Naval sector and Decarbonisation using Industry 4.0

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Synopsis

The Paris Agreement forced the International Maritime Organisation (IMO) to create fresh paradigm for the maritime industry to achieve net zero carbon emissions by 2050. In doing so, IMO exempted warships from complying with these emission norms. However, advanced navies promulgated several initiatives to contribute progressively towards net-zero emission. While the 'Climate Change and Sustainability Strategic Approach' of the UK Ministry of Defence (MoD) and the 'Green Fleet Navy' of the US are well known, efforts such as the joint venture of the Indian Navy with the Indian Oil Company to develop a fuel recipe by varying over 22 parameters to reduce GHG emissions from warships is also noteworthy. In recent years, the EU initiative of 'Adaptation of Industry 4.0 Model to the Naval Sector' has aimed to reduce carbon emissions in the naval sector using automated technologies of Industry 4.0 by creating new techniques to monitor, control and manage emissions from the ships, repair yards, shipbuilding yards and mercantile marine. It is expected that by carefully curating and cataloguing the emissions from naval assets, both movable and immovable, positive changes towards emission control from the naval sector can be achieved. The paper thus aims to discuss Industry 4.0 to provide a better trajectory towards net zero carbon emission from the maritime domain in general and the naval sector in particular. In doing so, the Green Initiatives of the Indian Navy using Industry 4.0 are discussed.

Keywords: Industry 4.0; Decarbonisation; Digitalisation; Automation; Emissions; IMO

Author's Biography

Captain (Dr) Nitin Agarwala, a serving naval officer, has experienced various facets of a warship as a user, designer, inspector, maintainer, a policymaker, a teacher and a researcher. He has authored over 80 articles, papers, book chapters and two books. He was a Research Fellow at the National Maritime Foundation from 2017- 2019 and is presently a Senior Fellow at the Centre for Joint Warfare Studies and a Visiting Faculty at the Naval War College, Goa and the Centre for Maritime Studies at the University of Mumbai.

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1. Introduction

In The Kyoto Protocol of 1997 was based on scientific consensus that global warming is due to anthropogenic efforts (Agarwala and Polinov, 2021). It *commits* States to reduce greenhouse gas (GHG) emissions from aviation and shipping through the International Civil Aviation Organisation (ICAO) and International Maritime Organisation (IMO) respectively (IMO, n.d). Since it gave binding targets, the US negotiated the Protocol to ensure that their expeditionary military was exempted from emission reduction (US Senate, 1998). Based on the Protocol, in December 2003, IMO adopted resolution A.963(23) "IMO Policies and Practices related to Reduction of GHG Emissions from Ships" that led to numerous studies by the Marine Environment Protection Committee (MEPC) to identify and develop mechanisms for GHG reduction from shipping. Accordingly, CO_2 emissions were addressed by Phase 1 studies (Buhaug *et al.*, 2008) and other GHG emissions by Phase 2 studies (Buhaug *et al.*, 2009). Since these studies were based on agreements of the Kyoto Protocol, they excluded military and fishing vessels.

Subsequently, the 2015 Paris Agreement (UNFCCC, 2015) allowed nations to decide on sectors to cut emissions which could be the military or some other sector. Since then, many navies have made concerted efforts to move towards net-zero emission. Some efforts include '*Climate Change and Sustainability Strategic Approach*' of the UK that aims to move the military to products, practices and behaviours that are climate aware, environmentally sound and reduces emissions using fuel standards, energy storage and more (UK MoD, 2021). Similarly, the US Navy deployed '*Great Green Fleet*' in 2016 that used nuclear energy, energy efficiency, and alternative fuels such as diesel-biofuel, and hybrid electric-diesel propulsion to demonstrate their ability to perform with new energy-saving measures. These efforts were with 10% blend of biofuel with an intention to reach 50% (Chambers and Yetiv, 2011; EESI, 2016). Other efforts include those of the Italian Navy's Green Fleet Project ('*Flotta Verde*') of 2012 to develop alternative marine fuel such as renewable synthetic fuel, innovative eco-design technologies and energy saving procedures (Ministero Della Difesa, n.d). Closer home, the Indian Navy's '*Green Initiatives Program*' (GIP), aims to achieve reduction, diversification and use of clean technologies (Batra and Prakash, 2018).

While these efforts are path breaking and considered critical to achieve commitments of the Paris Agreement, they are not conclusive due to environmental sustainability of biofuels (Jeswani *et al.*, 2020) and not considered reliable to achieve decarbonisation. To achieve decarbonisation, indirect emissions and environmental costs should be considered for alternate fuels (Agarwala, 2022d) and operational changes when using energy efficiency methods are to be considered (Hodgkins, 2021; Bowcott *et al.*, 2021). However, these changes cannot be adopted due to various considerations.

As ships become sophisticated with digitalisation at its core, the focus for decarbonisation has shifted to use of digitalisation (Agarwala *et al.*, 2021). It is no wonder that the EU initiative of 'Adaptation of Industry 4.0 Model to Naval Sector' aims to reduce carbon emissions in the naval sector using Industry 4.0 (I4.0) by creating techniques to monitor, control and manage emissions from ships, repair yards, shipbuilding and mercantile marine. By carefully curating and cataloguing emissions from naval assets, using I4.0, positive changes towards emission control can be achieved.

With this understanding the paper discusses I4.0 to provide a better trajectory towards decarbonisation from the naval sector. It will first provide a brief background of the military carbon footprints followed by evaluating areas where I4.0 can help reduce carbon emissions for naval vessels. To show these methods can be used, the Green Initiatives of the Indian Navy using Industry 4.0 will be discussed next. The paper will conclude by discussing possible options for naval assets to achieve decarbonisation using I4.0.

2. Curating and Cataloguing Emissions of the Military

Exemption of the military from emission norms by the Kyoto Protocol was to cater for the US interests. However, it exempted a major contributor of government emissions (80% for the US and 50% for the UK and Canada) (Hodgkins, 2021).

Analysis of emissions from military activities shows that emissions from equipment operations are accounted for while equipment procurement is not. Accordingly, for the EU in 2019 while direct emission was 8 million CO_2e, indirect emission was 16.8 million CO_2e. That for the UK in 2018 was 3 and 8 million CO_2e respectively (Conflict and Environment Observatory, 2021b). The military emission evaluation is difficult as the military lacks transparency. Then there are conflicts that add to emissions (Parkinson, 2020; Conflict and Environment Observatory, 2021a). Yet another area of emission by the military is their Bases which account for nearly 1 to 6% of the global land area (Zentelis and Lindenmayer, 2015). The way land is used impacts global GHG emissions. In addition, waste management is responsible for carbon emissions to about 3% of global GHG

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emissions (Hannah *et al.*, 2020). It is thus important that the military reduces and manages the waste generated (surplus materiel, equipment, ammunitions and ground contamination). Such calculations also disregard emissions from supply chains which require evaluations of 'corporate responsibility' reports of suppliers.

Studies have shown that the total carbon emission by the US military in 2017 was 59 million CO_2e at an average of 66 million CO_2e for 2010 to 2018 of which Bases account for 40% while fuel use accounts for the remaining (Crawford, 2019). However, once again this figure does not include supply chain emissions. A comprehensive estimate of net emissions is possible if data on energy consumption and economic activity is available. Unfortunately, this is published by only a few nations and hence estimation becomes difficult. These notwithstanding, estimates indicate military emissions including those from supply chains are between 3.3 to 7% of the global total (Parkinson and Cottrell, 2022). **Table 1** shows a breakdown of these emissions for various branches of the US military.

Table 1: CO_2 emissions (kt) by branch for the US military for 2017 (Source: Belcher *et al.*, 2019)

Branch	Kt CO_2e FY-2017
Air Force	13,202.4
Army	2,204.7
Marines	112.1
Navy	7847.8

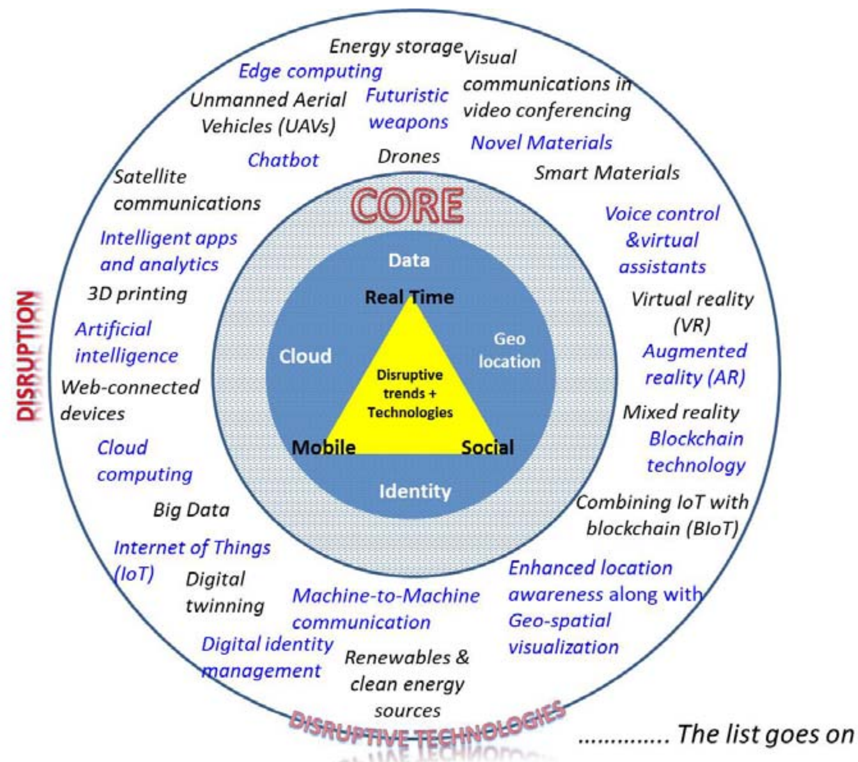

Figure 1: Disruptive technologies in the maritime industry (*Source*: Agarwala, 2022a)

3. Evaluating and Reducing Emissions from Naval Assets using Industry 4.0

Emissions occur from a naval asset during design, production, operation, maintenance and scrapping. With advancements in Industry 4.0 these facets can be monitored more closely to ensure monitoring and minimising of carbon emissions. It is important to mention that the definition of I4.0 is viewed differently by different researchers. With available disruptive technologies increasing daily for the maritime domain, as seen in Figure **1**, the canvas of I4.0 is increasing. Some consider it as increasing automation, some as an umbrella term for new technologies and concepts while others consider it a manufacturing concept to gain competitive advantage.

While these views reflect some part of I4.0, for the authors, I4.0 is about transformation to digital form to achieve digitalisation (Razmjooei et al., 2023).

For naval assets, emission reduction is critical as even though countries are not obliged to cut military emissions under the Paris agreement, they are not exempted either (Neslen, 2015). To achieve this, use of I4.0 is a possible option. Some efforts to reduce emissions of naval assets using I4.0 are summarised in Figure 2 and discussed in some detail in Figures 3 to 6. To appreciate the effectiveness and the factual use of these technologies, the efforts of the Indian Navy in reducing carbon emissions will be discussed in the subsequent section.

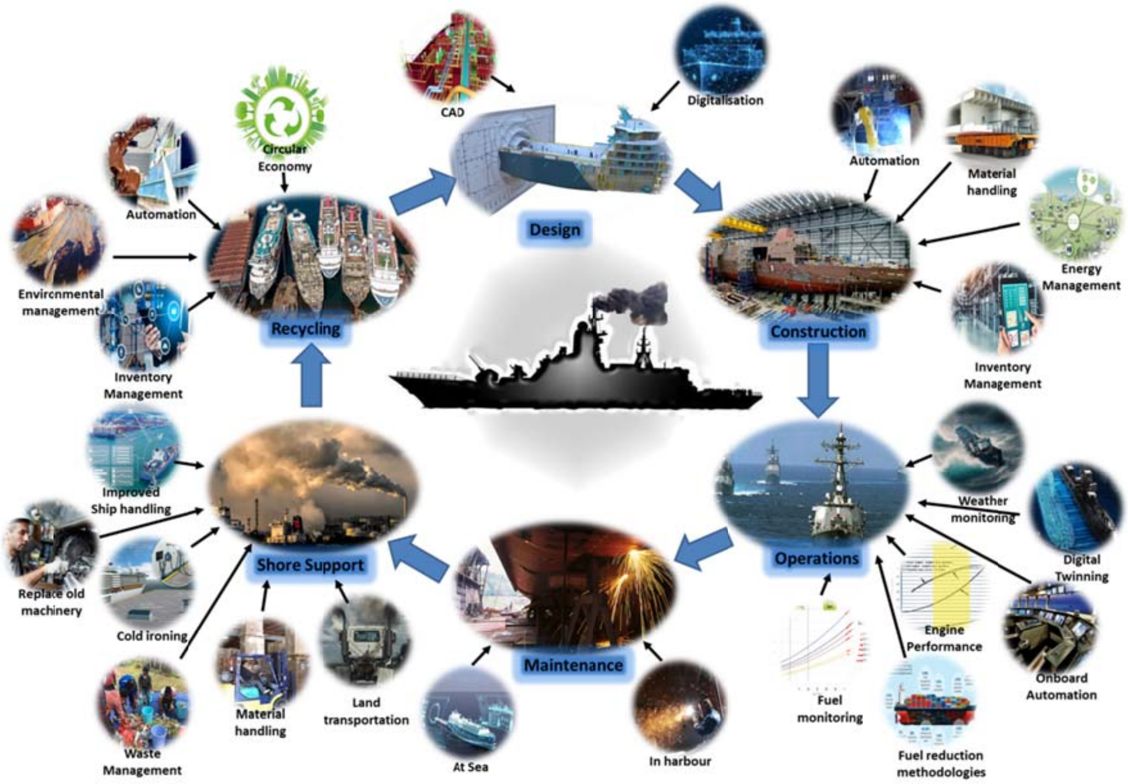

Figure 2: Emission reduction by naval assets using Industry 4.0

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Process	Description	Processes where I4.0 can be used for reducing carbon emissions	Advantages
Ship Design and Construction	Shipbuilding • custom-built industry • energy-intensive and polluting • contributes 29% of CO and around 4–8% of CO_2 (Vakili et al., 2022) Required • Replace manual efforts by digital processes / I4.0 • increase efficiency • reduce emissions	Computer Aided Design (CAD) and Virtual modelling	Help designer to • create intricate designs • identify potential issues using simulations Reduces • energy consumed • selection of energy efficient equipment • reduce wastage • hence emissions Outcome • Stakeholders understand roles • Improve workflow
		Robotics and 3D printing	Allows • greater precision during manufacturing • reduces wastage • improved speed of construction Outcome • easier manufacturing • higher productivity • lesser errors
		Design	Lessons learnt from previous designs can help optimise new efficient designs
		Improved functioning	Inventory management, operational agility and safety – biggest challenge Internet of Thing (IoT) devices • Allow - data sharing, transmission, processing and utilisation seamless • Make process efficient and less polluting Data capture and visualisation, data analysis, actuation, and support systems can improve efficiency of SMEs (Schönfuß et al., 2021)
		Managing low value supply chains	Shipbuilding industry an aggregator of components of other industries Industries usually environmental unfriendly Digitalisation can • improve efficiency • reduce carbon emissions • reduce waste generation
		Material handling	Numerous components used repeatedly Require frequent handling Use automated guided vehicles (AGVs) with digitalisation for efficiency and reduced emissions
		Energy Management using Smart Grids/ Micro Grids	Smart Grids • optimise energy distribution to various shipyard consumers • reduces carbon emissions for electricity generation • With clean energy increase advantages Micro grids • meet needs of smaller users (cranes, forklifts, compressors, pumps and winches) • greater efficiency • reduced carbon emissions (Vakili et al., 2022)

Figure 3: Emission reduction during Ship Design and Construction (*Source*: Authors)

Process	Description	Processes where I4.0 can be used for reducing carbon emissions	Advantages
Ship Operations	Numerous control mechanisms instituted by IMO Full scope of impact of digitalisation on decarbonisation of shipping industry and support industries discussed elsewhere (Agarwala et al., 2021)	Rate of fuel consumption	Fuel consumption trends (per hour per nautical mile) with ML can recommend speed and route for best performance and minimum emissions If automated can improve fuel consumption based on weather conditions, route, equipment condition and cargo carried. Will reduce ship emissions
		Engine performance	Fuel consumption can provide efficiency of engine By monitoring – power output, fuel combustion efficiency, temperature, pressure and rpm – nature of emission and engine maintenance predicted With AI and ML evaluate engine performance to pre-empt defect
		Weather conditions	Adverse weather increases fuel consumed and emissions With sensors – wind speed, wave height, precipitation, atmospheric and ocean temperature, hull accelerations, and propeller loading –monitored to predict weather conditions to be avoided Will reduce emissions
		Emission reduction techniques	Using digitalisation, remotely monitor Exhaust Gas Cleaning (EGC) systems or scrubbers for prolonged life and effective functioning
		Digital twin	Digital copy of ship and equipment to monitor functioning and defects Allows • preventive maintenance to reduce emissions • online monitoring of fuel consumption
		Improved automation	Digitalisation allows greater automation through remote operations Provides improved • Safety, communication and navigation, and manoeuvring (Agarwala and Guduru, 2021) • performance and reduced emissions

Figure 4: Emission reduction during Ship Operations (*Source*: Authors)

Process	Description	Processes where I4.0 can be used for reducing carbon emissions	Advantages
Ship Maintenance	Maintenance can be proactive or reactive Reactive maintenance costly Proactive maintenance is industry standard	Maintenance at sea	Digital twins proactive maintenance reduce downtime and carbon emissions IoT sensors, remote monitoring and vessel management • proactive maintenance at sea
		Maintenance in harbour	Use digitalisation for • Identifying scheduled maintenance, demanding and procuring spares, ensuring spare availability, planning OEM maintenance activities, undertaking trials and quality checks Can help improve efficiency and reduce emissions
Ship Recycling	End of life management as important as actual operation/ construction A potential source of revenue when recycled This process has been unregulated, labour intensive and environmentally unfriendly IMO promulgated Hong Kong Convention (IMO, 2009) to come in force in 2025 Will minimise risk to human life and environment	Automated processes for ship breaking	Use robotics and automation to make process efficient and risk free Automated techniques like – cold cutting using high-pressure water jets or abrasive materials –produce reduced carbon emissions
		Inventory management	Recovered items to be managed by processes like Green Passport system (Agarwala, 2023b) Will encourage • greater traceability and Circular Economy • simpler, reliable and faster retrieval of items
		Environment Monitoring Systems	Sensors can collect real-time data for ensuring safe processes health and safety of workers health of environment

Figure 5: Emission reduction during Ship Maintenance and Recycling (*Source*: Authors)

Process	Description	Processes where I4.0 can be used for reducing carbon emissions	Advantages
Shore Support Systems	Shore establishments important to ship for supplies (fuel, water, ammunition, spares etc.), stores (rations, stationary etc.) maintenance Air pollution from port has gained impetus due to focus on carbon emission reduction (GEF-UNDP-IMO GloMEEP Project and IAPH, 2018) Focus on governments across the world on Green Ports (Agarwala, 2022b)	Shore supply for reducing carbon emissions	• Ships forced to run diesel engines for power alongside as shore supply not available • Causes excessive emissions in harbour • Ports contribute 2% of GHG emissions which is on the rise (Cammin et al., 2022) • Use cold ironing instead • Cold ironing supported by clean energy such as solar panels recommended • Effectiveness of solar panels improves by using –single axis sun tracking technology with computerised monitoring and control
		Energy consumption reduction	Use occupancy sensors, battery operated vehicles, solar street lights, LED lights, SCADA (Supervisory control and data acquisition) based electric metering etc. for reducing energy consumption
		Changes to existing machinery	Existing machinery using fossil fuels to be retro-fitted to reduce emissions.
		Logistics for efficiency and carbon emission reduction	• Improve supply chain by using digitalisation and robotics, logistics chains (Agarwala, 2023a) • IoT devices can make material handling seamless, effective and environment friendly • Will ensure minimum time for procurement of supplies and spares to improve efficiency and reduce emissions (Nguyen et al., 2023)
		Waste management for reducing pollution	• Waste generated on ships and shore treated in accordance with MARPOL • Collected waste can be assorted using artificial vision and ML or processed to generate alternative fuels such as biogas • Management techniques will encourage Circular Economy and reduce carbon emissions for sustainability (Agarwala, 2023b).
		Local transportation for carbon emission reduction	Use of battery operated vehicles or alternative fuels such as biofuels, CNG, LNG, LPG can reduce emissions
		Communication for improved ship handling	5G can be used by • Logistics Service Providers (LSP) for material handling and financial transactions • shore based activities such as remote pilotage, video surveillance, remote control of cargo handling facilities (Agarwala and Guduru, 2021)

Figure 6: Emission reduction during Shore Support (*Source*: Authors)

4. Efforts of the Indian Navy towards decarbonisation

The Indian Navy (IN) adopted the Green Initiative Programme (GIP) in 2014 with an aim to add a Green footprint to its Blue Water capabilities. To monitor implementation of green energy programmes, the IN established an Energy and Environment Cell at Naval Headquarters (PIB, 2016). Since 2014, they have been instrumental in working towards Clean and Green energy from Renewable Energy, formulation of an Environment Conservation Roadmap (INECR) to provide impetus to green operations, maintenance, administration and infrastructure/ community living, and sustained use of biodiesel for all motor transport vehicles (PIB, 2019). The set goals would be achieved through efficient operations, predictive and proactive maintenance, energy efficient infrastructure, informed community living and regulations adhering administration.

While these set goals contribute to a Green Planet, let us look at those efforts that contribute directly to reduce carbon emission from naval assets.

4.1. Generating clean energy and reduction of energy consumption

As discussed, contribution of carbon emissions from the military is both from shore establishments, personnel and military hardware. Accordingly, in an effort to reduce emissions from shore establishments and ships in harbour, alternative energy and power sources that generate clean energy are considered essential. Accordingly, the IN has promulgated numerous policies to ships and establishments for reducing existing energy consumption and to produce clean and green energy.

The IN has pledged 1.5% of its ‘Works’ Budget for generating energy from renewable sources with a focus towards rooftop and land based solar photovoltaic (PV) projects. This helped achieve 11 MW of solar capacity by July 2020 (PIB, 2021) and 15.87 MW by June 2023 (PIB, 2023b) at naval stations as seen in Figure 7. Since these plants are grid connected, they utilise the state of art single axis sun tracking technology with computerised monitoring and control.

Figure 7: Solar Power Plants under Jawaharlal Nehru National Solar Mission

Additionally, 16 MW of projects are at various stages of execution (PIB, 2023b). Pilot projects of wind and a mix of solar and wind (hybrid) are also being progressed. Renewable energy generation has been successfully experimented on INS Sarvekshak in 2017 (Figure 8) wherein a 5kW solar power system was installed onboard (PTI, 2018).

Figure 8: Solar Panels Installed on the Hello Hanger of INS Sarvekshak

To reduce energy consumption and emissions, energy conservation measures such as occupancy sensors, battery operated vehicles, solar street lights, LED lights, audit of yards, SCADA (Supervisory control and data acquisition or Integrated Platform Management Systems) based electric metering etc. are being encouraged. Where applicable, they are used both on ships and shore establishments (PIB, 2023b).

4.2. Green Fuels

Sustained usage of biofuel (B-5 and B-7 blend of High Speed Diesel) has been implemented in motor transport vehicles used in establishments. In addition, used Cooking Oil-based biodiesel has been experimented with to reduce vehicular emissions (PIB, 2023b). Similarly, to reduce emissions from fossil fuel used by ships, a joint venture with the Indian Oil Company to develop the HFHSD – IN 512 (High Flash High-Speed Diesel) fuel by varying over 22 parameters to reduce carbon footprint (PIB, 2020) has been experimented with.

To use Hydrogen as an alternate fuel, successful shore trials in a Hydrogen Aspirated Diesel Engine have been conducted, Figure 9. The engine is now being tried out on a ship for efficacy. To move away from fossil fuels, construction of a ferry craft powered by a hydrogen fuel cell within India as a developmental project is being explored (PIB, 2023b).

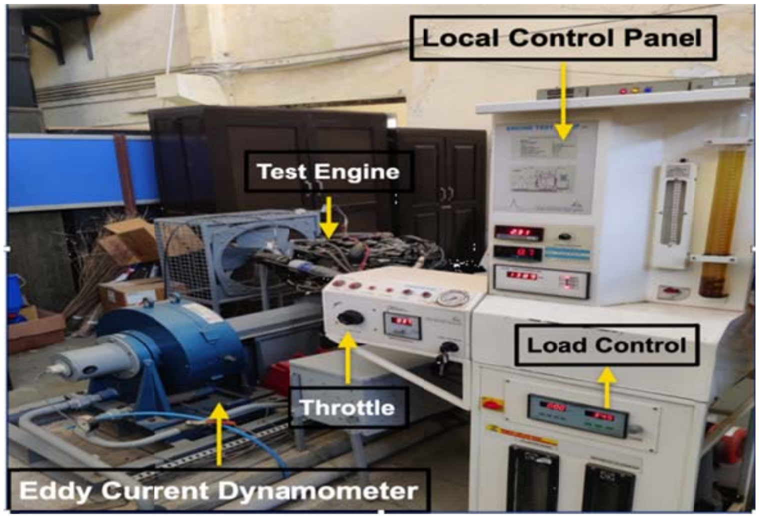

Figure 9: Hydrogen Aspirated Diesel Engine Trials

4.3. Technological Changes

To achieve goals of GIP without altering primary task of the organisation, both behavioural changes and technology are being tried out during design and acquisition, operations, and maintenance. As part of their behavioural change, the Indian Navy has been conducting energy conservation awareness drives, coastal cleaning, lectures, Shramdaan (Volunteer Work), etc. with an aim to contribute to developing better and clean communities and contribute to the "Swachh Bharat Abhiyan (Clean India Campaign)". On ships, some technological changes are.

(a) *Design*. Indian Navy has nurtured and developed its own dedicated Warship Design Bureau for more than six decades and has progressively incorporated advanced design features and State of the Art technologies (Raghavan, 2018). Amongst many other parameters, special attention has always been paid to reduction in energy consumption as well as reduction in emissions. For older platforms, energy efficient modules have been retro-fitted.

(b) *Operations*. With the crew becoming more and more conscious of decarbonization, there is a general tendency to minimise energy consumption, of course without comprising on the either the safety of the ship or its missions. In addition, green energy technology such as renewable energy is being used to reduce emissions. To reduce power consumption during operations, smart LED lighting has been adopted and HVAC and waste heat recovery systems have been optimised (PIB, 2023b).

(c) *Maintenance*. With large amount of data collected over the years by the Indian Naval Ship Maintenance Authority, AI and ML I4.0 technologies are finding their way into predictive maintenance on board IN ships by leveraging the strengths of startups (DIO, 2022: problem statement 29).

4.4. Emission Reduction

To reduce emissions from legacy shore based diesel engines an indigenous patented retrofit device has been developed and successfully tried out by M/s Chakr Innovations, Figure 10. The retrofit reduces Hydrocarbons, Carbon Monoxide, and Particulate Matter in the exhaust by 70% (PIB, 2023a).

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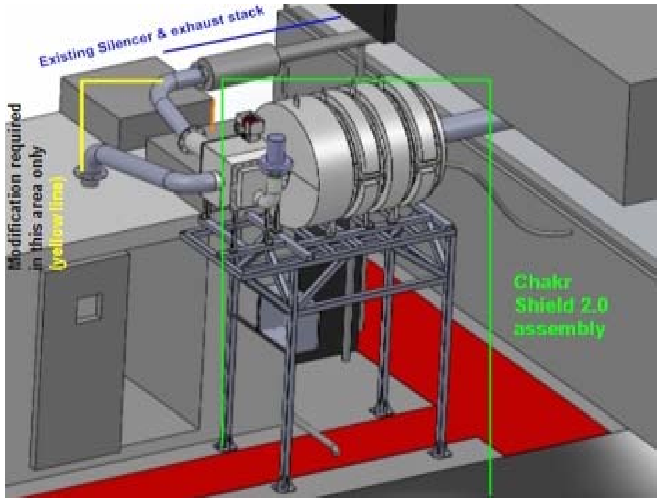

Figure 10: Diesel Engine Emissions Reduction

4.5. Natural Refrigerant AC Plant

To phase out HCFCs, the IN in collaboration with Indian Institute of Science (IISc, Bangalore) has developed a 100kW capacity AC plant that uses Carbon dioxide as a refrigerant. The plant (Figure 11) is currently under trials and has completed 850 hours of successful operations (PIB, 2023a).


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Figure 11: AC plant with CO_2 as a refrigerant

4.6. Air Pollution

Plantation, arboriculture and horticulture are means of reducing emission impact and need to be encouraged. Accordingly, the Indian Navy has focused on various environmental remediation measures by plantation, arboriculture and horticulture, anti-plastic drive, bio toilets, effluent treatment plants etc. This has led to plantation of more than 18,000 plants in one year and can mitigate an estimated 365 tonnes of CO_2.

4.7. MARPOL Compliance

To control pollution in harbour and seas MARPOL compliance is essential. For this, the IN uses sullage barges for collection of effluent from ships, effluent treatment plants to neutralize toxic waste before discharge, and ensures that newly inducted equipment is MARPOL compliant. To combat oil spills in harbour, eco-friendly marine bio-remedial agents have been indigenously developed by Naval Materials Research Laboratory (NMRL) that clean sea water by consuming oils by using a combination of micro-organisms. In addition, Segregated Waste Collection Centre (SWCC) aims to treat and manage collected waste. By using biogas plants, compost

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pits and paper recycling, an estimated savings of 140 LPG cylinders per year has been achieved. This reduces the overall emissions by reducing consumption and using alternative and renewable resources as fuel.

4.8. Leveraging Growing Startup Eco-System in India

The Ministry of Defence has created a Defence Innovation Organisation through which they are propagating the problem statements that define technical challenges needing efficient solutions. These are prepared by the Indian Army, the Indian Navy, the Indian Air Force and other entities under them. These statements are issued as series of Defence India Startup Challenges (DISCs), under the umbrella of Innovations for Defence Excellence (iDEX) (https://idex.gov.in/). Response from the start-ups has been encouraging with many products and systems finding their way in use in the Indian Navy, including those utilizing I4.0 technologies for the naval sector decarbonization

5. Discussion

Emerging need to reduce carbon emission from all facets of our lives has becomes an essentiality and is no more a desire. Under the Paris Agreement, while countries are not obliged to cut their military emissions, they are not exempted either. This necessitates curating and cataloguing emissions of these assets to address global emissions. Using data on energy consumption and economic activity (Parkinson, 2020) published by nations of the Organisation for Economic Co-operation and Development (OECD), one can estimate emissions by the military. However, for growing economies that have otherwise heavy military expenditures, lack of this data disallow any estimates.

With advances in disruptive technologies, the required task of measuring carbon emissions from naval assets can be simplified and have been discussed in this paper. One notices that while disruptive technologies exist and are in use in various ways, there is limited impetus towards monitoring carbon emissions. In some cases, these technologies are still to make inroads in naval assets due to legacy equipment.

This requires that environment conscious nations take a lead to showcase advantages such digital technologies can provide in both monitoring of equipment and systems and achieving decarbonisation of the naval sector. In this regard, the paper has discussed efforts of the Indian Navy in moving the Green way. While these efforts are commendable, resulting changes would be better appreciated if the before and after carbon emission calculations are used and made available. By imbibing digitalisation in various aspects of naval assets, these calculations would not be difficult and would require formulation of procedures with a plug and play module that would synthesise data collected from numerous sensors to provide desired carbon emissions.

Since the usage of I4.0 is known to improve energy efficiency between 15-20% (Vakili et al., 2022), use of I4.0 should be encouraged. With advancement in sensors and technology, these benefits will only increase. Since use of this technology is equally applicable to commercial shipping, their use would eventually help achieve the desired decarbonisation goals of IMO.

6. Way Ahead

There is no denial that the need of accounting carbon emission from naval assets and other military assets is becoming important. While so far this computation has been avoided and disregarded, there is a growing need and focus on developing ways and means of accounting and calculating GHG emissions of the military. Since the procedure is complicated as it involves numerous downstream organisations the task has been speculative. Accordingly, some efforts such as those by Crawford (2019) and Parkinson (2022) are noteworthy. However, with digitalisation as discussed here, the efforts can be simplified. The present need is to ensure that these efforts are taken forward to define a logical process and schema that will permit a plug and play module for calculation of carbon emissions.

In addition, present use of digitalisation should encourage fine tuning of existing sensors and development of more sensitive ones to ensure improved data gathering. This should encourage development of new digital technologies that can further improve and simplify data collection and computation. Advances made by AI using ML and DL such as those towards object identification and segregation of pollutants (Agarwala, 2021) are some future areas of development in assessing carbon emissions that need greater scholarship. Similarly, use of ocean energy as a means of producing renewable energy for meeting power requirements (Agarwala, 2022c) of the shipping sector needs greater scholarship.

In terms of monitoring carbon emissions from the shipping sector, they are currently experimental and involve isolated monitoring activities for scientific research (Zhou et al., 2022). However, this is an area of serious scholarship that needs to be perfected and implemented. Such a comprehensive monitoring when linked to the flag of the ship will act as a deterrent and address growing concerns of ‘Flags of convenience’.

Yet another important and critical aspect that needs continuous updating is the need of cyber security for systems that are digitalised and are connected. Inability to provide necessary confidence in cyber related security issues to owners and operators will not allow accruing benefits of digitalisation. Since cyber security is a 'cat and mouse' game, efforts have to be ongoing and continuous to ensure economic and security interests of all stakeholders.

7. Conclusions

The paper has discussed usage of Industry 4.0 in monitoring of carbon emission from the naval sector, a sector that has been under no obligation to address emissions. Since the global environment does not differentiate between the military and the civilian domain, the present concept of 'no obligation to address emissions' needs to be reconsidered. Self-driven efforts to reduce carbon emissions by the Indian Navy have been discussed and considered commendable. The need of the hour is to raise the bar and develop plug and play solutions for calculating overall contribution of carbon emissions from the naval sector with an aim to reduce it to net zero in line with the Nationally Determined Contributions (NDC). After all the Earth is one and there is no Planet B where we can move to if this one face destruction due to lack of our commitment to reduce global warming.

While the paper has discussed available avenues wherein digital technologies can be used to monitor and achieve reduction in carbon emissions these are considered a work-in-progress which are meant to initiate debate and further advancement in terms of use and technology development. Since every good has a flip side, use of digitalisation and connected networks is susceptible to cyber vulnerabilities which will need to be addressed to avoid compromising defence capabilities for the military and financial loss for the commercial sector.

Disclaimer

Views expressed are those of the authors and do not reflect those of the Government of India or the Indian Navy.

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