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(Review Article)

Electric propulsion for lifeboat

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Abstract

This paper presents the integration of the electric propulsion technology in the lifeboat maneuvering system to enhance efficiency, reliability and sustainability. The present lifeboat propulsion system often relies on the internal combustion engine which requires fuel to propel and also has various challenges to face such as emissions, maintenance, and overall environmental impact. This paper delves into the design, economics, ergonomics, engineering challenges and performance assessments associated with the successful implementation of electric propulsion for lifeboats. Special emphasis is given to the research and development of lightweight, high-capacity energy storage systems (ESS) and efficient electric motors which are suitable for the maritime emergency evacuation applications. The features of electric propulsion (EP), such as reduced harmful emissions, lowering maintenance requirements and improving maneuverability draws more attention for this research field. The paper also explores the integration of green energy sources such as solar and wind that can be used to supplement the electric propulsion system which enhance the autonomy and sustainability of the lifeboat during emergencies. This work focuses on the overall advancement of maritime emergency safety equipment and will also help in contributing to make maritime services more eco-friendly by offering a comprehensive analysis of electric propulsion integration in lifeboats, providing insights for further future developments.

Keywords: Electric propulsion; Emergency; Energy saving; Lifeboat; Renewable energy

1. Introduction

The rise of electric propulsion technology has brought about a pivotal shift in lifeboat maneuvering systems, bringing in a new era of heightened efficiency, reliability, and environmental sustainability. Departing from conventional methods, the electric propulsion system uses battery-powered electric motors, granting higher precision in control and maneuverability. This comprehensive paper dives into the undisputed role of electric propulsion within lifeboat systems, providing an in-depth analysis of its components, advantages, and diverse applications. Through the integration of cutting-edge technology, electric propulsion not only ensures the safety and responsiveness of lifeboat operations but also stands as a tremendous advancement in maritime safety and rescue. By avoiding the limitations inherent in traditional propulsion systems, we delve into the transformative potential brought by this innovative technology.

The seamless integration of EP holds the promise of heightened reliability, efficiency, and maneuverability in lifeboat operations, thus significantly enhancing safety and performance at sea. This study undertakes the challenge of addressing technical intricacies and refining control strategies, ultimately striving for a seamless transition that amplifies safety, efficiency, and environmental sustainability in maritime rescue operations. In contributing to the ongoing evolution of propulsion technologies, this research is a pivotal step towards fostering a greener and more resilient maritime future

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It is feasible to run a power system with fewer generators by incorporating an ESS [1][2]. The different ways that engine manufacturers can reduce emissions of SOx and NOx is explained in [3] while also elucidating the primary factors that they take into account when selecting the best technology. The historical development of the use of electricity in naval boats is presented in [4]. In addition to other relevant ideas, [5][6] provides an overview of the state of the art in the scientific community on the application of transactive energy, market-based control, and peer-to-peer energy trading. In [7], the conventional technologies have been examined for electric propulsion and generation for various ship types. It then goes on to highlight the key features of novel architectures designed to generate electric energy for use in powering the electric propulsion systems and onboard auxiliaries. The introduction of EP drives, which paved the way for the development of all-electric ships, is discussed in [8]. Next, technologies for producing and controlling electricity are included, allowing the integrated electrical power system to be utilised. In the Split port area, a thorough examination of the electrification requirements for one hull type and one ferry route has been carried out [9]. The possibility of a hybrid power system for medium-sized oceangoing ships is illustrated in [10]. Several criteria are used in the decision-making process, and various possibilities are evaluated in relation to a variety of elements and sub-factors as explained in [11]. The key enabling technology for the electrification of large ships has been shown in [12]. Improved controllability of the ships when manoeuvring and docking is another benefit of electric ships [13]. A detailed discussion is held in [14]-[18] regarding how new conversion technologies, including as power electronics, battery energy storage, and the dc power system, may affect the course of this development. An analysis of technology to mitigate emissions from marine engines is given in [19]. The characteristics of some of the main motor classes that could be employed in ship propulsion are described in [20]. Electric propulsion on passenger cruise ships in the commercial domain is explained in [21].

1.1. Electrical propulsion system

A typical EP system layout often involves several key components as shown in Fig. 1:

- Power Source: This could be batteries, fuel cells, or a combination of both. The power source provides electricity to drive the propulsion system.
- Electric Motors: These are the main parts that transform electrical energy into mechanical energy in order to produce thrust. Electric motors come in various types, including brushed DC motors, brushless DC motors, and induction motors.
- Motor Controller: The motor controller regulates the power supplied to the electric motors, controlling their speed and direction of rotation. It ensures efficient operation and protects the motors from overloading.
- Propellers or Thrusters: These are the elements that generate thrust to propel the vehicle forward (or in any desired direction). The choice between propellers and thrusters depends on the specific application, with propellers being more common in aerial vehicles and thrusters in underwater or space applications.
- Power Distribution System: This system manages the distribution of electrical power from the source to the motors and other components of the propulsion system. It includes wiring, switches, circuit breakers, and sometimes power conditioning units to ensure stable voltage and current levels.
- Control System: The control system includes sensors, actuators, and software that regulate the operation of the propulsion system. It monitors various parameters such as motor speed, temperature, and battery voltage, and adjusts the system's operation accordingly.
- Cooling System: Electric motors and power electronics generate heat during operation, so a cooling system is often required to maintain optimal temperatures and prevent overheating. This can involve air or liquid cooling methods.
- Auxiliary Systems: Depending on the specific application, additional components such as battery management systems, power converters (for converting between AC and DC power), and energy storage systems may be included in the layout.

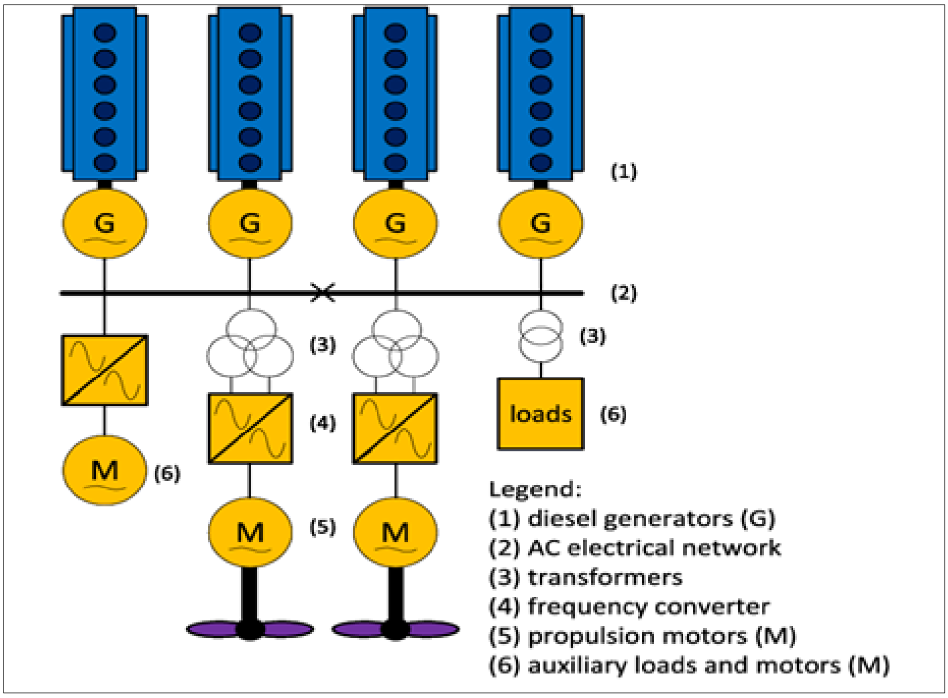

Figure 1 Typical electrical propulsion system layout

2. Working of EP of lifeboat

Electric propulsion system (EPS) facilitates the system of propulsion and navigation for lifeboat. This technology is popular in terms of efficiency, reliability, and environmental friendliness. EPS for lifeboats include the following components:

2.1. Electric Motor

Power provided to EPS for lifeboats are mainly by electric motors. Based on the design and requirements of the system these motors can be either AC (alternating current) or DC (direct current)

2.2. Power Source

The power source for the EPS depends upon common options as batteries, fuel cells, or a combination of both. Batteries store electrical energy and during propulsion it is used, whereas fuel cells generate electricity upon chemical reaction of oxygen and fuel. When lifeboats are mainly of EPS then it is mainly equipped with batteries. It is charged and stores electrical energy which supplies power during emergencies when conventional propulsion systems are not feasible.

In some cases electricity is generated by fuel cells upon burning of the fuel through chemical oxidation. It provides a continuous and reliable source for electric propulsion.

2.3. Control System

An advanced control system is required to manage the effect of control system. It includes sensor, data, software, controller to control and regulate the power output which ensures safe operation of propulsion system

2.4. Thrust Propulsion

A thrust is generated upon propelling of the lifeboat which can be used in the form of propeller of air jet. So it is monitored for efficient operation.

2.5. Emergency Use

Electric propulsion systems are valuable in lifeboats as they provide reliable power during emergency situations. This is crucial for ensuring the lifeboat can operate effectively when needed to rescue the life of seafarers.

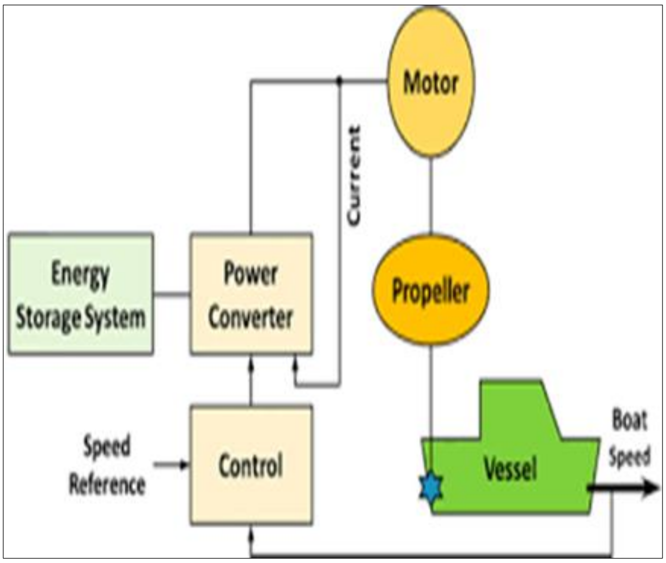

Figure 2 Electric propulsion system components

3. The potential of the EPS for CO2 emission

EPS have the potential to significantly reduce CO2 emissions compared to traditional combustion-based propulsion systems, particularly in transportation sectors such as automotive, aviation, and maritime. EPS are inherently more energy-efficient than internal combustion engines (ICEs). Electric motors can convert a higher percentage of electrical energy into mechanical energy, resulting in less energy waste and lower overall energy consumption. This efficiency contributes to reduced CO2 emissions, especially when coupled with renewable energy sources. Electric propulsion systems can be powered by electricity from renewable energy sources such as solar, wind, hydroelectric, and geothermal power. By utilizing clean energy sources, the CO2 emissions associated with electricity generation are greatly reduced compared to fossil fuel-based power generation. Electric propulsion systems offer a promising pathway to decarbonize transportation and mitigate the impacts of climate change by reducing CO2 emissions and promoting sustainable energy use.

Table 1 CO_2 Emission savings

		CO_2 emission			
		scenario 1		**scenario 2**	
voyage type	**no. of vessels in the world fleet**	**60% load**	**40% ballast**	**60% load**	**40% ballast**
handysize	1774	1.8	3.5	0.07	2.8
handymax	1732	0.23	0.095	0	0
panamax	1383	4.1	2.9	2.3	1.7
post panamax	98	0.51	0.25	0.33	0.14
Capesize	722	1.6	1	0	0

In the maritime sector, ships account for 3% of the world's greenhouse gas emissions. If the economy grows by 2050, greenhouse gas emissions will increase by 150 percent to 250 percent. This means that the world's greenhouse gas emissions triple economic growth. At the same time, to achieve the target of increasing global temperature by 1.5 to 2 degrees Celsius by 2050, all economic zones must have zero greenhouse gas emissions. The global shipping industry therefore faces a major challenge in reducing carbon monoxide emissions as it aims to reduce the impact of climate change. There are many studies on measures to reduce CO2 emissions in maritime. The solutions such as improving design; economies of scale; architecture of electrical power and propulsion systems; build a fast ship; use other fuels and renewable energy; and optimizing extraction plans. can be taken into consideration.

Hull design covers everything related to the size, shape and weight of the boat; This helps improve hydrodynamic performance and reduce drag. Economies of scale are another way to reduce emissions, as larger ships and cargo will produce more energy per unit of cargo

In general, when the payload capacity doubles, the need for electricity and fuel consumption also increases. Fuel consumption per unit is reduced by approximately two-thirds. Energy and propulsion includes the design of electric motors, hybrid solutions, increased energy efficiency, waste energy recovery and the reduction of onboard power required by energy-saving equipment such as kites and sails. Hybrid systems can make good use of many energy sources, such as combining the battery with the internal generator.

To get the best results from all technologies, for example the battery can be used negatively to meet high energy needs. power required and prevent the internal combustion engine from running at low power. Speed is related to the ship's operating speed and design speed. Traditionally, ships are generally designed to operate at the hydrodynamic speed limit; This is the speed at which the resistance curve for a body begins to increase with increasing speed.

Since power must be directly proportional to the product of speed and resistance, this means that when the boat reduces its speed, fuel consumption will also decrease, and when the boat reduces its speed in the boundary zone, the maximum fuel consumption will decrease. fuel savings are achieved. Fuel and Alternative Energy covers anything related to replacing or supplementing the marine fuel HFO-MGO with other energy products. By moving to fuels with lower overall emissions, CO2 emissions can be decreased both immediately and over the course of the fuel cycle, which includes distribution, refinement, and production.

Like LNG and biofuels. Hydrogen is attracting increasing attention due to its use in combination with renewable energy sources such as wind and solar energy. Weather routing and planning will take into account the current, tides and weather, find the best sailing route and speed and deliver according to the contract or published schedule, thus consuming less fuel and using less fuel.

4. Advantages

There are several advantages of electric propulsion system which is mentioned below:

4.1. Environmental Impact

Reduced emissions: Electric propulsion systems in lifeboats produce fewer greenhouse gas emissions compared to conventional engines, contributing to a cleaner maritime environment.

4.2. Operational Efficiency

Electric motors provide instantaneous torque, enabling rapid acceleration and response in critical life-saving scenarios.

4.3. Simplified control

EPS in lifeboats often have fewer moving parts, leading to simplified control systems and potentially lower maintenance requirements.

4.4. Maintenance

EPS in lifeboats typically have fewer components prone to wear and tear, resulting in lower maintenance costs.

4.5. Longer lifespan

Electric motors in lifeboats often have a longer lifespan compared to traditional engines, contributing to the overall reliability of the lifeboat.

5. Dis-advantages

The disadvantages are mentioned below:

5.1. Limited Range

Range limitations: Electric lifeboats may face constraints in terms of range, particularly in situations where extended operation is required.

5.2. Battery technology

The current state of battery technology poses challenges related to energy density, weight, and charging times, potentially limiting the operational capabilities of electric lifeboats.

5.3. Initial Cost

The initial investment for electric propulsion systems in lifeboats can be higher than traditional counterparts, potentially impacting the overall affordability of life-saving vessels.

5.4. Infrastructure

Infrastructure requirements: Charging infrastructure for electric lifeboats may be limited, especially in remote or emergency scenarios, posing challenges for their adoption.

5.5. Reliability Concerns

Electric propulsion systems in lifeboats rely heavily on a stable power supply, raising concerns about reliability in situations with power outages or system failures.

6. Conclusion

Throughout this study, we explored the intricate design considerations, engineering challenges, and performance evaluations associated with integrating electric propulsion into lifeboats. Special attention was directed towards the development of lightweight, high-capacity energy storage systems and efficient electric motors tailored for maritime applications. The advantages of electric propulsion, including reduced emissions, lower maintenance requirements, and improved manoeuvrability, have been thoroughly discussed. Moreover, the exploration of renewable energy sources, such as solar and wind, as complementary components to the electric propulsion system, has been presented as a means to bolster autonomy and resilience during emergency scenarios. Real-world case studies and simulations have substantiated the feasibility and manifold benefits of electric propulsion in lifeboat contexts. Finally, this research contributes significantly to advancing maritime safety, environmental stewardship, and the efficacy of emergency response systems, paving the way for the integration of electric propulsion as a cornerstone in the evolution of lifeboat technology.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare no conflicts of interest regarding the publication of this paper.

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