Electric Propulsion for Warships

In modern naval warfare, the methods of remaining undetected while detecting the enemy have to be considered with a basic design of a propulsion system. Throughout the history of shipbuilding, the key challenge too often has been the right ship around a given propulsion system, rather than creating a tailored propulsion system for the ship. That was true when the best propulsion "engines" available were sails, and it is also true for today's diesel, gas turbines and electric hybrid systems as well. A war ship requires detecting an enemy war ship before it can be detected. To achieve these various systems presented, the board needs to be designed with the aim of having minimum maintenance, minimum noise signature and minimum time requirement to make operational and minimum cost towards improved operational efficiency. These factors have to be considered while designing a suitable propulsion system for warships.

At present in Navy, there are various types of propulsion systems operating ranging from steam turbines, gas turbines, diesel engines to Electrical and Nuclear. Steam propulsion is highly reliable. However, the maintenance required is exhaustive and the time required to prepare it for sea is high. Gas Turbines are robust, require less maintenance and can be operated at high speed. However, they all require a complex and bulky design of gearbox. The machinery noise produced by these engines is vulnerable and can be led to early detection by enemy sensors. This forces us to focus our attention towards electrical propulsion systems which requires minimum maintenance, and which are easy to prepare for sea; makes lesser noise; does not require a complex design of a gear box and saves space for other applications. Further, in the long run, they are most economical even though the electric propulsion system means a high investment.

Electric propulsion refers to a concept where a single generator is used to cater for all the ships' power requirements including the propulsion. This is different from other ships that have a separate system for propulsion and electric power needs. In this system the source generators are used which are referred as power generating nodes. The central power bus feeds power to various systems through distribution nodes. Thus, a single source caters for the entire power requirement of a ship.

Figure 1: A Simplified schematic power propulsion system of a type 23 frigate.

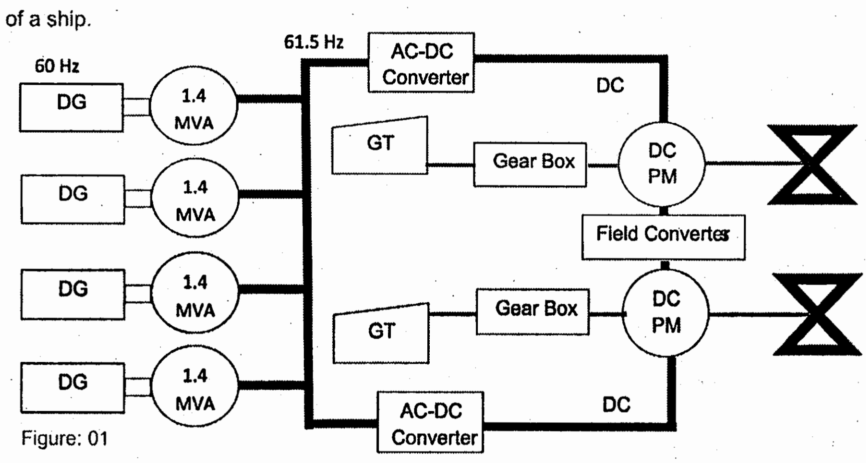

Figure: 01

Figure 1 shows a simplified schematic of the power propulsion system of a type 23 frigate. The system was the first to be installed as an electrical power system using parallel operated generator as a standard line up in the Royal Navy warship. The system employed a half controlled unidirectional main AC-DC converter. It was a result of the need to create a four quadrant electrical propulsion system which has the ability to propel in both directions and absorbs regenerated power in both directions, and a need of a bi-directional field system to enable the armature "back" to be reversed independently of the direction of armature rotation. Conversely, the field converter was designed with a fully controlled rectifier to enable the converter to force the current to reverse more quickly, but being a low current and a low power system, the cost penalty was reduced to an acceptable level. To limit the propulsion current as much as possible the voltage of the main propulsion AC power system is set at 600 V rms which provides a maximum DC system voltage of around 900 V and it is set at iis level in order not to exceed the limitations. The presence of propulsion rectifiers imposed significant distortion on the ships' electrical power system and this was isolated from the ships' service sub-system through the use of rotating motor generators. However, the use of induction motors for the ships' service Motor Generators (MGs) required an amount of slip to be allowed, so the 650 V systems were designed to be operated at 61.5 Hz.

When designing a warship there are two main reasons to be considered. The first and the foremost is the fighting capability of the ship. The fighting capability of a ship refers to the ability of the ship to present itself to take on the challenge offered by the enemy. This includes a large increase in the available power which is a must to operate the weapon systems, communication systems, damage control systems and the propulsion of the ship. Whilst doing so there is a need to make an attempt to reduce the amount of engineering spaces and use these spaces for installation of more effective weapon systems and storage of weapons. The second reason is the quality of life of men on board. Whatever technology is used it should not lower the quality of sailors' lives on board. Men are the working force and their morale is of utmost importance. This means that the technology should provide more space and reduce manpower requirement.

The electric propulsion system seems to be answering all the requirements of a warship since it meets both the major requirement by allocating a great deal of power to war fighting capabilities. At the same time it increases the stealth capability by reducing the noise signature. In addition it reduces the requirement of manpower. The following factors contribute more to the migration to electric propulsion systems rather than the conventional systems.

Speed and Vibration

Diesel engines are used as the prime movers for both the propulsion system and for the electrical power generation. Diesel engines are broadly categorized by means of their speed, ranging from low speed diesel engines to high-speed diesel, which exceed 1000rpm. Against these advantages there is a very poor power-to –weight and power-to –volume ratio. As a result, low speed diesel engines are large and heavy. High speed diesel engines, despite their disadvantages, are very attractive for ships where space is at a premium. A major drawback of diesel engines is that their reciprocating components tend to produce a high noise and vibration. These can increase the ships' noise signature and have a detrimental effect upon other sensitive equipment. Their material and construction render diesel engines more susceptibility to underwater shock than other prime movers. In ships where diesel engines are shaft mounted, the machinery noise produced is very high. Further, the design of a gearbox and CPP mechanism is also exhaustive.

In comparison, in a motor driven ship, the prime mover can be placed high, so that the machinery noise is avoided. A lesser amount of transmission losses generated due to the use of generators and motors and it is worthy as they cannot be detected by enemy submarines. The prime movers can be placed high as they need not to be on the same level as the shaft and it would be suffice if only the power cables from the generator are brought down to the motor. This will give scope for a placement of better shock absorbers, to reduce the level of vibration being transmitted to the hull.

Noise Signature

The underwater noise produced by a surface ship is of vital importance because it is the means by which it may be detected. In addition, any noise which the ship produces can interface with its own sensitive equipment and receivers, thereby reducing its efficiency. The additional noise signature will depend on the ship's speed. At low speed, machinery noise is caused by vibration of rotating and reciprocating. In summary, the radiated noise signature of a ship has three major sources. The source which dominates the signature depends on the speed of the ship. At low speed, the machinery noise dominates but at speed above ten knots the flow noise becomes more important until the cavitation onset speed is reached when the propeller is the most important source.

In shaft mounted diesel engines, the machinery noise is very high at low speed as well as high speed, whereas in the motor driven ships, noise signature is minimal at low and high speed. Reduction of machine noise involves good design and maintenance. This is easily achieved in a motor driven ship. Complex reduction gears are not required in motor driven ships. Instead, there are quieter generators and motors that have shorter shafts which are easier to align. Further, the motor is connected to the generator via cables and hence, a solid shaft no longer acts as a path for noise to go to water. The cables are also flexible; it is easier to isolate the engine and generator from the hull, and thus makes it more effective in keeping the noise from going to water.

Survival of a Warship

Redundancy carries a lot of importance, especially in the case of warships where the possibility of damage factors is very high. In case of an all electric ship, this factor is also catered for quite well. Power sources in this case are distributed throughout the ship eliminating the chances of damage to underwater areas like propulsion shaft, etc. In case of damage to one power generator, the ship is not left totally damaged and helpless as another generator located at some other part of the ship can start acting as the energy source thereby maintaining life of the ship at sea. The power can be re-routed and the ship can be reconfigured to survive better to handle the damages.

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