at the upper part of the air induction pipe, such as when the draught is high and the vessel's speed is below the critical level, the boundary level needs to be pushed down to just above the blade of the WAIP unit to be able to generate the microbubbles (**Figure 3**).

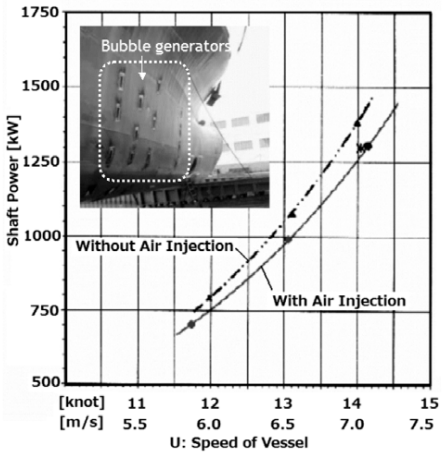


Fig. 3. Comparison of Shaft power with and without air injection by WAIP

To achieve this, a small-size air compressor will be used to lower the boundary to the level above the wing of the WAIP unit. This application of WAIP assisted by compressor is called WAIP air compressor and will enable any ship, whatever its draught or speed, to benefit from WAIP.

III. AIR CAVITY SYSTEM

Air cavity system is an air lubrication technology for reducing the frictional resistance of the hull surface (**Figure 4**).

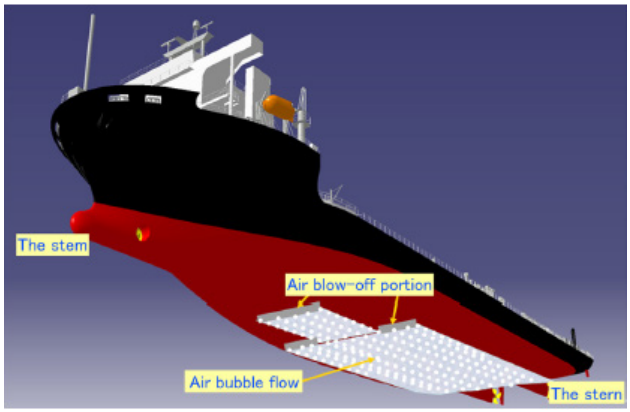


Figure. 4. Air lubrication (ship's bottom)

Air discharged from the air blow-off portion mounted on the bottom of the hull turns into air bubbles because of the tearing-off forces of the surrounding flows and then runs to the direction of the stern with air bubbles covering the bottom of the hull.

In approaches toward putting the air lubrication method into practical use, researchers have recently measured total resistance and local skin-friction resistance working on a model hull i.e. a flat plate hull having a total length of fifty meters and have confirmed that these resistances decrease. Among the several actual hull experiments on the air lubrication method that have so far been carried out, the roughly five-percent energy-saving documented by researchers on an actual hull experiment using a cement carrier has attracted interest in the effectiveness of actual hull experiments on an air lubrication method.

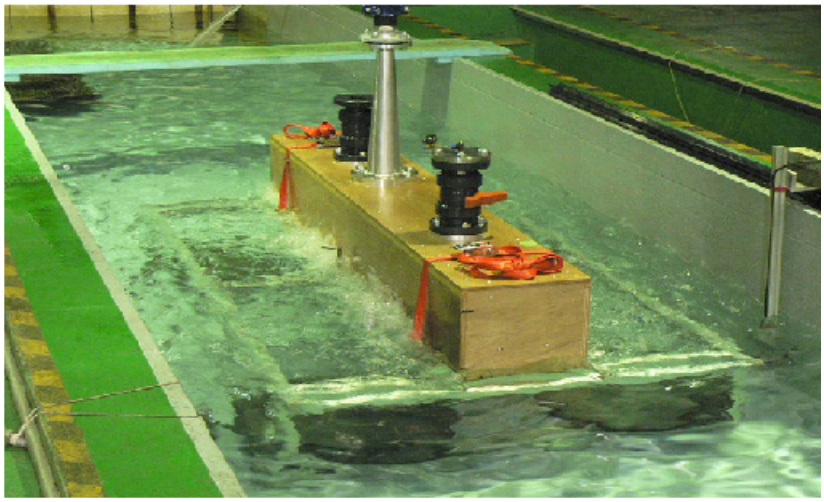


Figure. 7. Air blow-off conditions (underwater)

IV. MOCK-UP MODEL

Air discharged from blowers is temporarily stored in a head tank and fifteen air supply branch pipes connected to the head tank are piped to the air supply portion mounted on the bottom of the hull (**Figure 5**). One air supply branch pipe is connected to one chamber (air chamber). All of the chambers are housed in a recess. In the test, the recess and chambers of the mock-up model were fabricated and the air blow-off conditions were observed. The test was conducted in a sea keeping tank at MHI's Nagasaki Research & Development Centre.

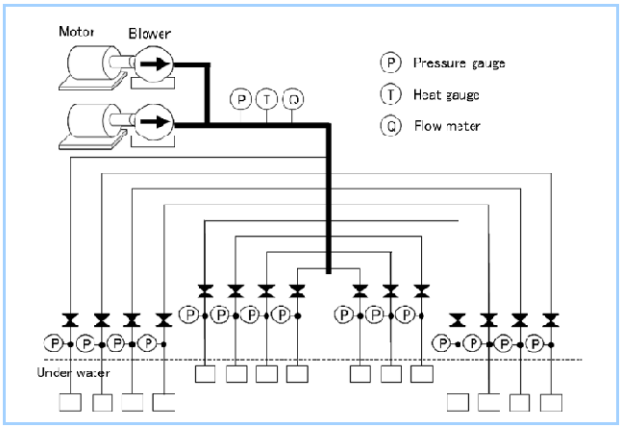


Figure. 5. Piping diagram

With an air film of half a millimetre thick, a drag reduction of 90% was obtained although no Reynolds effects were taken into account

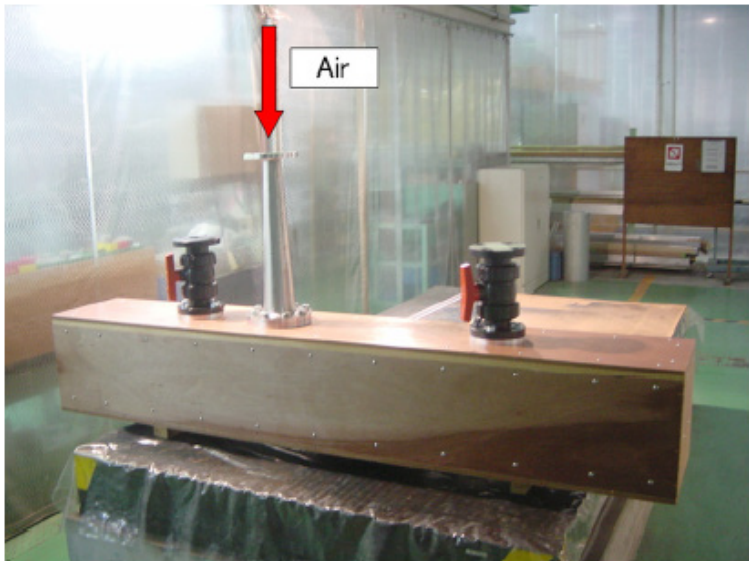


Figure. 6. Test chamber

A communicating pipe connected to the air supply pipe is attached to the top portion of the chamber (**Figure 6**), where its attached point is offset by 200 mm away from the centre of the chamber. On the bottom portion of the chamber are installed sixteen small apertures from which air is blown off.

A picture of the air blow-off conditions, with the chamber placed underwater (**Figure 7**).

V. AIR LAYERS

The air layer concept can be seen as a combination of micro bubbles technique and air cavity ships. An air stream is injected into the bottom region of a ship and an air film forms. This air layer is subjected to influences as turbulence and the natural instabilities that occur on any fluid-liquid interface. With an air

film of half a millimetre thick, a drag reduction of 90% was obtained although no Reynolds effects were taken into account.

Researchers carried out experiments with air film lubrication on a flat plate and for model ships, all without a water-repellent coating. They managed to obtain drag reduction, but had difficulties in obtaining a stable air film, especially at higher flow Reynolds numbers. They noted that the air layer can increase the frictional drag when the liquid-gas interface become instable, resulting in breaking up the layer in larger sized bubbles that also may reduce frictional drag.

VI. CONCLUSION

There are many technical levers to save fuel and thus emissions for ships. The best option for improving the power consumption on ships is to evaluate and optimise the design systematically with regards to the underwater and propulsive efficiency in calm water and in a seaway. Various concepts for hull flow smoothing may give valuable improvement in individual cases but require systematic evaluation in each case.

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[This paper was included in the proceedings of the National e-Conference on Energy, Environment and Sustainable Shipping organised by IMU Chennai campus & IME(I) in December 2020]

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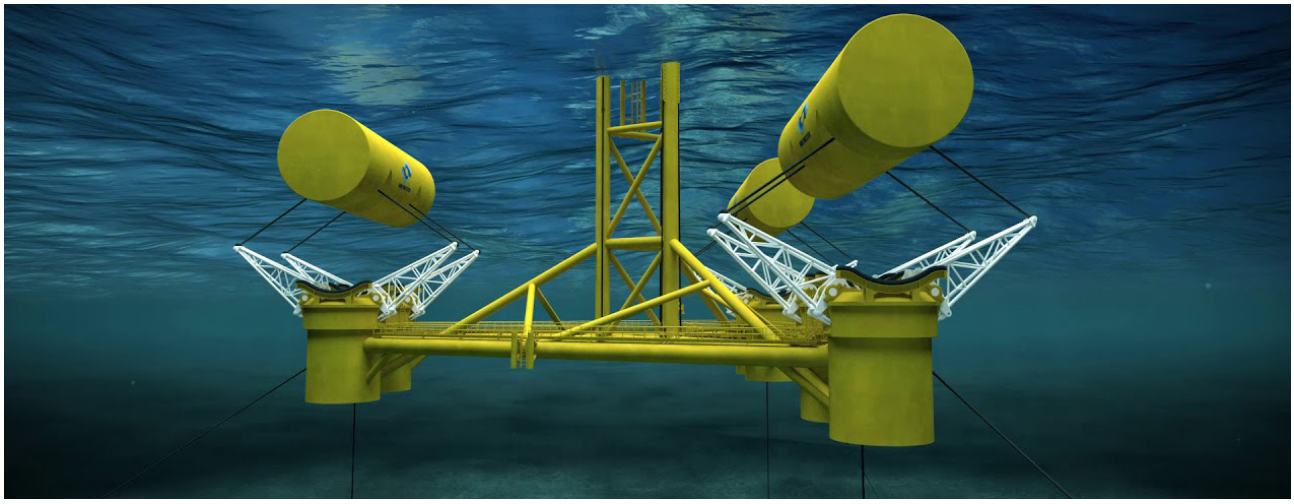
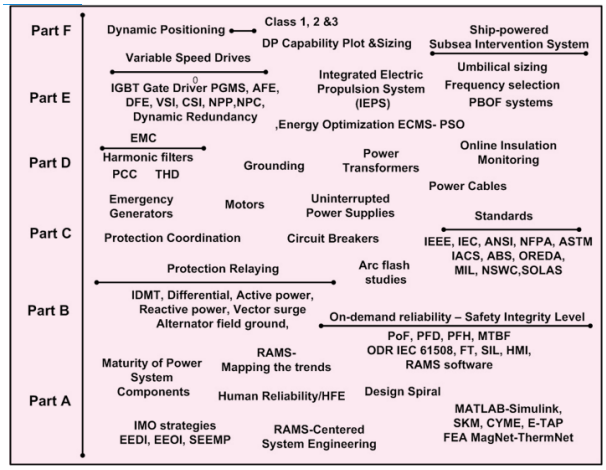
RAMS-CENTERED SYSTEM ENGINEERING AND OPERATIONS OF MODERN MULTI-MEGAWATT CAPACITY MARINE POWER SYSTEMS - PART D



N. Vedachalam

Abstract: This article in six parts (this is the fourth, Part D) discusses the importance, trends and integrated approach to RAMS-centred system engineering, key design and operational considerations for low- and medium-voltage marine power systems, including alternator protection, effective protection coordination, integrity requirements of relaying, emergency diesel generators and uninterrupted power supplies, significance of grounding, condition monitoring of power transformer, cables, motors, harmonics filters and the methodologies for realising fault-tolerant voltage source inverter based variable speed drives and dynamic positioning systems.

Part A (first part), Part B (second part), Part C (third part) of the series were published in the November 2021, December 2021 and January 2022 issues respectively.



Index terms: Cables, EMC, Inverters, Grounding, VSD

Grounding practices

The ship's hull is the zero potential reference for the vessel power, electronics and radio communication systems. The vessel onboard antennas require a proper ground reference for reliable transmission. The IEEE Practice for Shipboard Electrical Installations recommends that the grounding of 600 Volts (or lesser) systems should ascertain reduction in the transient over voltages, continuity of service during single line-ground (L-G) faults and minimise ground fault current in the hull structure.

The ungrounded systems should have continuous L-G fault monitoring; and in the case of high resistance grounding, the currents during single L-G faults should be <3A. Hence solid grounding systems are limited only to non-critical circuits. The comparative characteristics of various grounding schemes (**Figure.1**) are summarised in **Table.1**.

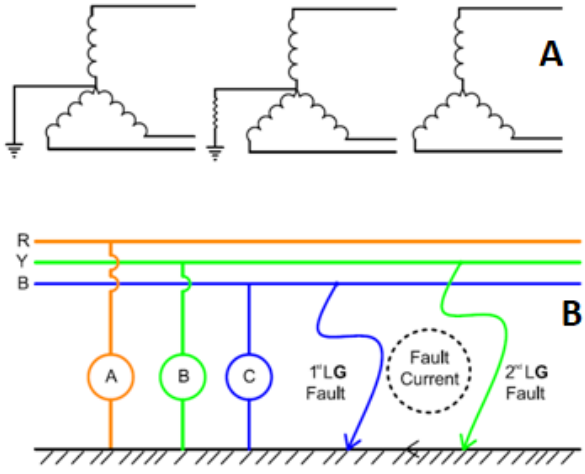


Figure 1 a. Solid resistance and ungrounded systems b. Faults in ungrounded system

Table.1. Characteristics assocoaited with methods of grounding

Characteristic	Type of grounding		
	Solid	Ungrounded	High R
Ground fault current	High	Low	Limited
Probability to develop into a multiphase fault	High	Low	Low
Risk of arc flash	High	Low	Low
Personnel safety	Low	High	Very high
Equipment damage potential	High	Very low	Very low
Fault localization	Easier	Difficult	Easier
Continuity service with single G fault	No	Yes	Yes
Approx transient overvoltage level	2.5 times	> 6 times	2.7 times
Possible selective tripping	Yes	No	Yes
Alarming without tripping	No	Yes	Yes
Cable insulation requirement	1.0	1.73	1.73
Surge protection level	1.0	1.73	1.73

Table.2. Orgin of various types of fault [2]

Type of fault	Origin
Phase to Ground fault	>98%
Phase to phase fault	<1.5%
Three phase fault	<0.5%

Table.3. System ground monitoring using three indicators

Status of indicators/ Relays			Nature of fault
A	B	C	
0	0	0	System healthy
0	1	1	Red phase grounded
1	0	1	Yellow phase grounded
1	1	0	Blue phase grounded

Even though the high resistance grounding is safer with respect to arc-flash, the ungrounded systems in the marine industry have been quite reliable and relatively safe [1]. The reason is based on the statistics (**Table.2**) of the origination of electrical failures. Practically all faults originate as L-G fault with a very few number of faults originating as a phase-phase fault. Practically no faults, except for human induced fault originate as a three-phase fault.

However, design considerations for high resistance grounding include careful consideration of the charging current that depends on the system capacitance, line voltage and the zero-sequence reactance.

$$\text{Charging current} = V_{LL} / (1.732 \times Xco)$$

Both the high resistance and ungrounded systems allow continuous service (with the hull energised and without any human risk) unless a second ground fault occurs on another phase (**Figure.1**). Hence the first ground fault has to be cleared as early as possible. With the presence of one ground fault, the voltage on the other healthy phases will increase by up to 1.73 times that of the normal line-to-neutral values.

It is imperative that all equipment should withstand the higher-than-normal voltage. The API-14F provides a caution for any vessel hull cathodic protection system operating above 50V, the voltage difference between any two points one meter apart should be ≤10V [3].

In marine power systems, the traditional mechanism used for detecting the first L-G fault is of immense use, as the second fault leads to power outage

In marine power systems, the traditional mechanism used for detecting the first L-G fault is of immense use, as the second fault leads to power outage. The healthiness of the system ground based on the indicators A, B and C (**Figure.1)** is summarised in **Table.3**.

At present, advanced online insulation monitoring systems (IMS) measure the insulation between the completely galvanically interconnected AC network and its protective ground. The IMS injects a sequentially coded measuring signal into the monitored system. The signal flows to ground through the path of the insulation fault and the level of flow indicates the insulation resistance. The measuring accuracy is not influenced by any normal kind of load attached to the AC network.

Based on the recommendations of IEC 61557-8, the IMS based on three different principles include DC superposition method, double frequency principle and zero-sequence current. Amplitude comparison method helps to monitor both symmetrical and asymmetrical deteriorations in the insulation.

Table.4. Special standards for marine grade cables[4]

IEC	Tests
IEC 60331-1,2,21	Fire resistance when exposed to a flame at 750˚C for 90 minutes.
IEC 60092-360	Temperature withstand of 90ºC with halogen-free sheath and flame-retardant thermoplastic compound
IEC 61034	Smoke density
IEC 60754	Conformity to halogen free cable materials
IEC 60092-300	Manufacturing quality
IEC 60754-2	Corrosion resistance and acidity attack

Table.5. Cable material &time constants with Cu conductor [5]

Insulation material	Max Temperature	K
Thermoplastic PVC	90ºC	100
Thermosetting XLPE	90 ºC	143
Thermosetting Siliconerubber	185 ºC	132

Table.6. Derating of bunched cables in tray[5]

Number of layers	% Ampacity de-rating
1	0.85
2	0.65
3	0.45
4	0.35

Cables

The major factors to be considered for selecting a marine grade power cable include operating voltage, cross-section area, conductor material, number of cores, voltage drop, short circuit rating, type of armor, sheathing material, insulation grade, shielding,de-rating factors, bending radius, operating environmental conditions, fire resistance, smoke generation limits and the corrosion resistance. The IEC standards recommended for marine grade power cables are shown in **Table.4**.

To ensure proper protection coordination, the short time current rating of power cables is calculated based on the guidelines provided in IEC 60364-4-43.

$$Ish = k\ A/\ sqrt(t)$$

Where k depends on the cable construction material (**Table.5**).

When the power cable is laid in cable trays in a multi-layered configuration, appropriate ampacity de-rating factors are to be applied (**Table.6**) so that the hot spot temperature of the cable is within the safe operating limits.

When the cables are used in an environment other than defined by cable manufacturer specifications,

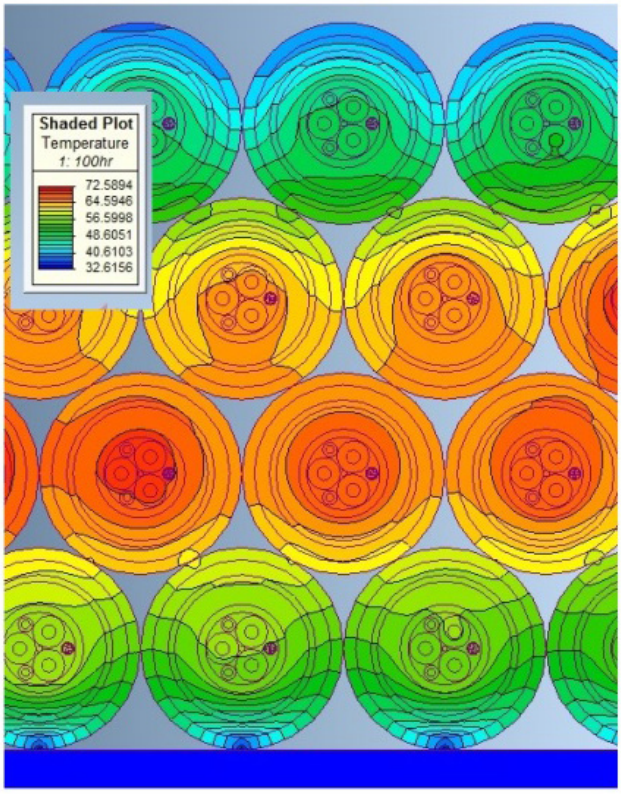


Figure 2. Electro-thermal FEA of multilayered cables [7]

electro-thermal finite element analysis (FEA) should be performed as per the guidelines of IEC TR 62095 considering the cable material properties to ascertain the safe application of the cable.

As an example, **Figure.2** shows the FEA results for a 3 core, 6 mm^2 copper 37.5mm diameter marine power cable operated in four layers in a metallic cable tray carrying a current of 30A at an ambient temperature of 30°C. The electro-thermal FEA was done using Infolytica Corporation's MagNet and ThermNet FEA softwarev7.4.1[6]. The assumptions include 2-D heat flow, convective heat transfer coefficient of 15 W/m^2 and cable material thermal conductivity of 0.25W/m-k (**Figure.2**).

The higher temperature in the second and third layers is due to the reduced heat flow in the underlying and overlying layers. The lower temperature in the first and fourth layers is due to the conductive heat transfer with the metallic cable tray and convective heat transfer with air, respectively. The ampacity derating factors for 1, 2, 3, 6, 12, 18 and 20 layered configurations are 0.85, 0.71, 0.62, 0.33, 0.21, 0.17 and 0.15, respectively [7].

Even though the cables are selected to meet the operational and environmental conditions, planned maintenance and condition monitoring are the key requirements for reducing the cable failures, which are reported to have a probability of failure (PoF) of 5% in a period of 1 year.

Over time, the aging and degradation mechanisms caused by the operational stresses can eventually lead

to early failure of the cable. These could be identified by periodic inspection, off-line testing and online condition monitoring.

The boundaries of an electric cable system that are to be monitored in a cable condition monitoring program will typically include the electric cable, cable splices, insulated connectors from their source terminals, electrical connectors, bushings and terminal blocks. The off-line tests include insulation resistance (IR) measurement, AC voltage withstand in which double the rated voltage applied for 15min between conductor and ground, DC high potential and step voltage as recommended in IEEE Std. 400.1/ 141, dielectric loss (tan δ) measurement over a wide range of frequencies and polarisation index(PI) measurement.

The PI is the ratio of the insulation resistance at 10 minutes to the insulation resistance at one minute. The PI is the consistent and repeatable indicator of cable insulation integrity as it indicates time-dependent behavior of capacitive charging current, leakage current and dielectric absorption current.

Specifically, for medium voltage (MV) cables, partial discharge testing in which a sufficiently high voltage stress is applied across a cable's insulation to induce an electrical discharge in the small voids present within the insulation.

Occurrence of partial discharges indicates the presence of degradation sites in the insulation

Occurrence of partial discharges indicates the presence of degradation sites in the insulation. The stress cone used in the MV cable joints and terminations to relieve electric stresses at the junction point of insulation and conductor screen requires appropriate design against damages due to partial discharges during transients.

Variable Speed Drives

IEPS and VSD

Variable Speed Drives (VSD) are used for operating the on-board pumps, blowers and compressor motors at variable speeds to meet the varying load demand conditions. A typical Integrated Electric Propulsion System (IEPS) comprises of Power Generation and Management System (PMGS), Control Computer and Sensor System (CCSS) and the VSD-driven Thruster System (TS) [8]. The PGMS with full redundant diesel/turbine power generators and power management system (PMS) caters to the vessel power requirements.

The PMS receives the total vessel power demand needs from the CCSS and allocates the active (kW) and reactive

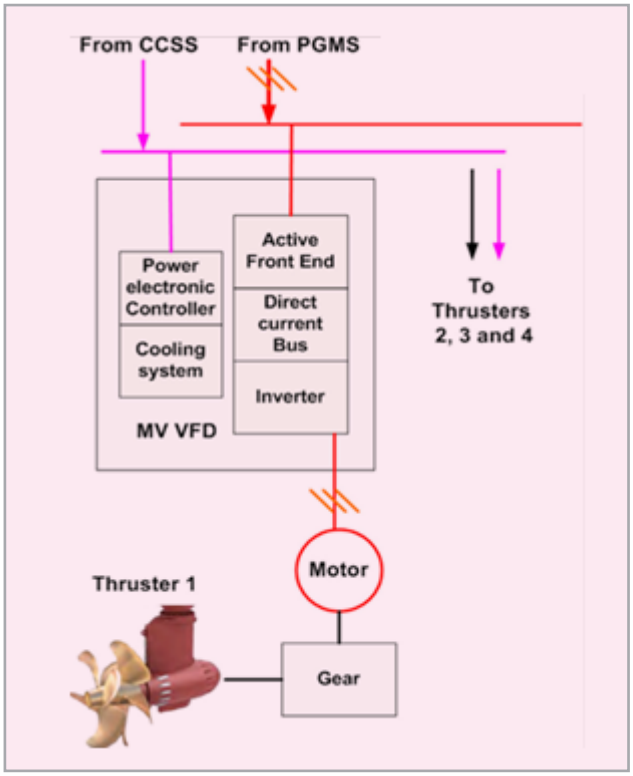


Figure 3. Architecture of a typical VSD forming part of IEPS

(kVAR) power to be supplied to the individual power generators based on their speed and voltage droop characteristics, respectively.

Based on this real and reactive power allocation, the electronic speed governor in the respective diesel engine/ turbine throttles the fuel/steam valve to meet the active power target, and the Automatic Voltage Regulator (AVR) to meet the reactive power demand.

The PGMS also manages the starting, stopping, synchronous operation of the generators, manages the engine, cooling and the lubrication systems

The PGMS also manages the starting, stopping, synchronous operation of the generators, manages the engine, cooling and the lubrication systems. The architecture of a typical MV-MW-VSD operating a propulsion thruster forming part of IEPS and receiving inputs from PMGS and CCSS is shown in **Figure.3**.

Maturing Medium Voltage Multi-MW VSD technologies

Over the past four decades, the impressive developments in the high-power water-cooled semiconductor devices has resulted in discrete semiconductor modules such as Insulated Gate Bipolar Transistors (IGBT), Injection Enhanced Gate Transistor (IEGT) and Gate turn off thyristors (GTO) modules capable of handling power in the order of megawatts (MW) with switching frequencies upto hundreds of kHz (**Figure.4**).

IGBT has the advantages of scaling their voltage ratings and refinements to their gate structure by very large scale integration (VLSI) technologies compared to its counter parts. The innovative package design using aluminum and silicon nitride ceramics has enhanced the thermal capabilities and long-term reliability of the IGBT.

These developments in the semiconductors, control electronics and system engineering supported by the finite element electro-thermal modelling tools, redundant architectures, system autonomous intelligence, diagnostics and prognostics capabilities have helped in achieving safe, reliable, efficient water-cooled medium voltage-multi-megawatt (MV-MW-VSD) of capacities up to 40 MVA with power densities of ~1.5 MVA/m^3[10]. Reliability studies indicate that ~42% of the IEPS failures are contributed by VSD and thrusters.

The architecture of MV-Multi-megawatt Active Front End VSD (MW AFE-VSD) comprising of power, control and the cooling systems is shown in **Figure.5.** Power regulation by varying the output voltage and frequency is done in the machine bridge and in the mains bridge (AFE) sections of the VFD.

The AFE enables bi-directional power transfer between the motor and the PGMS power generators during vessel deceleration. The IGBT are active components in the VFD, that regulates power based on Pulse Width Modulation (PWM) techniques.

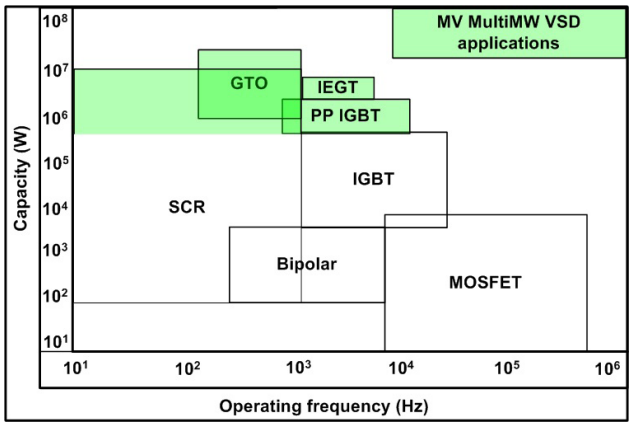


Figure 4. Application trends in power semiconductor devices [9]

The inverters in the machine side and AFE includes a programmable real-time Master Controller (MC) that calculates the pulse width modulation (PWM) pulse timings (based on the voltage and current measurements) and dispatches the timing signals in an electrical format to the optical interface board which converts the signal from the electrical to the optical format.

The Gate Driver (GD) is an IGBT-mounted autonomous programmable electronic circuit board that receives the PWM switching command in optical format and converts the same to an electrical command with the power levels suitable for triggering the IGBT [11].

The GD also monitors the health of the operating IGBT,the rate of increase in the collector-emitter voltage (VCE), device junction temperature and its self-health. The GD is co-located with the IGBT to have minimum loop inductance and stray capacitances in the electrical circuit between the GD and the IGBT gate, as it has significant influences on the performance during high speed switching.

The cooling section provides adequate cooling to the water-cooled IGBT by circulating the de-ionized cooling water through the heat sinks. The VSD also incorporates soft starting, fault stress limiting and overload protection features improving the reliability of the electric motor, mechanical power transmission gears and the propeller.

The VSD output total harmonic distortion (THD) is reduced by suitably designed sine filters or by interlaced switching of multiple IGBT stacks. Typical 12, 18 and 24 pulse inverters have voltage THD of 10, 5 and 3%, respectively.

According to IEEE 519 requirements, the voltage THD should be < 1.2% and the current THD to be < 5%. The AFE has the advantage that the voltage THD is ~5% and they require lesser filters [12]. The contribution of the

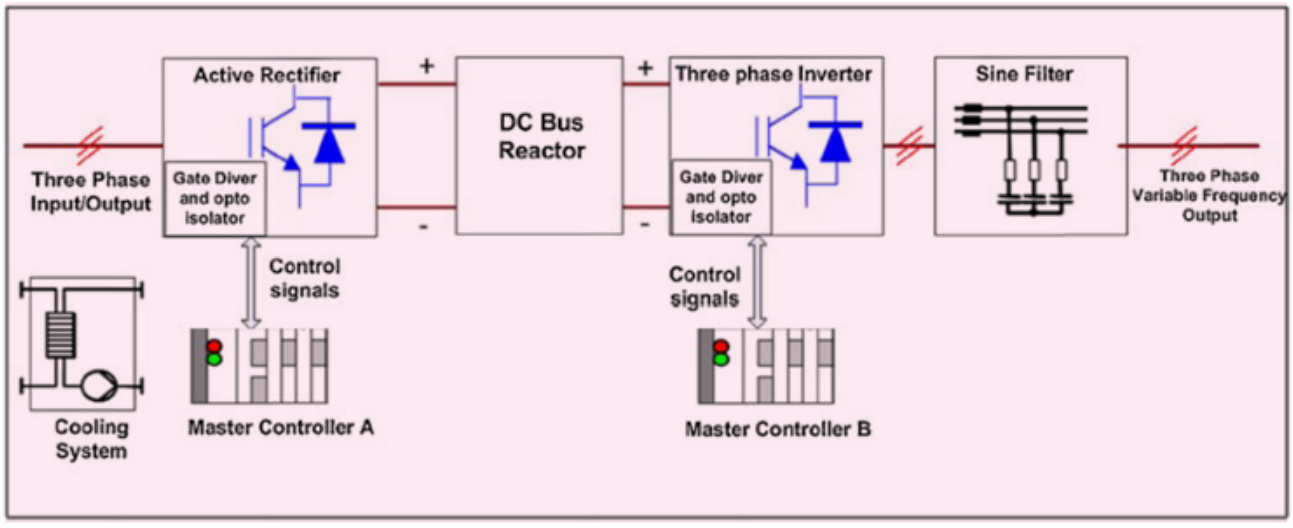


Figure 5. Architecture of a typical MV-MW AFE-VSD

subsystems to VSD failure (**Figure.6**) indicates that the machine side inverter and the mains side AFE inverter contributes to 78% of the VSD failure.

Inverter topologies

The architecture of the mains bridge (AFE) and the machine bridge inverters are based on Neutral Point Piloted (NPP) and Neutral Point Clamped (NPC) topologies (**Figure.7**). The NPP topology does not improve the system efficiency over NPC, but does allow for increased current throughput and potentially higher switching frequencies due to more even distribution of switching losses.

These two advantages of the NPP topology collateral benefits of semiconductor and additionally, in a given application, could reduce the number of phase-legs and therefore the number of semiconductor devices needed. The recently developed press-pack IGBT comprises of IGBT co-packaged with anti-parallel Si-C Junction Barrier Schottky diodes (JBS) features non-snappy voltage recovery characteristics.

Vessel power optimisation using VSD

The power optimisation algorithm implemented in the PMS ensures optimal loading of the vessel generators ensuring fuel efficiency and reduced emission

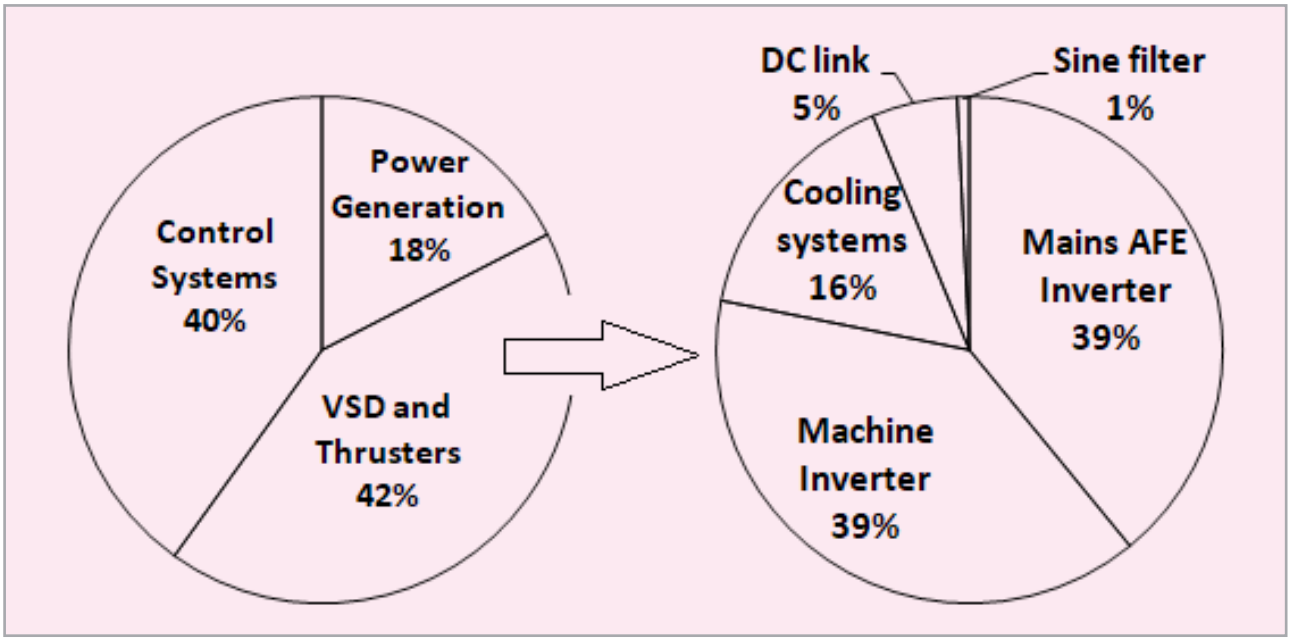


Figure 6.Contribution of subsystems to IEPS &AFE-VSD failure

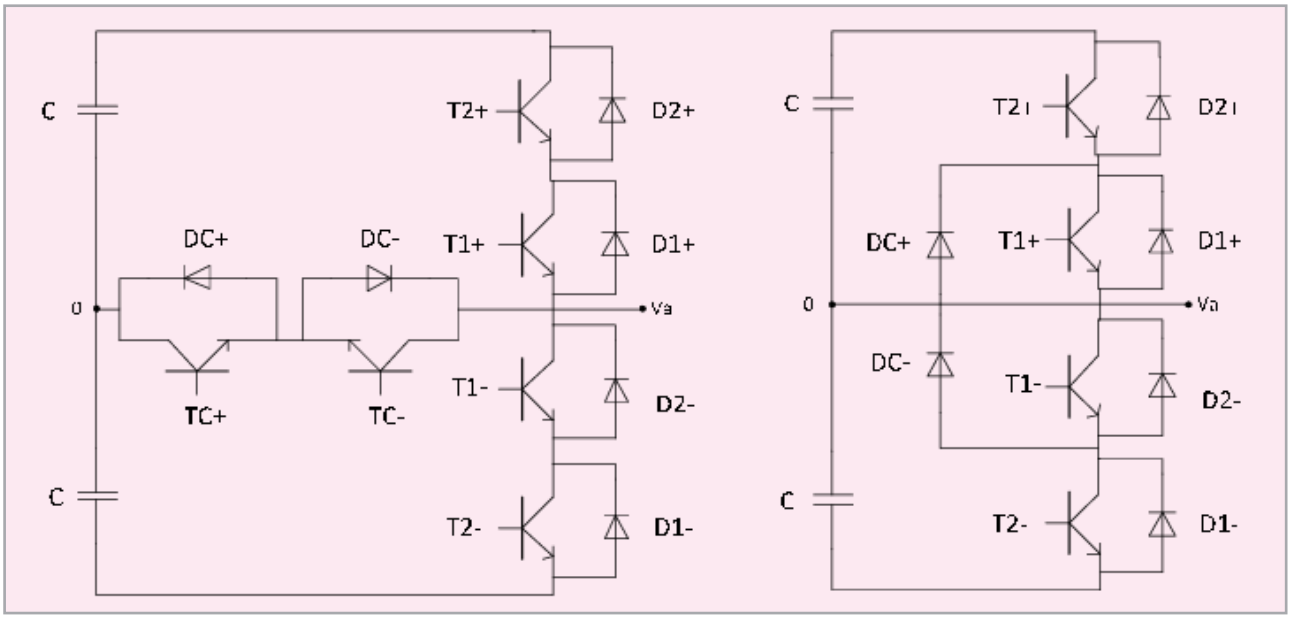


Figure 7. Architecture of inverter NPP and NPC topologies

The power optimisation algorithm implemented in the PMS ensures optimal loading of the vessel generators ensuring fuel efficiency and reduced emission. Intelligent power management is required to deal with the high-level complexity of the IEPS configuration together with dynamic non-linear loads arising from a wide variety of load profiles. The presence of such loads causes marine engines to operate in unpredictable conditions which in turn impair ship fuel/ energy efficiency.

Effective implementation of Equivalent Consumption Minimization Strategy (ECMS) is essential to achieve the International Maritime Organization (IMO) mandated Energy Efficiency Design Index (EEDI), Energy Efficiency Operational Indicator (EEOI) and Ship Energy Efficiency Management Plan (SEEMP) targets [13].

The ECMS-based supervisory control (**Figure.8**) facilitates optimisation of fuel consumption by converting electrical power into the equivalent fuel consumption ensuring optimal load sharing between the power generators and other power sources such as batteries and renewable systems.

During uncertainties in dynamic response and time-varying weather conditions, modern ECMS uses predictive control methods such as Particle Swarm Optimization (PSO) techniques to mitigate power system instabilities and maintaining energy efficiency and reducing emissions [14].

The important component of the ECMS is the propulsion system operated by gallery of propulsion thrusters. Each thruster chain comprises MV-MW-VFD, 3-phase induction motor and fixed-pitch propellers. The azimuth and tunnel thrusters are operated by independent VSD. Majority of the VSD are driven by Voltage Source Inverter (VSI) and Current Source Inverter (CSI), in which VSI is used widely in marine propulsion (**Figure.9**).

The VSI has proven efficiency, reduced harmonic generation, higher reliability, faster dynamic response, lower torque pulsations, reduced common mode noise, operating in a multi-motor configuration and capable of running asynchronous motors without de-rating.

Harmonic filters and electromagnetic compatibility

Increased use of power electronic converters/VSD and other non-linear loads leads to higher harmonic generation and could result in voltage waveform Total

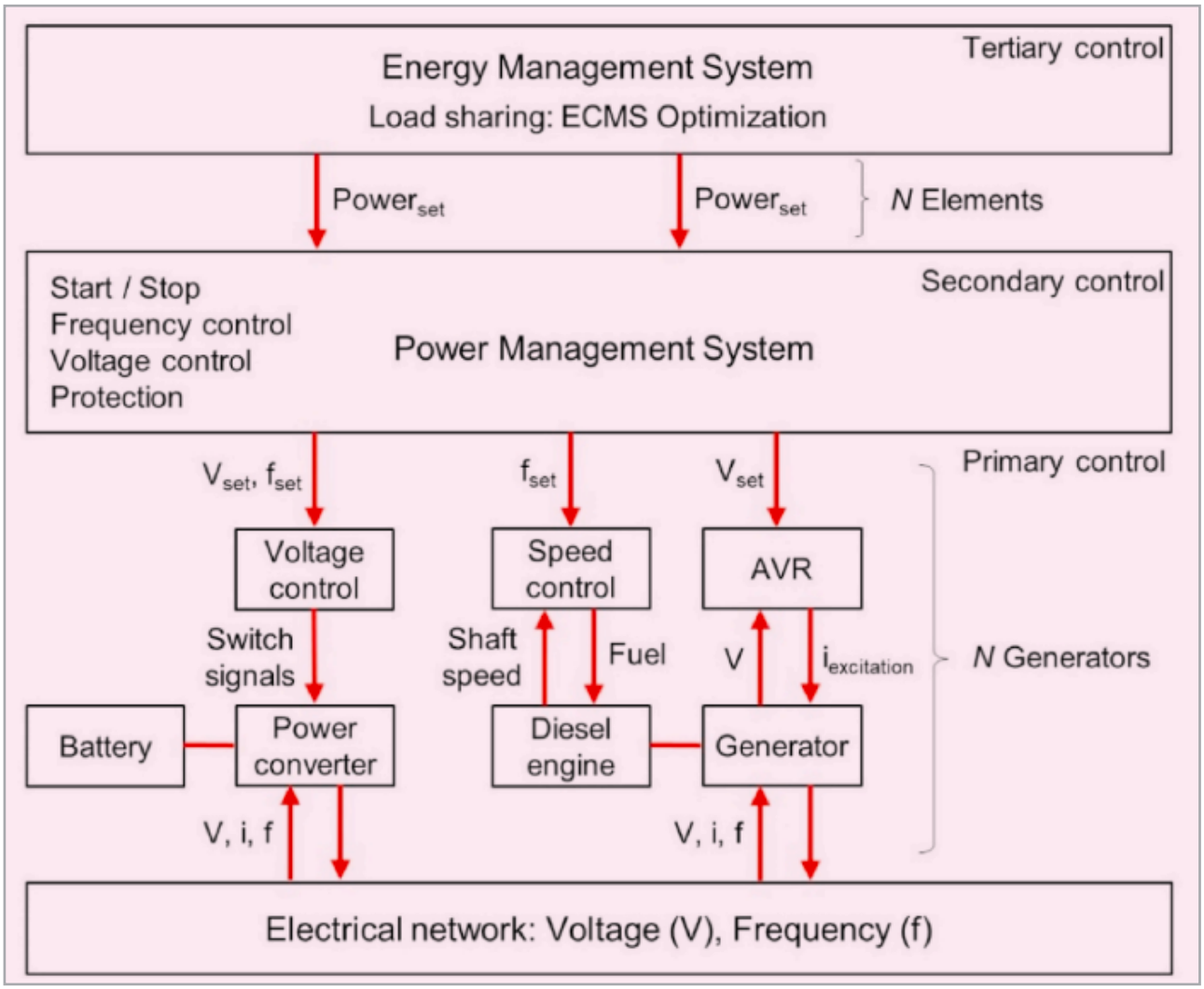


Figure 8. ECMS for marine propulsion

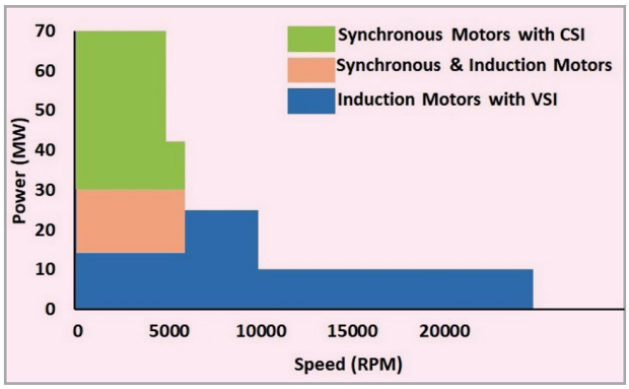


Figure 9. Applications of VSI and CSI configurations

Harmonic Distortion (THD) up to 20%, in which 3rd and 5th harmonics could reach up to 20% of the fundamental, depending on the dynamic loading conditions. The order of the harmonics produced by the multi-pulse VSD depends upon the inverter switching frequency.

These higher order switching harmonics generated by VSD switching are usually mitigated using k-rated converter transformers with multiple phase-shifted secondary windings. The VSD with Active Front End (AFE), capable of regenerating power back to the mains are designed to have a voltage THD at < 5% under all loading patterns.

Harmonics lead to overloading of power factor correction capacitors, motor heating, overloading and heating of transformers, and increased iron losses leading to reduction in efficiency, tripping of protection devices and electric insulation degradation.

For mitigating the harmonics generated by other non-linear loads, passive and active harmonic filters are used. These harmonic filters must be installed as close as possible to the loads that are generating harmonics, as voltage distortion at the point of common coupling (PCC) can be aggravated due to of resonances between the power factor compensation capacitors and the inductance of the distribution systems.

Standards recommend minimum power quality that limits the maximum distortion levels for the voltage supplied at the PCC. According to IEC 61000-2-4 for LV networks, Class 1 and 2 recommend THD of < 5 and 8 %, respectively. Class 2 involves power supply to sensitive electronics systems and Class 3 for normal networks. As power factor correction capacitors are vulnerable to harmonics, IEC 60831 recommends capacitor manufacturers to design with 30% higher than the nominal current [10].

Active filters that inject current at the PCC are categorised as selective Fast Fourier Transform (FFT) and broadband FFT operating techniques. The selective FFT filters respond in 40-50 ms and mitigate only the selected order of the harmonics, while the broadband filters that respond in <100 μs treat all the non-fundamental components, and not just integer harmonics.

Based on the technological trends in the harmonic mitigation systems, DNV-OS-201 A201 section and Section 11 of ABS recommends THD to be <5% as the limit in marine power systems [15] [16]. The international standards that recommend harmonic emission limits for units and systems connected to the network are summarized in **Table.7**.

For electromagnetic compatibility (EMC), International Association of Classification Societies (IACS) Unified Requirements UR-E10 covers minimum standards for equipment on-board commercial ships.

The SOLAS convention is supplemented with IEC 60533 and 945 standards for EMC regulations for operational and safety of on-board electrical and electronics equipment. They cover equipment steady state and transient immunity tests with conducted and radiated emissions in the range of 10kHz-30MHz and 50kHz-2 GHz, respectively.

Conclusions

The reliability of the propulsion, protection and life support power systems in an Integrated Electric Power System needs careful evaluation during the design and operational phases, as the ramifications of non-operation or mal-function could be catastrophic. Hence, safety-centered system engineering with a reasonable reliability, safety and efficiency trade-off is essential for multi-megawatt vessel power systems.

The first part of the article discussed the maturity of marine power system components, importance of RAMS-centered system engineering and developments in the RAMS computation tools. The second part discussed on the integrated approach to RAMS estimation, power system protection coordination based on current-time characteristics and methods for determining SIL-compliant circuit breaking based on numerical tools with field-failure data as inputs. The third part of the article discussed the methodologies for determining the proof test intervals for emergency diesel generator sets and uninterrupted power supplies.

Various possible induction motor failure modes, winding and rotor fault detection methods and bearing failures are detailed. The importance of off-line and on-line condition assessment methods for motors and transformers were discussed. The developments in the active magnetic bearings and its reliability are presented.

Table.7. Standards on harmonic emission limits [4]

Standard	Tests
IEC-61000-2	EMC for LF conducted emissions in LV networks
IEC-61000-3	Limits for harmonic current emissions
IEEE-519-2014	Practices and requirements for harmonic control in electric power systems

This part the article describes the advantages of ungrounded neutral, recent developments in online insulation monitoring techniques and the need for higher insulation voltage to withstand ground faults, the stringent quality needs for marine grade power cables, their integrity monitoring and the ampacity de-rating for multi-layered configurations with the help of finite element analysis tools, maturing variable speed propulsion drives and inverter topologies, role of variable speed drives in vessel power optimisation and regulations for electromagnetic compatibility.

The fifth part, taking into consideration the importance of reliability of the propulsion systems during vessel critical maneuvers and operations, shall describe methodologies for reducing the failure rate of the active-front-end high power density variable speed propulsion drives by incorporating dynamic redundancy in the inverter power electronics. Based on dynamic redundancy, the reliability assessments for various classes of dynamic positioning systems are computed.

The importance of RAMS in the strategic marine sector including autonomous ships, subsea boosting systems, renewable power grids, offshore power transmission and remotely operated vehicles shall be discussed in the sixth part, published in two parts. It is evident that RAMS studies based on field-failure data shall be of immense help in identifying a tradeoff betweenthe capital investments, operating expenditure, redundancy requirements, system modularity and maintainability, as well as meet the stringent regulatory requirements.

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LUBE MATTERS # 8
COLLECTING REPRESENTATIVE OIL SAMPLES

Sanjiv Wazir

Introduction

Without a representative sample, the oil testing & analysis is meaningless and may lead to dreadfully inaccurate conclusions. **A 120 ml sample may represent a small percentage of the oil in the system being evaluated**. The aim of good sampling should be to collect data-dense samples without causing excessive data disturbance. Good collecting practices, well located sampling points and proper sampling equipment must be considered.

Good collecting practices

1. Collect samples under normal, stable operating conditions & temperatures. Sample collected when equipment is idle is not representative of the oil flow during operation. If sampling during operation is not possible (for example, safety considerations, etc.), run the machine for at least an hour and collect samples within 5–30 minutes after shutdown.

2. Collect samples that are representative of the oil lubricating the operating components. Sample downstream of machinery components such as bearings, gears, pistons, cams, etc. and upstream of filters, separators, dehumidifiers. Sample from the drain plug at the bottom of the reservoir is unlikely to be representative.

3. Ensure sample lines, sample points, sample bottles, sampling equipment (suction pump, extra tubing, sampling valve, etc.) are flushed. Sampling site should be selected, and samples collected, in a manner that does not allow contamination of the sampling process. If necessary, install a dedicated sample valve for ease of collecting clean samples safely.

4. Collect subsequent samples from the same sampling point. Otherwise, trend analysis may be skewed. Wrongly identified sample points are a frequent cause of errors. Attach sample point tags to the sampling points.

5. Sample bottles should be filled to the fill mark on the bottle (usually 90% of bottle capacity). This minimises chance of leakage but leaves some ullage to enable lab to give it a shake & stir up the contents, before extracting for testing. For thick/viscous oil samples (> 150 cSt@40C) leave about 25% ullage.

6. Do not sample within 24 hours of an oil change or after a large top-up/sweetening. Allow the system time to reach a level of chemical and physical equilibrium before collecting the sample.

7. Sampling from high pressure and high temperature systems should be undertaken with appropriate caution and proper gear.

Choosing good sampling points

Often machines are not equipped with sampling valves. Sometimes it is observed that the operator needs to remove some fitting (for example, a pressure gauge) to be able to collect a sample. It is important to fit dedicated sampling valve at an appropriate point.

1. Sample from a pipe should be collected from a location with turbulent conditions. Turbulence keeps particles entrained in the oil.

2. If the pipe is large and flow is laminar, sample should be from near the centre of the pipe, not from bottom where old debris may be accumulating, to avoid getting the sample contaminated by precipitated sludge. Or locate sampling valve at elbow or sharp bend **(Figure. 1)**

Figure 1. Sampling from a turbulent zone (Ref. 2)

3. In the case of horizontal piping with a low flow condition with a risk of deposits in the bottom, the sampling valve should be placed near the side or top of the pipe instead of the bottom.
4. While sampling the content of tanks, collect the samples from near the centre and well clear of the bottom or the sides. A tube attached to a sampling port installed on the sidewall may enable capture the sample from the area of interest.
5. Some suggested sampling locations **(Figures 2,3,4,5)**.

Appropriate Sampling equipment

Sample Bottles

1. Sampling bottles come in many shapes and sizes. 120 ml PET (clear) or HDPE (opaque) are the most common. Where particulate contamination is a major concern, use of "Super Clean" bottles that have been cleaned by filtered compressed air may be considered.
2. Ensure all materials used for the sample collection are kept clean and uncontaminated.
3. Ensure bottle is capped and sealed immediately after it has been filled. Label the bottle correctly & place it in the provided plastic bag & seal the bag **(Figure 6)**.
4. Label the sample bottles immediately after sampling to prevent mix-up of samples. Wrongly identified samples are a common source of errors.

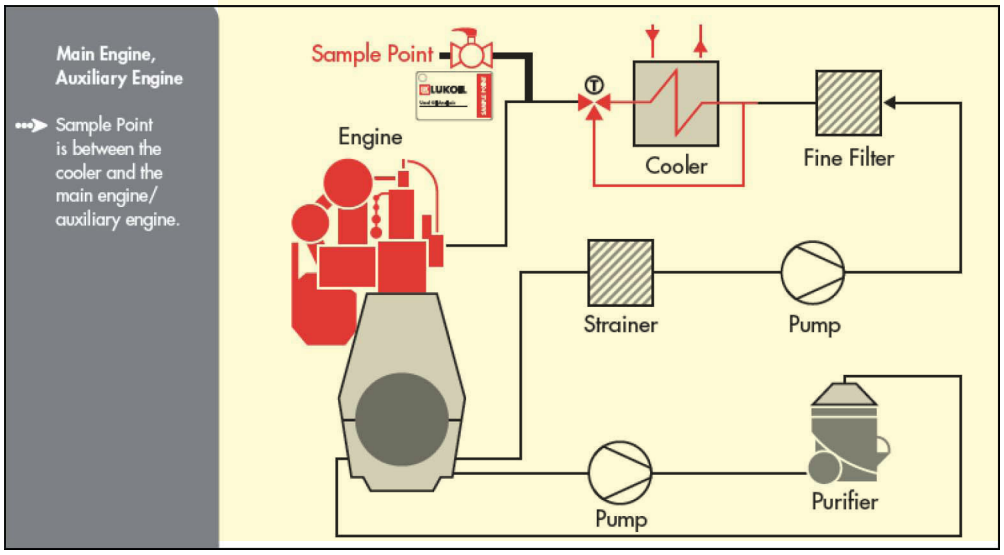

Figure 2. Sampling from Main Engine/Auxiliary Engine (Ref. 3)

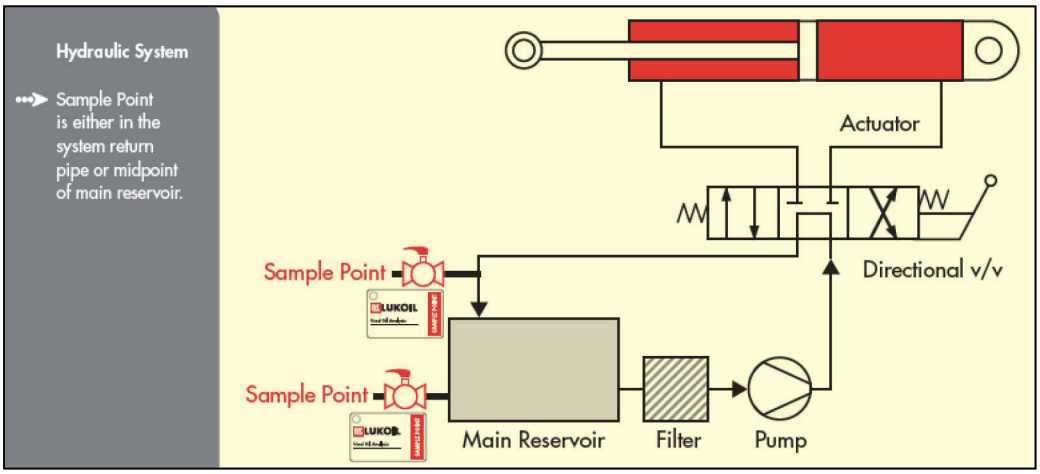

Figure 3. Sampling from Hydraulic System (Ref. 3)

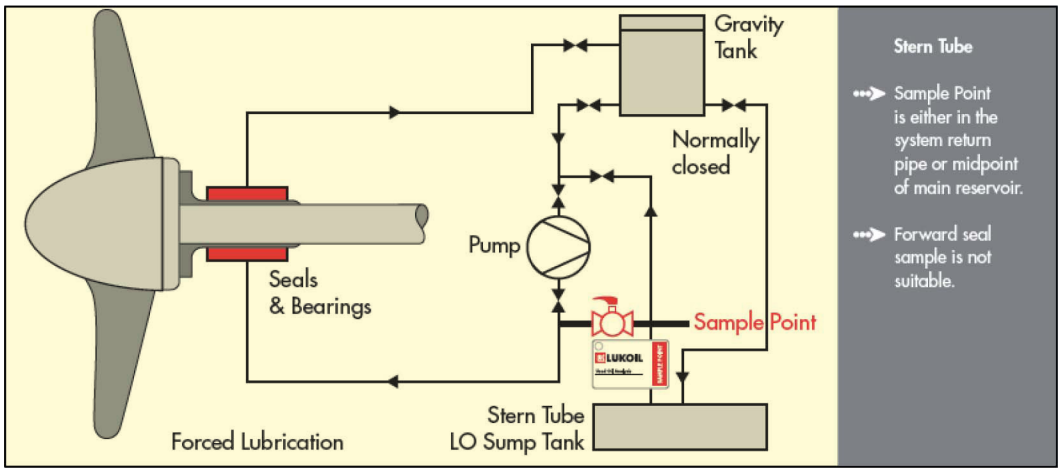

Figure 4. Sampling from Stern Tube (Ref. 3)

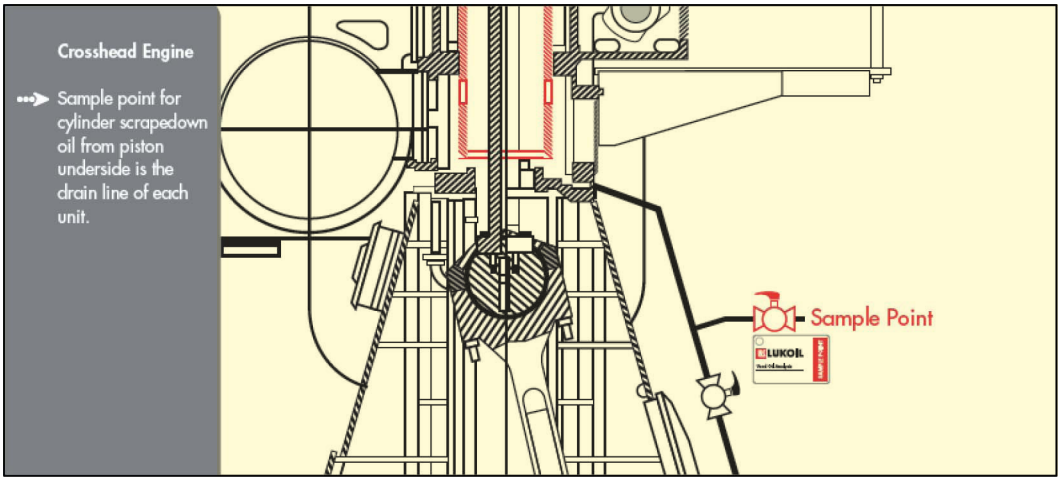

Figure 5. Samples for Cylinder Scrape-down Analysis (Ref. 3)

Figure 6. Sample collected, labelled, packed & ready for dispatch (Ref. 3)

5. The label attached to the sample bottle should be accurately filled. To ensure prompt testing and proper analysis, key information such as the name of the vessel, type/make of engine, type of lubricant, date of sampling and engine service hours & oil service hours are important. Errors and omissions in the label may delay the testing & make commenting difficult **(Figure 7)**.

Sampling accessories

Sometimes it is difficult to collect representative samples from the most desirable location. A wide variety of sampling accessories are available for collecting samples from special or difficult to reach places. Operators should evaluate the necessity for such devices **(Figure 8)**.

Sampling Interval

Trending of the test results is an important part and goal of oil analysis. Usually, the trending is done as a function of time or running hours. Graphical plotting of the trends can highlight any significant deviation from the normal trends and can trigger deeper investigation.

To monitor results as a function of time it is important to collect samples at regular intervals, which are usually defined by equipment makers, or the oil supply companies. The intervals may be optimised after sufficient data has been collected and trends analysed. The following guidelines should be kept in mind (Ref 2):

- Safety Risk (i.e., loss of life or limb if catastrophic failure occurs)
- Criticality of equipment (or lack of redundancy)

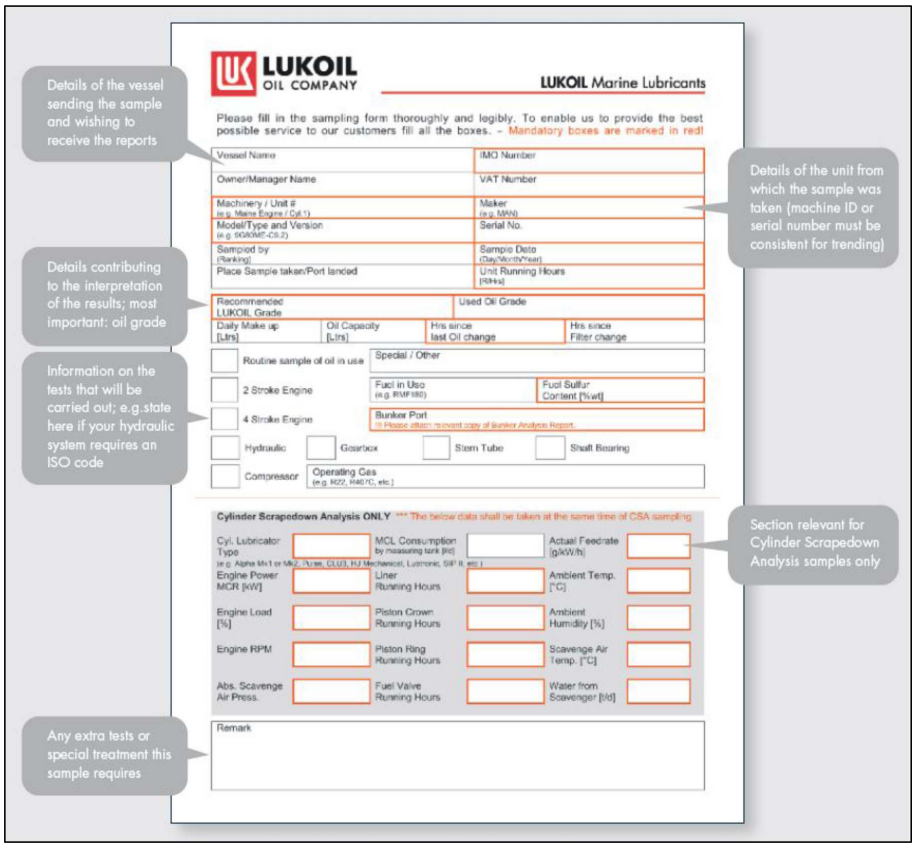

Figure 7. Example of sample label (Ref. 3)

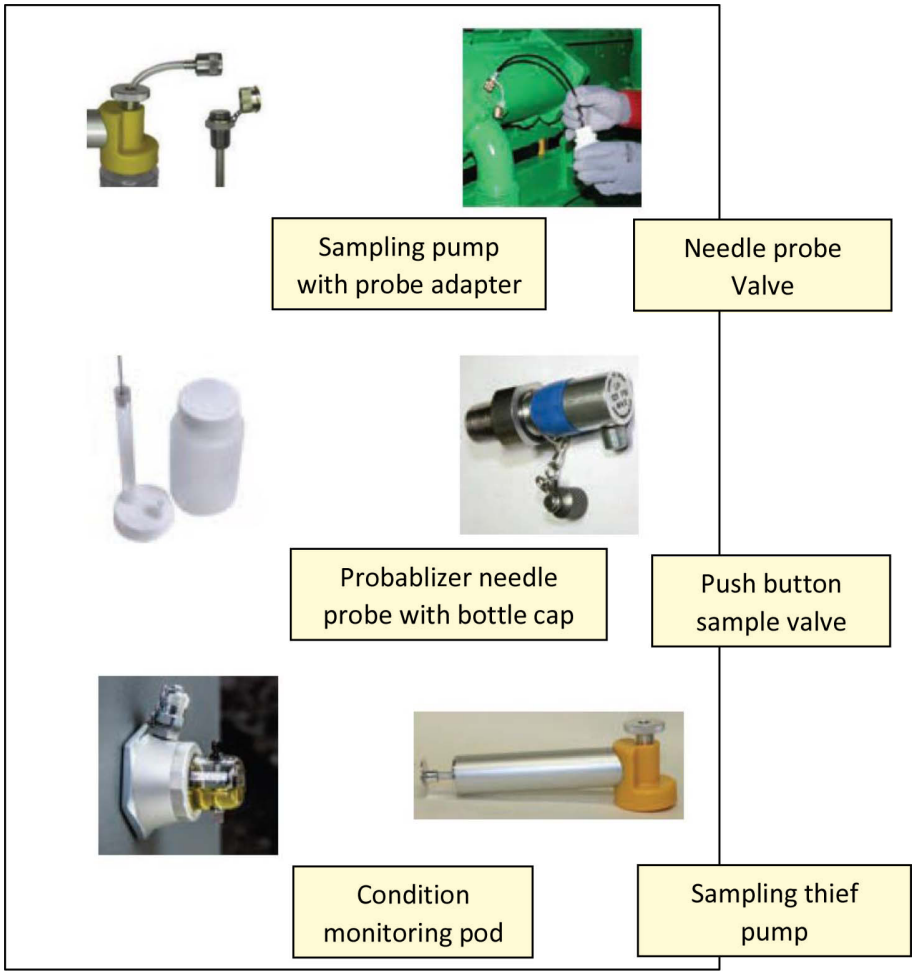

Figure 8. Some examples of sampling accessories (Ref. 2)

- Environment (wet, dry etc.)
- Operating conditions (load, speed, vibrations)
- What is the failure history?
- How costly is a failure? In repair cost/ Lost production/ Life and safety
- Have operating conditions changed to put more stress on the machine?

Conclusions

Analysis of used lubricants can provide information of lubricant condition and contamination as well as component wear. It can help predict or provide early warning of lubricant or machine failure. Collecting representative samples is essential to get meaningful diagnosis and actionable decisions. Sample collection should be conducted by personnel who are trained and understand that the samples play a pivotal role in the condition monitoring program.

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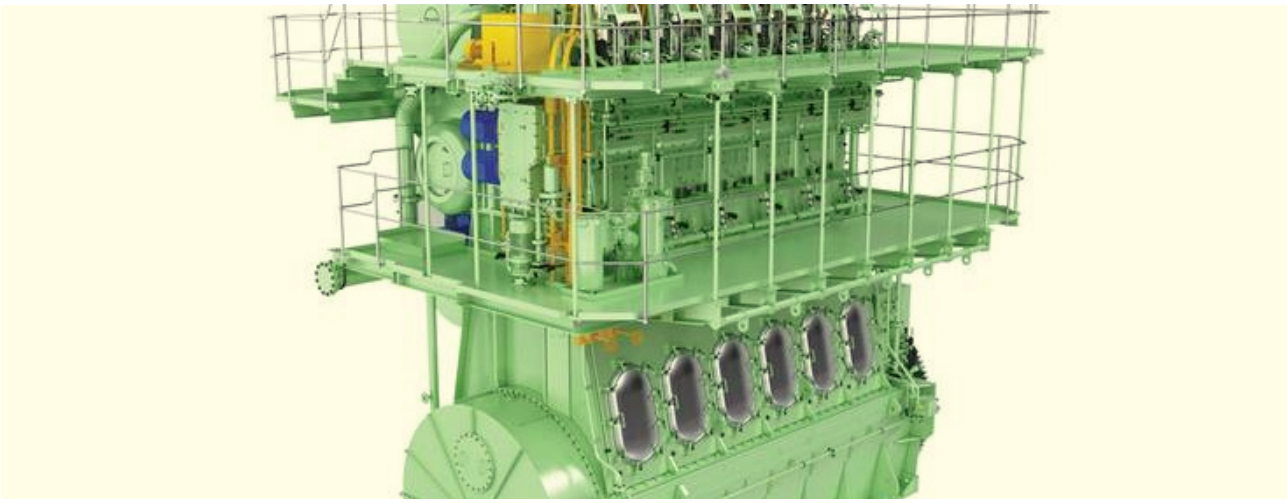
APPLICATION OF MILLER CYCLE ON 2-STROKE ENGINE WITH NO DEVIATION IN THE EXHAUST VALVE TIMING



Kumar Pratyash

Introduction

In uni-flow scavenging systems, the fresh charge air enters through piston controlled ports i.e. scavenging depends upon the movement of piston. For applying Miller Cycle on such engine, the only possible way is to change the exhaust valve timing. In this article, we will discuss a method by which we can change the scavenge timing with no deviation in the exhaust valve timing, which will result in decreasing the effective compression ratio. Thus, we will be able to achieve a good fuel economy, improved thermal efficiency and reduction in NOx emissions.

Miller Cycle and its application

In the conventional internal combustion engine compression and expansion ratios are same. With the introduction of Miller cycle, it was observed that larger the expansion ratio (than the compression ratio), it resulted in more effective expansion and more work and lower compression ratio resulted in lower combustion temperature with reduced NOx emissions. It was also observed that with the same amount of fuel more work can be extracted which reduced the Brake Specific Fuel Consumption (BSFC). One way to achieve a different compression ratio to expansion ratio is by altering the crank design which could increase the costs manifold than a normal arrangement. A simpler way to simulate different ratio is to decrease the amount of air and fuel in intake stroke.

Applying the Miller cycle solves this problem as in Miller cycle intake valve remains open for some duration during the intake resulting in fulfilment of the above requirement.

Above cycle can be easily applied in 4-stroke engines as the timing of the intake valve can be altered. But in case of 2-stroke engine with uni-flow scavenging system fresh air intake is dependent on the movement of the piston which cannot be changed. So, we change the exhaust valve timing.

For applying the Miller cycle on 2-stroke engine without interfering with the timing of exhaust valve, we will fabricate extra scavenge ports above the scavenge ports already present. After the fabrication, we will put cylindrical metal ring for covering the extra scavenge ports. This ring can be rotated with the help of hydraulic, pneumatic system or simple worm gear assembly **(Figures 1, 2)**.

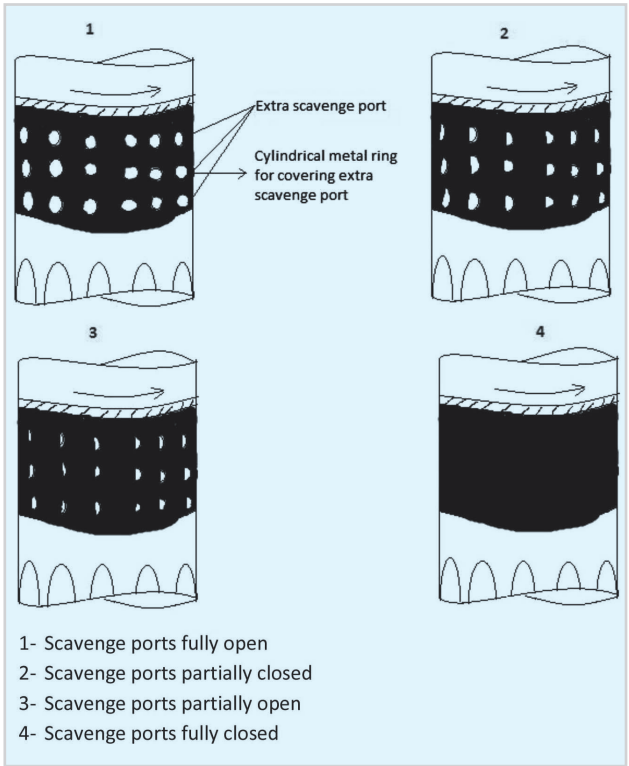


Figure 1. Rotation of cylindrical metallic ring and effect on the scavenge port

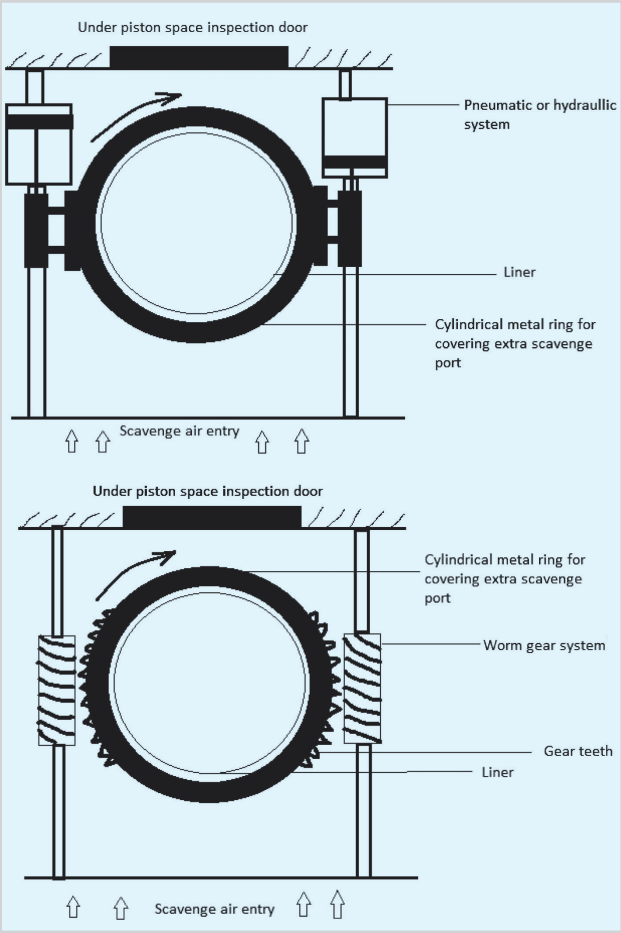


Figure 2. Arrangement for the rotation of the cylindrical metal ring

Rotation of the ring will result in opening and closing of the ports. When the port is in open condition, starting of compression is delayed which will result in lower compression ratio and when in power stroke the ports will be closed and thus more time for expansion.

Expansion ratio > Compression ratio

The compression ratio should be kept to a level such that neither is too high as it causes knocking and nor is too low as it results in pressure ratio required for turbocharger to get high, while keeping the expansion ratio higher than compression to ensure high efficiency. Miller cycle should be applied above 70% of MCR so as to obtain higher efficiency and good fuel economy.

To overcome the reduction in volumetric efficiency and engine power, a highly boosted turbocharging system must be used. For example, a two stage turbocharging system can be used.

From the P-V diagram where Miller cycle is applied **(Figure 3)**, we can see that timing for closing of the scavenge ports is changed without changing the timing of exhaust valve and the resultant compression timing is reduced.

Advantages of the Method

- No need to hold exhaust valve more than required as cold scavenge air will bring down the temperature of exhaust manifold.
- Application of Miller cycle in a better way in two stroke engines.
- More work can be drawn with same engine since the expansion is longer.
- Better scavenging can be achieved.
- Also we will have the control over scavenging and expansion time which was impossible to obtain in conventional uni-flow design.
- Easy start-up i.e. you can say better starting capability as more compression i.e. early start of compression can be achieved and hence resulting in reaching the auto ignition temperature earlier. So engine will start easily and quickly.
- Unit wise efficiency can be increased and decreased accordingly to keep up with the demand while keeping the engine balanced.
- Fuel oil saving as in Miller cycle more work is drawn with the same amount of fuel.
- When applied on ultra large long stroke engine difference can be significant.

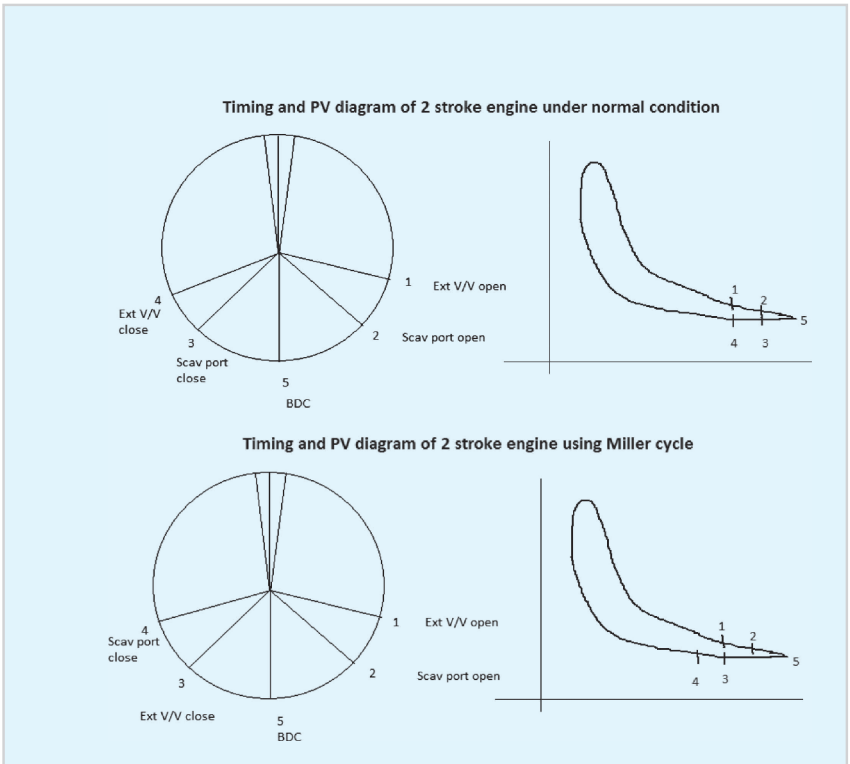


Figure 3. Timing and PV Diagram of 2 stroke engine under normal condition and when using Miller cycle

- Piston encounter less resistance when it moves upwards i.e. it results in reduction in the engine pumping losses.
- Since in cylinder combustion temperature is reduced by reducing the effective compression ratio, which results in **reduction in NOx Specific emissions** as NOx formation occurs at temperature excess of 1200°c.
- This system can be applied on 2-stroke engines already present on board with some modifications.

Maintenance

During the scavenge space and under piston cleaning and inspection, the cylindrical metallic ring should be cleaned and inspected. And if timely maintenance done, it will not cause any safety hazard and will not hinder the performance of the engine.

Cost Effectiveness

As far as cost effectiveness of the system is considered, installation cost is there but with reduction in fuel cost it will be economical in the long run. Also combined with reduction in NOx emission so less dependency on NOx reduction methods.

Conclusion

Above described system is theoretical method with no experimental and practical data. But if applied, we will be able to achieve the true purpose of Miller Cycle. We can also meet NOx emission standards.

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Kumar Pratyash completed his B. Tech. (Marine Eng.) from IMU, Mumbai Port Campus (Batch 2013-2017). After completing graduation, he sailed with Essar Shipping Ltd. He has cleared his MEO Class IV and awaiting sea assignments. He has a keen interest in marine blogging.

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Obituaries

SOLI CAWASJI ENGINEER
(01.04.1949 – 14.01.2022)

Shri. Soli Cawasji Engineer (F112) was an alumni of the Marine Engineering College (DMET) Calcutta. He joined Great Eastern and served for 35 years. He became the President Offshore Division in 2005 and worked in GOL Offshore from 2005 - 2013 and retired as Executive Director and CEO. He was Director in all its subsidiaries in Fujairah, Malaysia, with operations in the North Sea, Brazil and the Middle East. After leaving Great Eastern, he worked as an adviser to Swan Energy on the FSRU project. He was also adviser to ICICI Bank for ABG shipyard and Axis Bank for GOL Offshore.

Being a kind and fun-loving personality, he left a different identity in the hearts of all DMET Colleagues. Words fail to express the depth of our feelings.

SOLI, played like a winner and now he has raced to a new horizon.

(Based on inputs from Shri. Naresh Nanda and others)

VELLANCHERY RAMAN VENKATESAN
(15.05.1964 – 11.01.2022)

Venkatesan (A2722) fondly known as VRV, was a highly valued mentor of students and Faculty alike. An alumnus of DMET, he joined the HIMT Group in 2000 after his sailing years. His teaching style had attracted anyone who had approached him. His videos on various topics and articles in MER will stand in proof.

He will always be remembered as a kind hearted man with a ready smile and a word of encouragement to all. He was a great academician, strict teacher and a valued colleague.

A devoted family man, he is survived by his wife Sunita Venkatesan, and two young children, son Sidharth and daughter Varsha.

10 REASONS WHY DRILL PERFORMANCE IS SUBSTANDARD ONBOARD SHIPS

L S Ganapathy

Ref: Original article by Apostolos Belokas Managing Director, SAFETY4SEA

#1 Exhaustive/excessive number of drills is required

Besides SOLAS/MARPOL etc. requiring 5-6 basic drills, there is also an excessive number of drills required to be performed due to US or other local legislation, ISPS, Anti- Piracy and other SMS requirements bringing the total number in excess of 30 for a Tanker or 25 for a dry bulk carrier.

At the same time, given the lack of guidance the majority of the ships are performing these drills one by one making it a nightmare in terms of effort and paperwork.

That leads many executive teams onboard ships, having to cope with intense workloads, to select to prioritize other ship tasks ahead of drills. In light of this, in order to fully understand how these drills may be better scheduled and prepared, we need firstly to understand the realities and priorities of those working onboard.

#2 The scenarios exercised are not realistic

The majority of the drills are performed on a schedule basis with e.g. every Saturday at a convenient time a fire/abandon ship drill is performed in full day light in calm seas.

However, the majority of the emergencies are happening during heavy weather, not necessarily during daylight and in exactly the opposite way that we train our crews.

Realistic scenarios need to be provided to properly prepare with a full scale emergency, e.g. heavy weather, hull failure, and flooding, personal injury and helicopter operations.

Furthermore, real life constraints have to be taken into account as in many parts of the world lifeboat lowering maybe prohibited due to port or terminal restrictions.

The need to plan and execute drills in groups (say one large scale drill every quarter) is of paramount importance not only for injecting reality to these emergencies but also for minimising the burden of disruption of shipboard operations.

#3 Drill performance criteria are not set

In order to properly perform any given task, we need a performance specification as well as description of the roles and responsibilities and expected outcomes.

Onboard ships all these items are missing as drills are not properly planned before they are performed, with the exception of fire/abandon where we have a Muster List/Station Bill; however, in all other cases we are missing guidance on who does what.

Therefore, it would be nice to introduce Muster List/Station Bills or simple Roles & Responsibilities for each scenario or combined scenario with any role properly described and rehearsed.

Furthermore, checklists need to be in place for the preparation, execution and evaluation of each drill with guidance to all involved. As long as we do not analyse what is expected from each crew member, it is inevitable that they will not be able to perform.

#4 Crew responsibilities are not properly set/defined

As said above, not all crew need to participate in all drills and we have to make sure that they know it. Instructions are needed such as security muster list and station bill, and detailed guidance for every scenario such as collision, hull failure, muster station bill and so on and so forth, in order the crew to be properly prepared on the roles, responsibilities and expectations before a drill is set.

Planning is required with a discussion upfront on what the objective is and what it is expected from all participants.

At the end, feedback is vital both onboard and shore to ensure improvements are observed.

#5 Real Life needs are not addressed at the Drill Plan

When we are having real life emergencies, there are many instances that we need to drill in advance; it may be an ECDIS failure, a lack of GPS signal, a malfunction of the ballast water treatment system, an integrated Anti-Piracy Drill with the assistance of an armed team of PMSC, use of citadel, an entrance to a contaminated cargo tank or any other dangerous enclosed space with the use of an emergency escape breathing device for safety maintenance or rescue reasons.

It may be anything that has to do with the introduction of new technology or even the real life need to have people forming an enclosed space entry team while speaking the same language.

These real life emergencies need to be identified and addressed within the plan to make it worth in the long run.

#6 The way we execute drills is not in line with ship practices

Let's take the example of the fire drill:

SOLAS requires every member of the crew to participate in a fire drill every month but we have several different types of fires with totally different response strategies and tactics as well as areas happening onboard ships, e.g. fire in accommodation, in engine room, in the galley, in the cargo spaces or at the terminal, where we have to co-operate with the shore side.

As we are not properly analysing these real life needs and we don't properly present/explain the different response scenarios, we cannot expect the crew to properly perform a real life scenario.

There are numerous instances where crews have not been able to properly perform, for example, a fire drill in the galley int the presence of the coast guard.

In that respect, we are missing guidance from either industry bodies or company SMS (how often, what, when, where, how etc.) along with a set of best practices to be employed.

#7 Industry is having a paper work approach

To set it straight:

Have you done it? Show me the record! In many instances captains are having to face the challenge of keeping the records straight, along with increased workload or heavy weather or other unforeseen operational circumstances; but at the end of the day, 3rd parties (Auditors, Authorities, Inspectors etc.) are always asking for records that showcase if drills are being conducted as required etc.

#8 Paper work upkeeping is a nightmare

The only legislative requirement to have proof of every member of the crew participating in a drill every month comes with SOLAS Fire/Abandon ship requirements.

However, the majority of operators have taken it to the other extreme requesting record keeping for all drills and all members of the crew and creating a chaos with respect to record keeping.

Now many ship operators are requiring a risk assessment before you conduct a drill, plus a permit to conduct a drill, plus the record keeping requirements for work and rest hours that makes the whole issue a worst nightmare, especially when someone starts checking to identify same timings, signatures, marks from the copy machine etc...

#9 Drill performances is not audited in real life

We haven't seen the majority of the ship managers and operators auditing real life drills as part of a ship board attendance or as part audit of the ship or even having a 3rd party expert to train the crew, observe and provide immediate and effective feedback with the objective to improve performance.

One of the best practices observed across the industry is to video record (even with a smartphone) these trainings to circulate same across the fleet with or without video editing as a real life tool to improve fleet wide.

#10 No KPIs are set to monitor Drill Performance (Key Performance Indicator=KPI)

The industry has failed to identify and implement a set of KPIs to monitor drill performance such as:

- Number or % of drills not performed on scheduled time for any reason
- Number or % of crew not performed properly during a drill
- Number of % of violations of Rest hours due to participation in a drill
- Hours spend per person per month onboard ship to attend drills

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DEAD WHALES CAN BE SPEED-BREAKERS

Naresh Kumar Mishra

In the recent past it has been observed that human-related threats to endangered large whale species are diminishing and a number of large whale populations are increasing in abundance. However, injuries and deaths resulting from ship collisions with whales remain a significant threat. In North Atlantic right whales, for example, ship strikes are a primary culprit in the slowed recovery of a highly depleted population. Several papers provide accounts of mortality in large whales due to ship strikes (Laist et al., 2001; Best et al., 2001; Knowlton and Kraus, 2001). These papers review ship strike records through 2000, 1997 and 1999, respectively.

Likely, many ship strikes go undetected or unreported as they may occur in remote areas or struck whales may drift out to sea. Thus, the actual number of strikes is undoubtedly much greater than reported. Direct reports from ships, crew and captains are the most reliable source of information on an actual ship strike incident. In these cases, wherein the ship's crew was aware of the strike, it is often possible to obtain information on ship speed, damage to a ship and relative degree of severity of the strike to the animal. In such cases, there generally is no information on how, when, or where the strike actually occurred.

A dead stranded whale may drift a considerable distance from the site of the actual impact. Another type of record as shown in **Figure 1** is the occurrence of a ship entering port with a whale carcass draped across its bow. Generally, in these instances the ship's crew was unaware of the strike. Most often this occurs with large container, tanker and cruise ships, and a collision is only determined after the event when the whale is noticed pinned to a ship's bow by a pilot boarding the vessel or lookouts posted for harbour entry. In the known or probable cases of ship strike, evidence of a collision was only noticed when a whale was brought into harbour on the bow of a large vessel. In certain rare instances, time and location of impact can be estimated by back-calculating to correlate with a previously unexplained decrease in vessel speed.

Although the data provide valuable information regarding the wide range of vessels involved in collisions, care should be taken in interpreting these numbers. As noted earlier, captains of large ships, such as container ships, tankers, and cruise ships may not be aware that a collision with a whale has occurred and thus do not report the incident. It is also likely that captains of ships of all sizes who are under no obligation to report, in fact, do not, out of apathy or fear of enforcement consequences.

Figure 1. Images showing Dead whale struck on the Bulbous of the large ships

In addition to vessel damage, ship strikes to large whales can also pose a hazard to human safety. In several cases, particularly with small vessels and fast-moving vessels (e.g., ferries), passengers have been knocked off their feet or even thrown from the boat upon impact with a whale.

A similar incident took place in 2005 when the author was working as Technical Manager for a company based in Hong Kong. Since the incident is one of its kind and quite uncommon, the author has shared the incident with the fraternity through this article. The vessel sailed out from Singapore after the completion of dry-dock and was bound for east coast USA. It was a midsized, pure car carrier (PCC) with a service speed of 15.5 Knots. After sailing out from Singapore, technical team with the ship owner's technical superintendent were monitoring the performance of vessel. With the cleaning of hull as shown in **Figure 2**, it was expected to reduce the resistance of the ship's hull and in turn cause reduction in the fuel consumption.

Moreover, it was also expected that for the same fuel consumption, an increase in the speed of about 1.0-1.5 knots prior docking. With the good weather on offer, Ship achieved the speed of 17.0 knots i.e. 1.5 knots more than the speed prior docking. It was more than what was expected and the owners were happy about the vessel's performance. After about 20 days in good weather, when vessel entered north Atlantic, the vessel encountered bad weather. The vessel faced heavy pitching and rolling and after 3 days, the weather subsided.

However, suddenly, it was observed that with the same fuel consumption, the vessel's speed had dropped to 14.5 knots. It was a matter of concern and so the managers started investigating the behaviour of the vessel. The following parameters were checked during the investigation.

- All main engine parameters suggested that it is running at higher load than before the ship encountered rough weather. Average exhaust temperature was about 20o Celsius higher than before.
- Engine load was higher than before suggesting an increase in resistance of the ship, caused by some obvious reasons.
- Vessel was on ballast passage and all parameters were measured and were found to be corresponding with the load indicator.
- Turbocharger rpm was marginally higher, but other parameters indicated high load on the engine.
- Since governor was also had been overhauled, makers of the same have been contacted. However, all efforts went in vain with no fruitful outcomes from the same. All linkages of governor were inspected for undue play but found none.
- All tanks were sounded for any issue, however, that also went in vain, with no desirable results.

Nothing could explain an increase in the load on the engine. Even after the two days, crew of the ship were struggling to ascertain the cause and rectify the fault. Author asked the Master if he observed any difference in vessel's behaviour after the passing of bad weather for which he confirmed none. However, Chief engineer said that he observed change in the wave pattern developed by the bow of the hull. It was an educational input provided by him which needed an investigation. Author requested the Master to investigate the reason for the change in the wave pattern developed. Crew of the vessel were expecting a damage to bulbous bow which has altered wave pattern, which could have resulted in an increase in the resistance of the ship, in turn causing reduction in the ship's speed.

The Master with his team started inspecting the ship's hull to ascertain the point of altered wave pattern at the bow. The fore peak tank and spaces around were internally inspected and no damage was observed. However, when the Master leaned down to see the bulbous bow, he saw a whale stuck at the bulbous bow, which resulted in an increase in the included angle of divergent waves developed by the ship's hull as proposed by the Kelvin's wave pattern shown in **Figure 3**. Master arranged to push the whale from the bulbous bow by stopping the ship and using hooks.

Vessel was restarted and brought to service speed, the load on the engine came down and also the fuel

Figure 2. Images showing Ship's hull before and after cleaning it

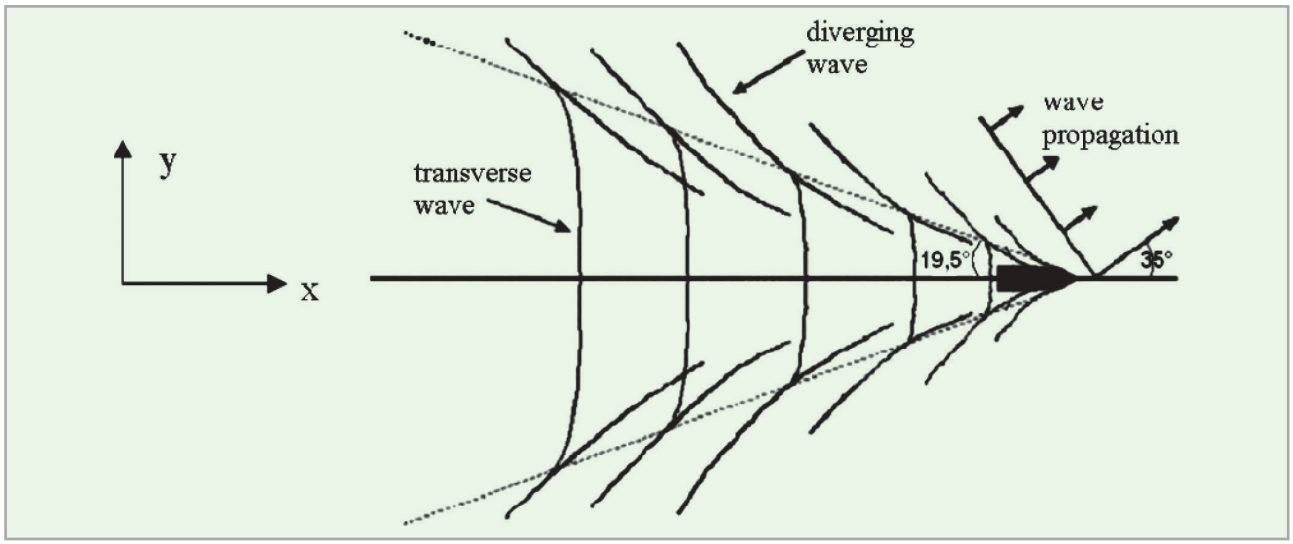

Figure 3. Typical wave pattern developed by the moving ship

consumption, obviously as resulted from the investigation, the culprit was the dead whale. Although the whale may be weighing just about 100 MT (estimated as per size), the increase in weight could not have caused the reduction in speed and increase in main engine load.

To understand the reasons for the reduction in the ship's speed, it is pertinent to have the knowledge of resistance of the ship. As a ship moves through calm water, the ship experiences a force acting opposite to its direction of motion. This force is the water's resistance to the motion of the ship, which is referred to as "total hull resistance" (R_T). Force required to pull or push a bare hull of the ship at a constant speed in a straight line but in still water is known as the Resistance of the ship. A ship's calm water resistance is a function of many factors, including ship speed, hull form (draft, beam, length, wetted surface area), and water temperature.

The principle factors affecting ship resistance are the friction and viscous effects of water acting on the hull, the energy required to create and maintain the ship's characteristic bow and stern waves, and the resistance that air provides to ship motion.

$$R_T = R_V + R_W + R_{AA} + R_A + R_E$$

Where,

R_T = Total hull resistance

R_V = Viscous (friction) resistance

R_W = Wave making resistance

R_{AA} = Resistance caused by calm air

R_A = Appendage Resistance

R_E = Eddy Resistance

The following reasons could be attributed to the reduction in the ship's speed.

1. The major component of hull's resistance is the resistance due to wave making. As a ship moves through the water it creates waves. These waves are produced at the bow and stern and propagate outwards from the ship. A ship moving through the water creates two types of wave patterns. They are the divergent and transverse wave systems shown in **Figure 3**. These two types of waves are developed by both bow and the stern of the ship which may cause detrimental wave interference based on the ship's speed and the shape of the ship's hull. The creation of waves requires energy. Any energy expended by the ship to create and maintain these waves represents energy that could have been used to make the ship go faster through the water. This lost energy is referred to as wave making resistance and becomes a limiting factor in the speed of a ship. With the whale struck at the bulbous bow resulted in the altered wave pattern, an increase in the included angle and the height of the divergent waves developed by the ship's bow. Since the energy in a wave depends on the square of the wave height, any increase in wave height requires a subsequent increase in energy required to create the wave, and an increase in wave making resistance.
2. Appendage resistance is the drag caused by all the underwater appendages such as the propeller, propeller shaft, struts, rudder, bilge keels, pit sword, and sea chests. For ships, appendages can account for approximately 2–14% of the total resistance. Appendages will primarily affect the viscous component of resistance as the added surface area of appendages which increases the surface area of viscous friction. With whale struck at the bulbous bow resulted in an increase in the additional appendage resulting in the increase in the wetted surface area of the ship and in turn caused reduction in the ship's speed.
3. The whale must have been dead and floating and during heavy pitching, the dead whale would have got stuck at the niche above bulbous bow. With the addition of weight at the forward end, the CG of the vessel would have shifted proportionately forward. This would have caused an increase in forward trim, which also could be the reason for an increase in the ship's drag.

- 4. With whale struck at the bulbous bow resulted in an increase in the draft of the ship, in turn, an increase in the displacement and the wetted surface of the ship. The ship's resistance increases considerably with an increase in both the above parameters, which caused reduction in the ship's speed.

Conclusion

A number of large whale populations are increasing in abundance. However, injuries and deaths resulting from ship collisions with whales remain a significant threat. In addition to vessel damage, ship strikes to large whales can also pose a hazard to human safety. Author presented here a case of an incident took place in 2005 when the author was working as Technical Manager for a company based in Hong Kong, wherein, a dead whale was struck at the niche of the bulbous bow caused a reduction in the ship's speed by 1.0-1.5 knots. Reasons for the reduction in the ship's speed could be attributed to an increase in the ship's drag due to change in the wave pattern developed by the bow of the vessel, increase in the appendage resistance as if the dead whale is considered as an additional appendage to the vessel, increase in the draft, wetted surface area and the displacement of the ship due to the additional weight of the whale and this addition of the weight at the forward end of the vessel caused a detrimental effect on the ship's drag due to the forward trim of the vessel.

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MODIFICATION IN BRAKING TECHNOLOGY OF SHIPS

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I. INTRODUCTION

Change is required for everything in terms of evolution. Similarly, mode of transport also has a progression in the vast oceanic area with thousands of vessels, million metric tons of cargoes, oil, gas etc., worth billions, and millions of seafarers sailing around the globe. This makes it a vital mode of transport and it has its share of risks. To an industry like this, safety plays the most pivotal role.

Any mode of transport is bound to have accidents. When it comes to shipping industry, though safety aboard has significantly increased in the last decade as claimed by various maritime organisations, the statistics show scary figures. Due to one reason or the other, merchant ships have continued to be involved in accidents.

The accidents have not only resulted in financial losses but have also taken lives of officers and crew aboard. Moreover, the accidents at sea also cause damages to seabed, sea depth, marine traffic, sea surface, habitat and harm the marine ecosystem, flora and fauna. Ultimately, it also impacts the weather and livelihood of the people. This article focusses on an idea to reduce the number of accidents on cargo ships. A design of a 'ECDS AND EBP System' for improved deceleration of the ships to avoid collisions at sea is proposed.

II. STATISTICS

Though many preventive measures are taken and many are worked upon, we get big numbers when we go through the analysis of accidents. There were reasons such as the poor maintenance, lack of proper training, equipment failure, natural calamities and primarily, collisions (**Figure 1**). It was reported that approximately 21325 ships involved in accidents leading to 25000 deaths and 8000 injuries in the period (2007–2020). If we do the

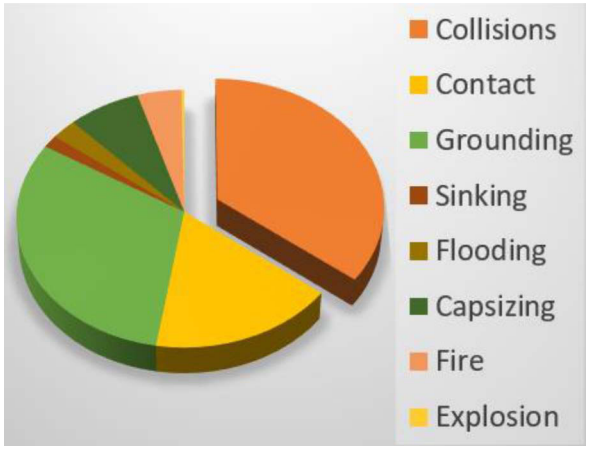


Figure 1. Statistics of collisions, contact and grounding

accident analysis, we find that collisions contribute 36% of the mishaps while vessel-contacts result in 17% of the damage. Summing them up, we get a figure of 53%. So if we focus on avoiding collisions and contact, we would prevent more than half of maritime disasters.

While going through data, we find that 20–25% of vessels involved in maritime accidents are cargo vessels Out of 15,103 ships involved in accidents during (2007–2020), 2848 were cargo vessels as shown by the graph (**Figure 2**). Our idea focuses to reduce the collisions and contact type accidents on cargo and container ships **by reducing the time to stop or decelerate a vessel**.

On an average, the length of such ships are between 200 to 300 meters and the average speed is 20–30 knots and the average time taken to bring such a ship to rest, it takes about 25–30 minutes. Here, the major problem occurs. Ships collide with other ships at periphery of ports and icebergs.

III. PRINCIPLE INVOLVED IN DECELERATION/ BRAKING OF SHIPS

The reason behind the collisions, that is, major part of accidents at sea is the slow deceleration of ship. When we

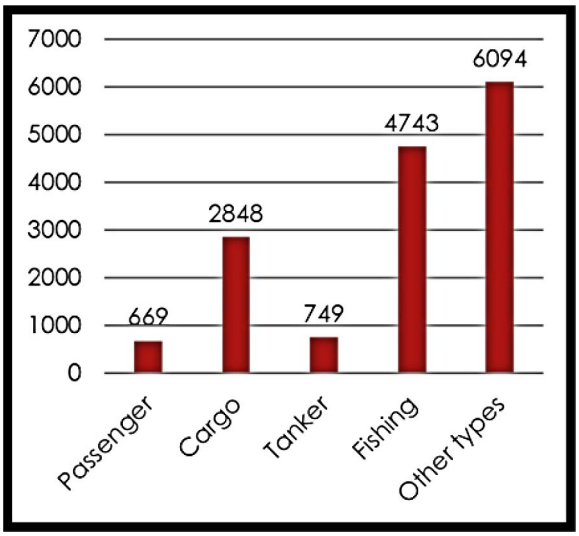
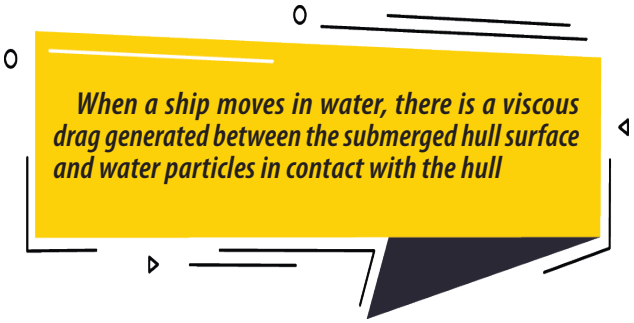


Figure 2. Statistics of passenger, cargo and tanker

look into the functioning of a ship, the ships are brought to rest with the help of propellers and varying function of engine. There are specifically two types of propellers:

1. **Fixed pitch propellers:** In this case, the RPM is lowered first, and then it is brought to no thrust position and ultimately the propeller is rotated in reverse direction to acquire reversal or resistive thrust.
2. **Controllable pitch propellers:** In this case, the propeller is brought to no thrust position by bringing the blades at parallel orientation and here the reversal thrust is acquired by reversing the angle of the blades.

The main concept behind the deceleration of ship is countering the forward thrust by the resistance of the ship. When a ship moves in water, there is a viscous drag generated between the submerged hull surface and water particles in contact with the hull. This drag is generated due to the viscosity of water and is directly proportional to the wetted surface area of the ship and varies to the square of velocity of ship.



Viscous Drag $\propto$ (p) (S) (v^2)

Where, p = density of water, S= wetted surface area, v= velocity of ship.

Therefore, the primary aim of braking any moving object, is to increase the drag force experienced by the body. This can be done in two ways:

1. Increasing the wetted surface area of ship.
2. Decrease the magnitude [or] change the direction of thrust on ship.

The idea herein focuses on executing both. As a solution to the emergency deceleration problems, two mechanisms highlighted are:

1. ECDS (Emergency Cargo Drop Stop) and
2. EBP (Emergency Braking Propellers).

A. EMERGENCY CARGO DROP STOP

This system suggests some part of cargoes on ship (10–15%) to be kept in specially designed boxes that would be ferromagnetic in nature or coated with ferromagnetic substances with the ability to be water repellent. These boxes would be kept on a sliding platform in the hold (hung by ropes), and operated on free fall or hydraulic power system. The boxes would be designed such as that while hanging, these boxes would open into two halves making 45-degree angle between them, this would increase the exposed area and when allowed to touch the sea-bed (when length is approachable) which would act as a POOL type anchor.

This system also will incorporate thick electromagnetic strips running across the hull below the water line. The strips will be activated when the ECDS containers are dropped off (hung by ropes/strings) in the sea water. The activation will be precisely at the moment when the ECDS system starts acting.

When situation is of extreme emergency and urgency to decelerate the ship, the boxes with the platform would slide outwards of the hull (fin like structures stretching

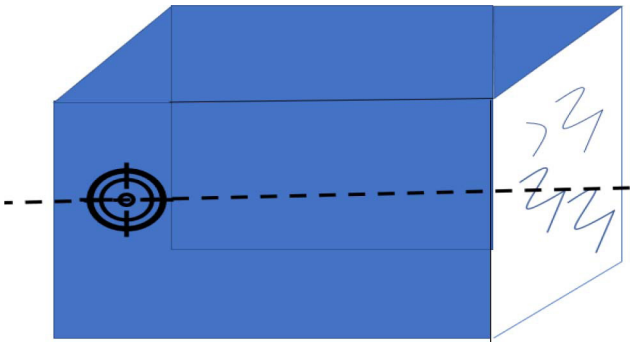


Figure 3. ECDS containers with hinge point

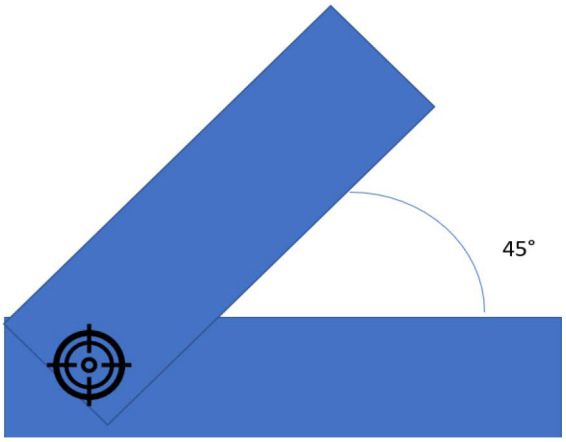


Figure 4. This is the 2 D view how the ECDS containers would open up into two parts. Black circle indicates the hinge point in Figures 3 & 4

out) and the platforms would fall and stay touching the hull while the boxes are dropped. **As soon as the boxes are made to drop into the water, the electromagnets running across the hull will be activated and the boxes would be made to stick to the electromagnetic strips**. The boxes would enhance the amount of the area exposed to the water exponentially adding up to the drag force, ultimately increasing the resistive force. When the ship's speed is lowered as per the need, the electromagnets will be deactivated and the boxes will be heaved up thereafter.

The specially designed ECDS boxes can also be dropped under free fall to the sea bed when the sea bed is not too deep and they can act as anchors.

This ECDS system would come into function with the help of gear box (installation of this should be near the tail shaft of propeller as per our idea) which will be designed in such a way that the translational motion of the platform with ECDS containers starts as soon as the propeller's RPM is set for lowering (in the case of fixed pitch) or when the blades start orienting themselves in parallel direction (in case of controllable pitch).

B. EMERGENCY BRAKING PROPELLERS

The second part of the solution suggests installation of add-on propellers to the already existing propellers but these propellers will be placed in the forward section of the ships. These will completely fit into the ship's side hull, maintaining the streamlined shape of ship and will only come out when EBP button is pressed. They will then drop into sea to the level of stern propeller and will start to operate in a direction so as to oppose the motion of ship. This will increase the resistance offered to the ship's motion. The stern propellers' rpm will be then reduced and with direction reversed, so that it reaches a no thrust position. The speed of stern propellers will then be increased in opposite direction so that it matches the speed of EBP and both the propellers end up having the same RPM, thus maintaining the stability of ship. After the successful deceleration, these EBP can be retracted back to their original position.

These add-on propellers can be used for steering the ships for sharp turns. This design could be worked upon.

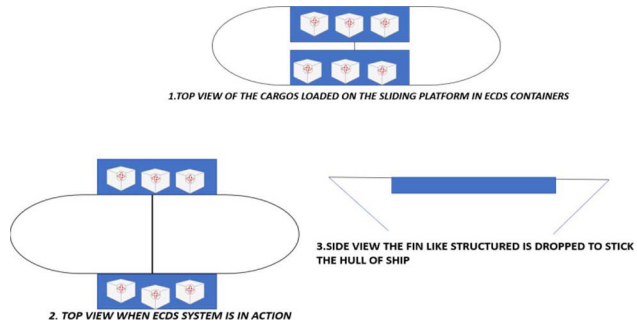


Figure 5. Mechanism of the sliding platform

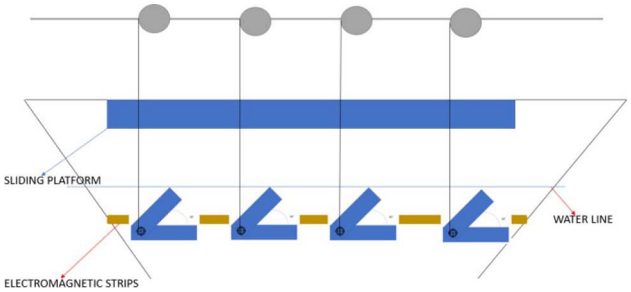


Figure 6. Skeletal depiction of ECDS system
(Brown strip symbolises the electromagnetic strip while the grey structure could be either a pulley operated system, or any mechanical load lifting or lowering device or some hydraulic crane type machinery.)

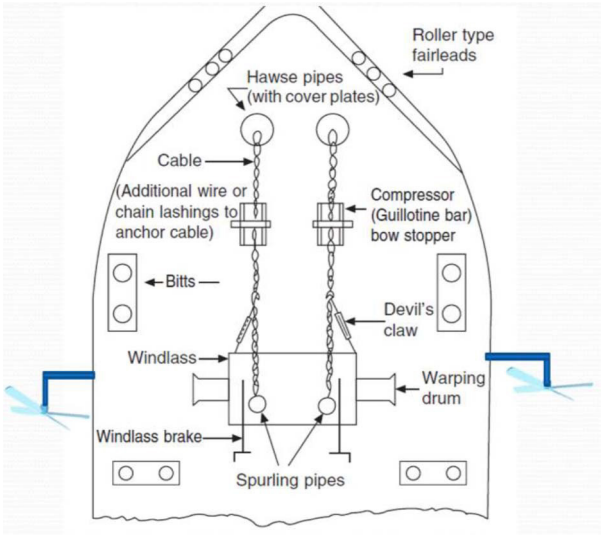


Figure 7. Location of add-on propellers

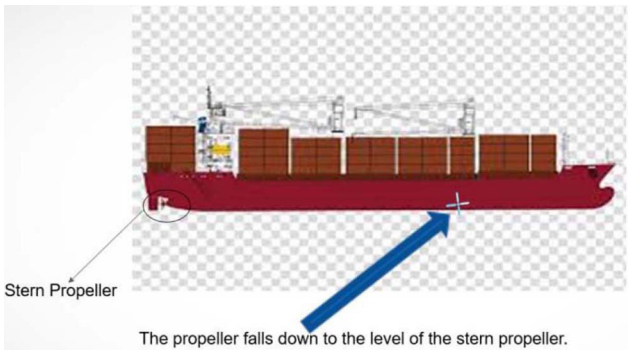


Figure 8. Mechanism of Emergency Braking Propellers System

IV. ADVANTAGES

- Avoid collisions by fast deceleration
- Safety of crew ensured
- Reduced number of collisions implying greater profits for the owners. Though it might result in damaging some part of cargoes which are stored in ECDS containers but would save the vessel with major part of cargo from wreckage.
- Effective even in extreme weather conditions
- Quick and effective braking system with low initiation time

V. DISADVANTAGES

- Might result in the damage of cargoes stored in ECDS containers
- Gear box installation near the tail shaft of the propeller adds to the complexity
- Heaving dropped ECDS containers might cause damages

VI. CONCLUSION

This system could be a solution for dangerous situation of collisions and could be helpful in developing an effective and more efficient crash manoeuvring. Though installation of such system might cost a huge amount, the primary concern and motive of this project is to deliver safer conditions to a situation which is life threatening.

References

[1]. Marine Accidents' statistics, Japan Transport Safety Board
[2]. Accident report, IMO

[This paper was included in the proceedings of the National e-Conference on Energy, Environment and Sustainable Shipping (Organised by IMU Chennai campus & IME(I)in December 2020. This version is published after considerable corrections.]

CLASS ACTION/INDUSTRY MOVES

Compilation : **Rashmi Tiwari**

INDIAN REGISTER OF SHIPPING CLASSED TUG 'BALBIR' DELIVERED TO INDIAN NAVY

Indian Register of Shipping classed vessel 'Balbir' was delivered by Hindustan Shipyard Limited to the Indian Navy earlier in January.. This was the 200th vessel delivered by HSL to Indian Navy. During the ceremony, the Class certificates were handed over to Cmde. Kunjumon E. Mathew, Director (Shipbuilding), HSL by Mr. Saikat Roychowdhury, Head of Survey Station, IRS Visakhapatnam. The 50-tonne bollard pull tug, sailed out on 08th January 2022 with HSL engineers on-board for delivery to Indian Navy at Naval Dockyard (Mumbai).

For more information, please visit: http://www.irclass.org

DNV SELECTED TO LEAD "PIONEERING" AMMONIA BUNKERING SAFETY STUDY IN SINGAPORE

DNV has been selected to lead an ammonia bunkering safety study by the Global Centre for Maritime Decarbonisation (GCMD) in Singapore. The pioneering study aims to define a robust set of safety guidelines and operational envelopes that will establish the basis of a regulatory sandbox for ammonia bunkering trials at two local sites. To that end, DNV will team up with Singapore's leading infrastructure developer Surbana Jurong and the Singapore Maritime Academy (SMA).

For more information, please visit: www.dnv.com/maritime

INDIAN REGISTER OF SHIPPING CLASSES FIRST 100 PAX HYBRID CATAMARAN (BATTERY POWERED) FERRY

Indian Register of Shipping has recently classed a hybrid catamaran (battery powered) ferry - 'Water Metro-01'. It is the first in a series of 23 such vessels being built by Cochin Shipyard Ltd. The 24.8 m catamaran ferry, designed for shore charging and certified to carry 100 passengers, is propelled by hybrid electric propulsion system by means of Lithium Titanium Oxide (LTO) batteries & DG Sets. The capacity of installed batteries is 122 kWh which are capable of fast charging.

For more information, please visit: http://www.irclass.org

PHILIPPINES AGREES TO BUY INDIA ANTI-SHIP MISSILE SYSTEM

The Philippines has agreed to buy an anti-ship missile system from India, shoring up its security in the face of growing Chinese aggression in the South China Sea. Defence Secretary Delfin Lorenzana offered few details about the nearly $375 million contract awarded to BrahMos Aerospace to supply an onshore anti-ship missile system to the Philippine Navy. BrahMos — a joint venture between India and Russia — has developed a cruise missile that the Indian defence ministry says is the fastest in the world.

For more information, please visit: https://economictimes.indiatimes.com/news/defence/philippines-agrees-to-buy-india-anti-ship-missile-system/articleshow/88904264.cms

DNV ASSESSES HYDROGEN READINESS OF HUNGARIAN GAS PIPELINE

FGSZ Ltd, the owner and operator of the Hungarian high-pressure transmission natural gas pipeline system servicing gas distribution companies, power plants and large industrial consumers has commissioned DNV to assess the suitability for partial to full hydrogen transport of one of FGSZ's pipelines. The intention of this project is to evaluate the suitability of FGSZ's DN600 system, consisting of a DN600 pipeline and valve station for hydrogen transportation. FGSZ has set up different scenarios to assess the implications of exchanging natural gas with up to 100% gaseous hydrogen.

For more information, please visit: https://www.dnv.com/news/dnv-assesses-hydrogen-readiness-of-hungarian-gas-pipeline-216291

BUDGET 2022: INVESTMENT IN INFRA TO BE GUIDED BY GATI SHAKTI BASED ON 7 ENGINES OF GROWTH

Finance Minister Nirmala Sitharaman on Budget Session 2022–23 said that 100 cargo terminals will be developed during the next three years under the PM Gati Shakti master plan. The seven engines that drive PM GatiShakti are Roads, Railways, Airports, Ports, Mass Transport, Waterways and Logistics Infrastructure. The scope of PM GatiShakti National Master Plan will encompass the seven engines for economic transformation, seamless multimodal connectivity and logistics efficiency.

For more information, please visit: https://economictimes.indiatimes.com/news/economy/infrastructure/budget-2022-investment-in-infra-to-be-guided-by-gati-shakti-based-on-7-engines-of-growth/videoshow/89267788.cms

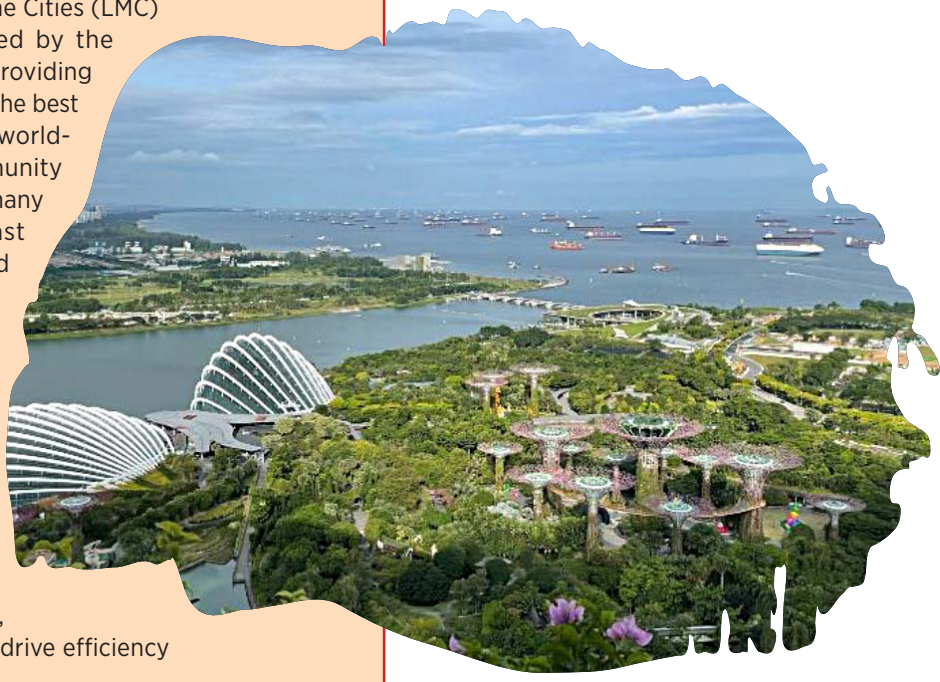
INDIAN REGISTER OF SHIPPING STRENGTHENS FOCUS ON SAFETY OF INLAND WATERWAYS

Indian Register of Shipping is forging ahead with a drive to enhance inland vessel safety throughout India to aid the country's economic growth. It played an integral role in the drafting of the Inland Vessels Act 2021 which was passed by the Indian parliament. Based on new IV Act 2021, IRS has drafted ten different rules in consultation with Ministries, State Governments, and various other stake holders. The draft–Rules and Regulations for Construction and Classification of Inland Waterways Ships are ship type specific to ensure safety of cargo, assets, environment. The draft Rules cover requirements for Passenger vessels, including Ro-Ro & Ro-Pax, tankers, gas carriers and dry cargo vessels. The rules also cover aspects of insurance, wreck & salvage, limitation of liabilities and other administrative provisions.

For more information, please visit: http://www.irclass.org

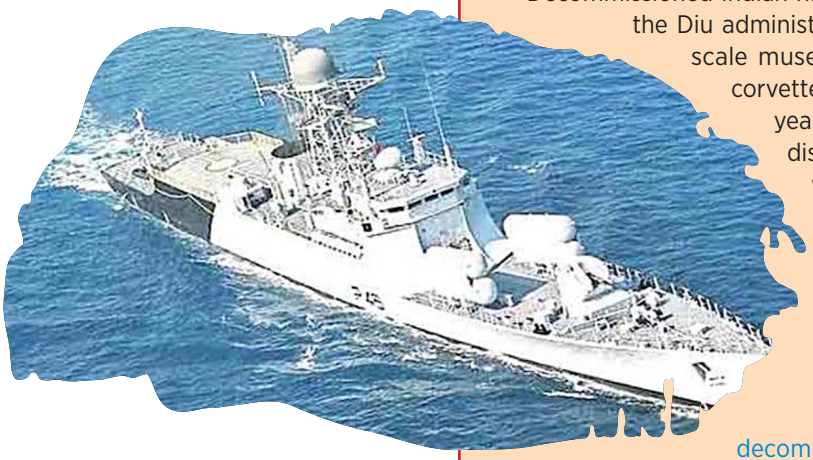
LEADING MARITIME CITIES REPORT 2022: SINGAPORE STILL IN TOP SPOT FOLLOWED BY ROTTERDAM AND LONDON

The 2022 edition of the Leading Maritime Cities (LMC) report was launched at an event hosted by the Singapore Maritime Foundation (SMF), providing fresh insights into which global hubs offer the best infrastructure, technology, finance, and world-class talent, to help the maritime community connect and prosper. There have been many dramatic developments since the last edition of the LMC report was published in 2019. For one, people still living with the pandemic. Two years of fluctuating restrictions have caused severe trade and travel upsets. Extreme weather events have made all more acutely aware of the climate crisis, another major driver of change. Shipowners, charterers, cargo owners and lenders are gearing up for a decarbonised future, with rapid adoption of zero-carbon fuels expected over the next decade. Ongoing digitalisation, including ports and the supply chain, will drive efficiency in support of this transition.



For more information, please visit: www.dnv.com/maritime

DECOMMISSIONED NAVAL SHIP INS KHUKRI TO BE DEVELOPED AS A MUSEUM



Decommissioned Indian naval ship (INS) Khukri will be handed over to the Diu administration so that it can be developed as a full-scale museum, the Indian Navy has said. The missile corvette was decommissioned on December 23 last year after 32 years of service. INS Khukri had the distinction of being part of both — western as well as eastern fleets — during its service, it mentioned. The decommissioned vessel is the second ship of the Navy to carry the name INS Khukri, the first having been lost during the 1971 India-Pakistan War off the coast of Diu.

For more information, please visit: https://www.ndtv.com/india-news/decommissioned-ins-khukri-to-be-handed-over-to-diu-admin-will-be-developed-as-museum-2729269

DNV AND PARTNERS LAUNCH CETO JOINT INDUSTRY PROJECT (JIP) TO DEVELOP LOW PRESSURE SOLUTIONS FOR CO2 SHIP TRANSPORT

Equinor, Shell, TotalEnergies, Gassco and classification society DNV announced the kick-off of a new JIP to develop low-pressure solutions for the transportation of CO2 by ships. The CETO (CO2 Efficient Transport via Ocean) JIP will carry out the technology qualification of a low-pressure ship design and identify solutions to scale CO2 transportation volume, while reducing the associated risks, to support the development of opportunities in CCS. CETO is funded by the project partners and GASSNOVA through the CLIMIT programme and is expected to be completed in 2023.

For more information, please visit: www.dnv.com/maritime

TERMINATION OF VESSEL SHARING AGREEMENT WITH ZIM ON ISRAEL EXPRESS

MSC & ZIM have decided to cease their cooperation on the North Europe – East Med trade. Within said reorganisation, the joint service on MSC's Israel Express will terminate effective as from end of March 2022. The last vessel of this joint service will be MSC LAUSANNE, southbound from Felixstowe ETA 7 March and northbound from Haifa ETA 29 March. MSC will continue to operate the Israel Express service as per the current set up and schedule rotation, and any future service update will be further advised separately.

For more information, please visit: https://www.msc.com/hrv/notices/2022-january/termination-of-vessel-sharing-agreement-with-zim-o?lang=en-gb

APM TERMINALS PIPAVAV SECURES NEW WEEKLY SERVICE TO THE GULF

APM Terminals Pipavav has secured a new weekly service, Nhava Sheva Mundra Gulf (NMG), operated by Unifeeder, which connects India to the Gulf region. The vessel deployed on NMG, *TSS Shams*, will operate between Jebel Ali, Sohar, Nhava Sheva, Pipavav and Mundra ports, adding capacity that will address existing supply chain issues between India and the Middle East. In particular it is expected to cater to the needs of exporters and importers in the states of Rajasthan, Gujarat, Punjab and Delhi, thereby strengthening the connectivity of the hinterland to Gulf markets for a range of products, including wastepaper, dates, bitumen, clay, ceramic tiles, handicrafts, stone, marble and agricultural commodities.

For more information, please visit: https://www.themaritimestandard.com/apm-terminals-pipavav-secures-new-weekly-service-to-the-gulf/

PRESS RELEASE

PRESENTATION ON THE FINDINGS OF "NAVIK JEEVAN" – A STUDY CONDUCTED BY RESEARCH AND TRAINING COMMITTEE OF INDIAN NATIONAL SHIPOWNERS' ASSOCIATION (INSA)

A custom-made study of all aspects of the professional life of the seafarers, including maritime education and training in India was conducted by the Training & Research Committee of INSA and the final report, titled "Navik Jeevan" (Life of Seafarers), was released by **Shri. Sarbananda Sonowal, Hon'ble Minister of Ports, Shipping & Waterways, Government of India** on 2nd December 2021. **Mr. Amitabh Kumar IRS, Director General of Shipping** and his team members at DGS also attended the event.

The findings of this exhaustive survey were presented to the industry in an online function at 1500 hrs. (IST) on 18th December 2021.

Mr. Sunil Kumar, CTO & Head - T&A Department, The Great Eastern Shipping Co. Ltd on behalf of Research and Training Committee INSA and as Master of the Ceremony extended a warm welcome to all guests.

Mr. Anil Devli, CEO, INSA, rendered the welcome address and expressed his gratitude to one and all present during the event.

The report highlighted various issues faced by the Indian seafarers and students during their service on board and training respectively. The report also brought out some interesting studies with regards to the motivation level of the seafarers to continue their seafaring career, some perennial challenges of Stress & Fatigue, shore leave, etc. Since the participation of the woman seafarers is on the rise, the survey also touched upon the equality in opportunity and discrimination in the workplace faced by them.

The event was inaugurated by **Mr. Amitabh Kumar IRS, Director General of Shipping.** He complimented INSA and commented that the findings will be useful to various stakeholders. He suggested that the outcomes of the study should be brought to the notice of all concerned, both nationally and internationally.

Dr. B. K. Saxena, Chairman, Research & Training Committee, INSA gave the background of this India-centric study and provided additional information on

the objectives of this research that covered not only the seafarers but also the students undergoing various pre-sea courses. He complimented the project leader, Capt. Manoj Hirkane and his team of faculty members from the Tolani Maritime Institute and the Great Eastern Maritime Academy who conducted the study. He thanked and acknowledged the support of the Directorate General of Shipping and the Maritime Training Trust and especially the members of the Research & Training Committee, President, and the office of INSA Secretariat for the support and assistance.

An E-Book of the Navik Jeevan Report was released on this occasion. The same is available on the INSA website - https://insa.in/Ebook/2021/mobile/index.html

The findings of the study were presented by **Capt. Manoj Hirkane, Project Leader & Sr. Vice Principal, Tolani Maritime Institute.** The Summary included a total of 5541 respondents from diverse backgrounds who had taken part in these two surveys, namely 'Life of Indian Seafarers' and 'Life of Pre-Sea Students'.

One third of the pre-sea students had taken bank loans for training. 21% of the students had experienced discrimination based on religion, caste or language and 12% of the students had faced ragging in their institutes.

At the end of the presentation, a Question and Answer session was moderated by **Mr. David Birwadkar, Advisor/ Head, GEIMS.**

The event was attended by some distinguished personalities representing international academic institutions and crew welfare organisations.

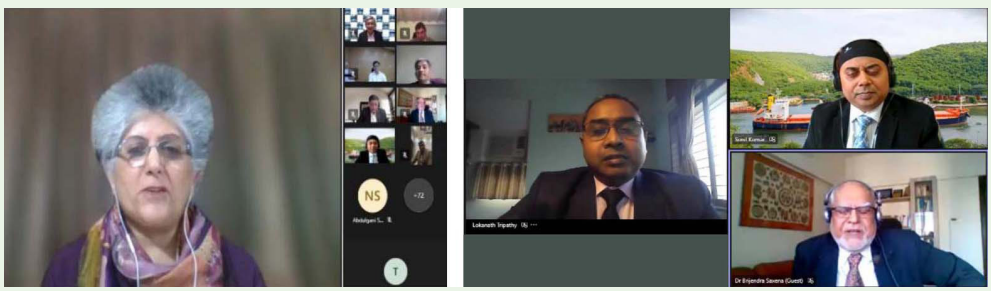
Dr. Takeshi Nakazawa, Executive Director, International Associations of Maritime Universities from Japan offered his views on the findings of this report. Dr Nakazawa also offered INSA to have a collaboration with IAMU in mutually interested areas.

Mrs. Karen Avelino PTC-Executive Director of Business, Philippines & President, Philippine Association of Maritime Training Centers also offered her views on the findings of this report and the overall event. She also mentioned about the similar survey initiatives which were undertaken in Philippines in the year 2006 & 2012.

Prof. Jan Horck, former faculty member, World Maritime University, Sweden, and **Ms. Carl Johan Carlsson, Senior Faculty, Chalmers University of Technology, Gothenburg, Sweden** also graced the occasion. This, we expect to open up new avenues of research in future in collaboration with those eminent International Institutes.

Towards the end, **Dr. Sujata Naik, Chairperson, Tolani Shipping, and President, INSA** addressed on the key points of the research findings and on the daunting issues regarding the crew welfare on board. She exhorted the Training institutes to work passionately for improving the experience at the pre-sea training stage to attract quality manpower. This would improve the overall quality of the life of the Seafaring Community.

Lastly, **Mr. Lokanath Tripathy, Head – QST, Greatship India Ltd**. proposed the Vote of Thanks.



PRESS RELEASE

2ND TECHNICAL PAPER COMPETITION CONDUCTED BY RESEARCH & TRAINING COMMITTEE OF (INSA)

2nd Technical Paper Competition event was organised by Research & Training Committee of Indian National Shipowners Association (INSA) on 8th January 2022 on a web platform with the theme of "Technological Advancements in Maritime sector: Benefits, Challenges & Way Forward" 2022.

Mr. Sunil Kumar, CTO & Head - T&A Dept, The Great Eastern Shipping Co. Ltd., as Master of the Ceremony extended a warm welcome to all. **Mr. Anil Devli**, CEO, INSA, rendered the welcome address. He acknowledged the presence of the dignitaries, the candidates from various Maritime Training Institutes for their participation in the competition and the judges for their tremendous efforts in shortlisting the Paper Presentations.

The event was inaugurated by the Chief Guest, **Mr. Arun Sharma**, Executive Chairman, Indian Register of Shipping. He complimented INSA for taking this initiative where youngsters are presenting the technical papers, taking interests towards innovations, and thinking out of the box, apart from daily routines. He appreciated INSA for getting the phenomenal response of 17 papers in the first event to 79 papers in second event, in a year. He further mentioned that shipping is at a point of major transition and over the next 3 decades the major concerns will be on compliance of GHG reductions, the decarbonisation and adaption of digitalisation mode, which are both technical and economical in nature. He expressed his good wishes to INSA and the participants for successful completion of the event and great takeaways from the event.

Dr. B. K. Saxena, Chairman, Research & Training Committee, INSA complimented Mr. Sharma for his speech. He further gave the background of the Paper Presentation Competition held by INSA and provided additional information on the objectives of this event. He expressed his warm welcome to the candidates and wished each one of them all the best for the competition.

Mr. Kumar then invited **Mr. David Birwadkar**, Advisor/ Head, GEIMS to explain the rules and regulations of the event. Mr. Birwadkar expressed his gratitude towards all the dignitaries and explained the Theme & Sub Themes of the event.

Mr. Kumar invited the 1st presenter Aniket Tagadpallewar, Shardul Bendre & Kapil Parab from Tolani Maritime Institute, Pune who presented a paper on the topic of Cyber-Security - Regulatory Aspects and Data Theft in Maritime Industry. Mr. Kumar then introduced the 2nd presenter Kamal Chauhan and Hrithik Kumar from the Tolani Maritime Institute, Pune who also presented the paper on the topic of Cyber-Security- Regulatory Aspects and Data Theft in Maritime Industry. The 3rd team of Krishna Prabu and Barnali Maji from the Indian Maritime University, Chennai Campus presented their paper on the topic of EEXI - Energy Efficient options for ships in line with IMO Requirement and Intelligent Engines – Decarbonisation of Shipping. The

4th presentation was delivered by Menon Pramod and Mithun Moudgal from the Tolani Maritime Institute, Pune who presented a paper on the topic of Digital Twin: A Deep Dive into Artificial Intelligence and Big Data Technologies.

During the break, video on Navik Jeevan was played for the audience. The 5th presentation was given by Mr. Shubham from B P Marine Academy, Raigad who presented paper on the topic EEXI - Energy Efficient options for ships in line with IMO Requirements. The 6th presentation was by Shubham Thakur and Param Sharma from the Indian Maritime University, Mumbai Port campus on the topic was on CO_2 Capture and Storage Using Nano Silicates. The 7th and the final presentation was by Shashank Shekhar and Sonu Rajpurohit from The Great Eastern Institute of Maritime Studies, Lonavala on the topic of Intelligent Engine Decarbonisation of Shipping Industry.

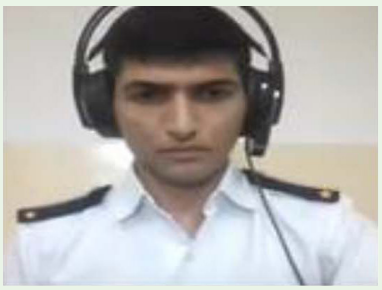
At the end of each presentation, a Question and Answer session was moderated by Mr. Kumar.

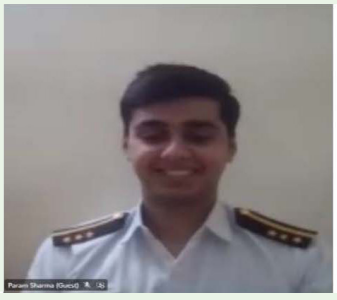
Dr. Sujata Naik, Chairperson, Tolani Shipping, and President, INSA gave the concluding remarks. She expressed her immense happiness towards the successful completion of the event hosted by INSA and congratulated the entire team.

The Judges of the event **Mr. Chitta Dash, Mr. Dilip Mehrotra and Mr. I.N. Bose** appreciated the efforts put in by the participants and their confidence while presenting and congratulated all the participants.

Mr. Kumar invited Mr. Birwadkar to announce results of the competition. The second runner up was Mr. Shubham from B. P. Marine Academy. Mr. Shubham Thakur and Mr. Param Sharma from the Indian Maritime University, Mumbai Port secured the first runners up position in the competition. Menon Pramod and Mithun Moudgal from the Tolani Maritime Institute, Pune secured the first position in the competition. Mr. Birwadkar congratulated all the participants for their hard work and dedication.

Lastly, **Mr. Lokanath Tripathy**, Head – QST, Greatship India Ltd. proposed the Vote of Thanks.





CHANDIGARH CHAPTER

SEMINAR ON DECARBONISATION

A seminar on the topic **Decarbonisation: Short Term & Long Term Challenges for Industry & Seafarers"** was held on 4th January 2022 at the Mindset, Aroma Hotel, Chandigarh.

Shri. Jagmeet Makkar, an MNOA member, IME(I) Chair at the IMU and the Chairman of the Hong Kong Branch of the Institute of Chartered Shipbrokers delivered the lecture on the topic. Shri. T. S. Bhatia, President, MNOA introduced the Speaker.

Shri. Makkar started his talk by giving an overview of the establishment of IME(I) Chair at IMU. He then discussed about Regulatory (environmental and financial) developments and challenges. This included the CII regulations, short term and medium-term impact on one's existing fleet and on the markets, across various sectors. Lastly, he highlighted about the new ships and decarbonisation dilemma. He said that the industry needs to invest in new ships but is presently at a loss about the sustainable future fuels.

The talk interestingly developed into a group discussion with most of the attendees participating enthusiastically. The seminar was followed by a Q & A session.

MUMBAI BRANCH

MEDITATION WITH YOGIC TRANSMISSION ON 22ND JANUARY 2022

The Mumbai Branch of The Institute of Marine Engineers (India) had again come up with the 'Meditation with Yogic Transmission' session, during this pandemic on 22nd January 2022.

Hon. Chairman, Mumbai Branch, Mr. A. K. Gupta welcomed Mr. Sanjay Bhatia, Upa-Lokayukta Maharashtra and Trainer for Heartfulness Meditation. Mr. Gupta in his welcome address thanked Mr. Bhatia for his kind affinity towards the Marine Engineers. While the whole world was undergoing the Corona stress, everyone was inside their respective homes, the last sessions on meditation were indeed useful to the participants. He also thanked Ms. Sonali Banerjee for arranging this session in the pandemic time though she could not join the session due to some exigency of work.

Mr. Saanjeev V Mehra Hon. Secretary, Mumbai Branch thanked and introduced Mr. Bhatia and requested him to take the session forward.

Mr. Bhatia commenced by conveying the importance and benefits of meditation as he himself is practising this for the last 16 years. He highlighted that by doing meditation how one can control the mind, anger and how one can develop his/her own personality. The experience in practising the heartfulness meditation is beyond words and is very essential and should be practised by all and especially by today's youngsters as today though their IQ levels are very high but their emotional quotient is very low. He explained to the audience about meditation and how to cleanse oneself by experiencing the divine spirituality through this. From relaxation to meditation, cleansing and prayer were explained to all. He also informed that "Hearts App" is available and those interested can download and take the sittings.

This was followed by a practical session that emerged as an enchanting and spiritual experience for all present and which was then followed by a Q&A session. Lastly, Mr. Mehra proposed the Vote of Thanks.

MEPC 77 Webinar Memento Being Handed Over to Chief Guest Mr. S. Barik, Chief Surveyor, Govt. of India

MISSED OPPORTUNITY TO DECARBONISE SHIPPING AT MEPC 77 AND THE FALLOUT

It is an equity issue although all of us are stakeholders, but there has to be an appreciation of the north- south-east-west divide in responsibilities for its containment now and that will not be by shirking leadership. The pandemic mix, Chennai floods, Kazak protests are visible signs of days to come.

One hopes private-public partnership is leveraged into measures to contain GHG, methane and such other emissions, which deplete ozone layer and increase smog. However, members at CoP26 failed to agree on basics of green funding; R&D for alternate fuel technologies and technical cooperation. So another wasted year has gone by, post Paris agreement and its protocol. There is no one-size-fits-all solution. The solutions have to be locally evolved and integrated into a well woven road map with realisable outcomes for realistic targets. Lower emissions or net zero by 2070 is crucial for sustainable development even for low lying areas and these are the aspirations of all besides livelihood for the global citizens.

Pledges @ Glasgow

- Protect natural environment and combat emissions from agricultural activities including meat and dairy
- Stop Methane nuisance
- Land based power/energy plants renewal
- Cap transport carbon foot print equitably and not punishing shipping alone

Low hanging fruits entailing little extra cost:

- Cutting back on Methane emissions, agro waste burning
- Wider, broad based policy of using water mode of transport wherever possible
- Efficient shipping in terms of fuel consumption and waste disposal
- Generating more and more renewable energy (e.g., PM has planned for 500 gW; fivefold increase in next 30 years
- Nurturing techno start ups
- Prevent rather than cure locust infestation and such other ill effects of chemical fertilisers and insecticides
- Start climate change education early
- Make resilient health systems

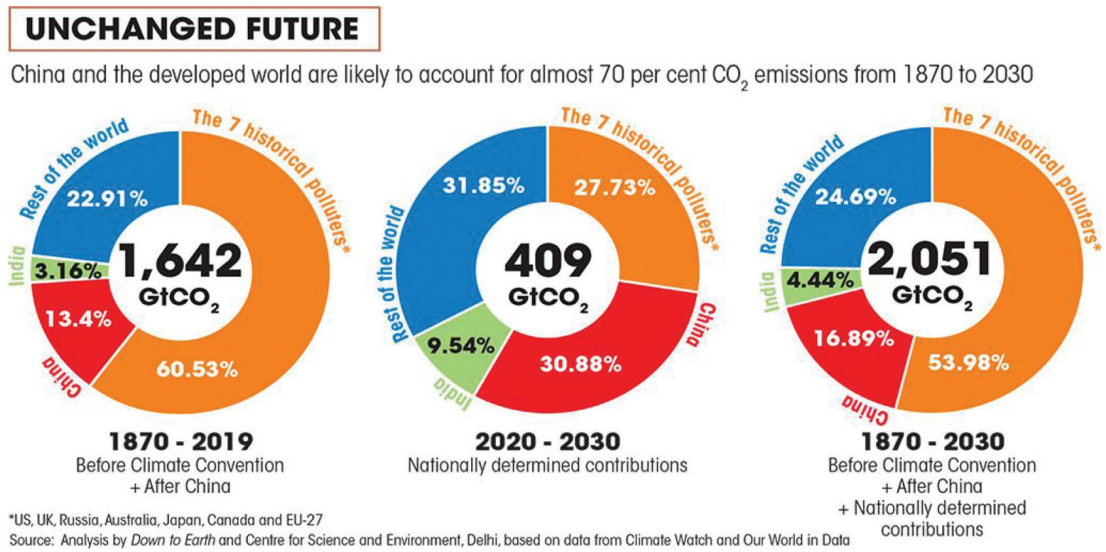
Clydebank declaration (not signed by India) at the end of CoP 26 recalls the long term temperature goal of increase well below 2 deg. C; noting that the measures impact the least developed countries and small island countries; accelerated action for GHG from shipping, aviation; setting of green corridor shipping routes – net zero carbon fuel use by 2040 including conglomerates like Amazon, IKEA & of interest to 22 signatories. Indian PM has a more pragmatic target of 2070.

In the words of ICS Secretary General there is disappointment that there have been no action points at CoP26, failing to take forward range of GHG reduction measures. We cannot keep kicking the can, he had said.

Where is the 5 bn USD R&D fund followed by levy based carbon pricing for shipping so that no one is left behind?

The IMO Maritime Research Fund is the only proposal on the table ready for immediate agreement. The goal for liner shipping is very clear, move away from fossil fuel quickly. But how?

Trade is equally important. “Debating ambitious targets for far-away deadlines avoids the more difficult



discussions on discrete actions to be undertaken and should not be mistaken for actual progress. We need the political establishment to move from targets to action."

An Intersessional Working Group on reduction of GHG emissions from ships (ISWG-GHG) has been set up by MEPC. It will propose mid-term GHG reduction measures to MEPC78. Members struggle at MEPC to allocate time, money, effort to discuss in detail the huge agenda on the table related to climate change basis Paris agreement and prevention of pollution by plastic, ballast water etc.

Concrete proposals including from intersessional working group have been requested for presentation in June 2022 at MEPC 78. With respect to Arctic waters, however, there is consensus that ships using Arctic route should only use distillate fuel not black carbon fuel.

We need to grow out of short term measures of planning, design efficiency, emission monitoring, and speed control, anti-fouling, bio fouling for smooth hull, propeller polishing, oil record book, LFSO, EEXI etc., both for new and existing tonnage. Later needs the most help to sustain global economy.

Member States are also invited within the IMO framework to take action to develop and update voluntary National Action Plans (NAP) with a view of reducing GHG emissions from international shipping by supporting actions at national level. This action is funded by a multi-donor trust fund (GHG TC-Trust Fund) established in May 2019 but not yet leveraged as was expected.

Challenge of course is the movement of goods more efficiently and cheaply for economic activities to continue. It is in this context CBDR principle is very important at all climate change forums so no one is left behind

It is against this backdrop that IMO participated in the UN Climate Change Conference (COP 26) in Glasgow, UK, on 31 October 2021. An update of IMO's work to address GHG emissions from fuel used for international shipping was provided to the Subsidiary Body for Scientific and Technological Advice (SBSTA) under agenda item 10(g) – "Emissions from fuel used for international aviation and maritime transport". Outcomes therefrom are mostly work in progress at MEPC 78. Several related reports and correspondence groups are working including the Belgian initiative for analysis of small vessels in its waters.

Indian PM, while emphasising on climate change road map for 2030-50-70 has declared five steps – non fossil fuel energy of 500 gW capacity to build by 2030; meet 505 of its energy requirements from renewable energy sources; reduce projected carbon emissions by 1 bn tonnes before 2030; reduce carbon intensity in its economy by 45% between 20022-2030; achieve net zero target by 2070. Challenge of course is the movement of goods more efficiently and cheaply for economic activities to continue. It is in this context CBDR principle is very important at all climate change forums so no one is left behind.

In conclusion, IMO members at MEPC 77 and CoP 26 participants have not reached any agreement on:

Green fund; Technical cooperation; Transfer of technology to change fuel for net zero emissions in near future; Work in progress to mitigate harmful effects of polluting earth, atmosphere by land infra, agriculture, meat processing, agri-waste burning, & use of cold fire boilers.

It is extremely important to engage with Indian delegation to MEPC 78 in June this year and those tasked in correspondence group / intersession working group, technical committee of INSA etc.

Climate is changing, so must we...

S.V. Subhedar
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IN THE WAKE

Rajoo Balaji

Corona Chronicles

Has the Neptune Declaration nudged the Nations to action?

The stats show some reassuring scores:

A survey of a set of Shipping Companies (9×10^4 seafarers) shows that many have been signed off and those on board beyond expiry of contract is <4% (those beyond MLC limit of 11 months' stay form only 0.4%).

More news...

The vaccination count also has gone beyond the 50–60% levels (Where is the vaccination hesitancy? East European/Russian seafarers. Sound like a red alert... which should turn amber and green soon.

A European statistic to bother: About 26 countries of the EU are reporting Covid 19 infections rise (of 1% of their population) every week.

There are issues other than the hesitancy: no universal standard for this vaccination (type of accepted vaccines, validity etc.; dose availability for booster/regular jabs etc.

Hope the homecoming holds up and the crew changes perdure... provided the threatening third wave does not take the wind out of the sails...

Shipping Matters

The pandemic pushes the passenger ships too. The ship-owners are deciding to delay deliveries of cruise vessels... maybe into the further end of the decade.

How many on order? 32 Mega/30 Large/37 Small Cruise ships ...

BTW, most of these will be LNG powered. If decarbonisation is driving the emissions away, the pandemic has pushed for purity of indoor air also.

Yes. HVAC systems are improvising the systems with filtration (multistage), bi-polar ionisation, photo-catalytic oxidation, UVGI etc.

A brief on how they work:

Bi-polar ionisation: High energy of the rotating machine generates O2- and H+ ions from water vapour. These positive and negative ions surround the air particles. If pathogens are present (bacteria/viruses), then the Hydrogen is pulled from them by the ions.

So... the protein coat of the virus becomes impotent and cannot infect.

Photocatalytic Oxidation: Uses UV light [UVC] + Catalyst (TiO_2) >> Hydroxyl radicals. These radicals cause destruction of cells (VOCs/Bacteria/Viruses). By products: dead cells and of course... H_2O/CO_2 too come out.

UVGI: That is Ultraviolet Germicidal Irradiation for you. Same like the former, the shorter wavelength UVC is employed to kill the pathogens.

The future ships will have killer machines all over (BWMS killing invasive species... AF paints terminating organisms... HVAC systems with pathogen perishing features.

While the World awaits these for times after the pandemic is pushed away.

Tech Talks:

Is there a chance to get high on Hydrogen? There are about 5 vessels already on the waters...

Ports are gearing up in smaller ways to power the port equipment with 'Green Hydrogen'.

Though many stakeholders have started blinking, popular solutions will get the votes only when ship-owners adopt and firm up on the trends.

About February

Couple of sober ones to mull about...

21 Feb: International Mother Language Day. Maybe we can speak in our mother tongue ONLY on this day... abandon the imperial English?

28 Feb: National Science Day. Theme for 2022: **Integrated Approach in S&T for Sustainable Future.** Looks like the integration will still be on line this year also. Let us hope that Science and Technology brings us face to face, physically, like before.

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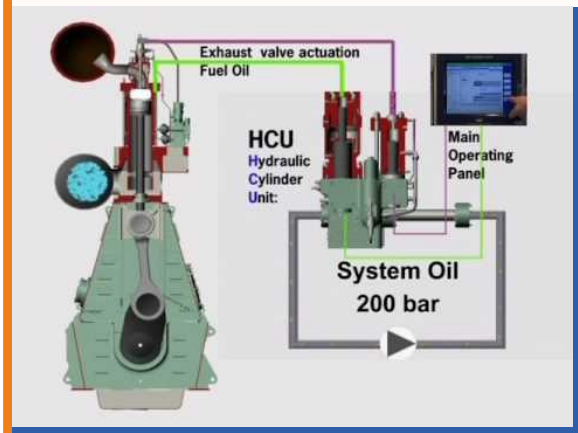
THE END VIEW

Idea, Words & Drawing: **Ramesh Subramanian**

MASSA Maritime Academy, Chennai

The Institute of Marine Engineers (India)

Electronic Engine Familiarisation Course (ME-Type Engine) Delivered online with Cloud access to ME Engine Simulator



This 3 days course is designed for all Ship's Engineer Officers and Electro Technical Officers responsible for the operation of ME Engine. This course consists of technical lessons and practical instructions on the design, principles, operating procedures and maintenance activities for the safe, efficient and optimal performance of the engine system.

Course Aims and Objectives:

The course aims to provide practical understanding of the principles, design, operation and maintenance of the ME Engine System, enabling participants to safely and efficiently operate the engine and perform fault-finding in the control system.

Coverage / Program Focus:

This course deals with the following training areas:

- **Introduction to ME Engine**
- **Hydraulic Power Supply (HPS)**
- **Hydraulic Cylinder Unit (HCU)**
- **Engine Control System (ECS)**
- **Main Operating Panel (MOP)**
- **Standard Operation**

Entry Requirement / Target Group:

Entry is open to all Ship's Engineers and Electro Technical Officers with basic knowledge of diesel engines.

DATE & TIMING	:	15th to17th **Feb.'22,** 15th to17th **Mar.'22.** **8:00 am - 4:00 pm IST**
VENUE	:	Web Platform / Zoom**. APPLICATION LINK:** https://forms.gle/e4As7kCucR5xoJBm9
REGISTRATION & PAYMENT	:	Rs. 15,000/- /- per participant – inclusive of taxes. For IME(I) Members 13,500/- per participant - inclusive of taxes. Payment to be made to: https://imare.in/buy-online.aspx (Under Category - Value added Courses) *10% discount available for IME(I) members*
FOR MORE INFORMATION	:	**@IME(I) - email:** training@imare.in, Ms. Anukampa **(M)**. 9819325273, **(T)** 022 27701664 / 27711663 / 2771 1664. **@ MASSA Maritime Academy Chennai - email:** mmachennai@massa.in.net Ms. Saraswathi, **(T)** 8807025336 / 7200055336 .

After registration and payment, please email the details of the receipt to: ***training@imare.in***

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