Comparative Study of Chinese and Foreign Ship Power Systems

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Abstract. With the current further exploration of the ocean by mankind, the shipbuilding industry is also receiving greater attention, and the shipbuilding industry needs to carry out deeper structural optimization and technological innovation. As the core of the ship, the ship power system is directly linked to the upper and lower limits of the entire ship. The pros and cons of the power system technology not only relates to the operation of the entire ship, but also directly affects the sustainability, reliability and stability of the ship. This article discusses and researches the ship power system at home and abroad, and analyzes the current development trend of the ship industry power system.

Keywords: Chinese and foreign ships, power systems, sustainability, trends.

1. Ship power system

1.1. Introduction to Power System
For ensuring the ship’s normal navigation and safety, normal operations, mooring and the safety of crew and passengers, the power system, as the core of the ship, is a necessary and the most critical system. The power system is one of the most important components of the ship. To provide various energy for ships and use these energy, the power system is mainly composed of the main power unit, auxiliary power unit, other auxiliary machinery and equipment. The improvement and optimization of the power system is the current focus and innovation of ship research.

1.2. Kind of power system
According to different ships' requirements for endurance, power, reliability and safety, and speed, there are various types of ship power systems. According to the different types of main engine and auxiliary engine in the power system, the power of the main engine is usually much larger than that of the auxiliary engine. Therefore, the type of ship power system is generally named after the structure of the main engine. At present, it is distinguished by the main engine type. As shown in Figure 1, the common power system types include nuclear power, steam power, diesel power, gas turbine power, combined power, aerodynamic propulsion (AIP) power, integrated power, etc.
2. Mainstream power system analysis

2.1. Steam Power
In a steam power system, fuel is burned in a boiler, and water absorbs heat and vaporizes into steam and enters the high-pressure steam turbine and low-pressure steam turbine to expand and perform work, so that the turbine impeller rotates to drive the propeller to work. The main data of steam-powered ships at home and abroad are shown in Table 1.

| Power/Khp | Pressure/Mpa | Temperature/°C | Advancing speed/(r/min) |
|-----------|--------------|----------------|-------------------------|
| MR (21-25)| 21-25        | 10             | 560                     | 80-90                   |
| URA (360-500) | 28-50      | 6              | 510                     | 85-105                  |
| UA (120-500) | 8-50        | 6              | 510                     | 85-105                  |
| GTZA-674  | 50           | 6.4            | 470                     | 300                     |

2.2. Diesel Power
In the diesel power system, direct heating is used to form high-temperature and high-pressure gas, which makes diesel burn in the cylinder to generate heat energy, and uses gas as a medium to convert the heat energy into mechanical energy. At this time, the gas pushes the piston down to rotate the crankshaft. Do work and drive the propeller to propel the ship. The main data of domestic and foreign diesel-powered ships are shown in Table 2.
Table 2. Diesel-powered ship parameters.

| Power/Khp | Pressure/Mpa | Fuel consumption /g*(kMh)^{-1} | Rotating speed/(r/min) | Overhaul period/h |
|-----------|--------------|---------------------------------|------------------------|------------------|
| MTU16V 4000M90 | 2720          | 2.39                           | 199                    | 2100             | 9000             |
| MTU20V 4000M90L | 4300          | 2.85                           | 220                    | 2100             | 12000            |
| MTU20V 8000M90 | 9000          | 2.7                            | 199                    | 1150             | 24000            |
| MAN B&W 20V28/33D | 9000        | 2.65                           | 190                    | 1000             | 32000            |
| Niigata 12V20FX | 3250          | 2.64                           |                        | 1695             |                  |

2.3. Air-Independent Propulsion
Air-Independent Propulsion (AIP) refers to the technology that can drive a submarine for a long time without obtaining oxygen in the outside air. Conventional AIP systems are mainly divided into two categories: electrochemical AIP systems and thermal engine AIP systems. Among them, the electrochemical AIP system is mainly a fuel cell AIP system (FC); the thermal engine AIP system mainly includes a closed cycle diesel engine (CCD), a closed cycle hot gas engine (SE), a closed cycle steam turbine (MESMA). At present, the most mature technologies are FC and SE.

2.4. Gas Power
The gas turbine is a new type of engine developed in recent decades. Its basic working principle is to use combustion gas as a working medium. The high-pressure gas generated by the combustion of the fuel in the combustion chamber drives the impeller to do work and drives the propeller to propel the ship. Its system uses an internal combustion engine. Gas turbine or jet engine as the prime mover. The main data of gas-powered ships at home and abroad are shown in Table 3.

Table 3. Gas-powered ship parameters.

| Power/KW | effectiveness/% | Fuel consumption /kg*(kMh)^{-1} | Weight/kg | Year of use |
|----------|-----------------|---------------------------------|-----------|-------------|
| LW2500   | 24618           | 37.1                           | 0.226     | 4763        | 1969          |
| LM2500+  | 30213           | 39                             | 0.215     | 5237        | 1998          |
| LM2500+G4| 35338           | 39.4                           | 0.214     | 5237        | 2005          |
| LM6000PC | 42768           | 42                             | 0.2       | 7303        | 1997          |
| MT-30    | 36000           | 40                             | 0.207     | 26000       | 2004          |
| MR-21    | 25252           | 42                             | 0.2       | 7420        | 1997          |
| UGT15000+| 20515           | 36                             | 0.23      | 9000        | 1998          |
| UGT25000 | 28670           | 36                             | 0.228     | 14000       | 1993          |

3. Comparative analysis of various types of power systems
Ships equipped with steam power systems, such as the Liaoning aircraft carrier, the US "Nimitz" class aircraft carrier. Its advantages are large single unit power, low vibration, low noise, high durability, and low fuel quality requirements. However, its shortcomings are also obvious. The main boiler and other equipment are equipped with large area and large fuel consumption. The economy is only half of that of the diesel engine. At the same time, it takes a long time to start up. It also needs a long time to cool down for sudden changes in the working conditions, and the mobility is poor.
Ships equipped with diesel power systems, such as Type 054A frigate and Type 051 destroyer. Its advantages are good economy, high fuel utilization, large power range, lower fuel consumption than steam and gas power systems, good maneuverability, easy start-up, simple operation, and correspondingly fewer auxiliary equipment and machinery. However, its shortcomings are also obvious. During use, it has large noise and vibration, poor stability during low-speed operation, and severe wear during medium-high-speed operation, low durability, and poor overload capacity.

Ships equipped with gas power systems, such as DDG-51 ships and 052D destroyers. Its advantages are unit power mass, extremely small size, fast start-up time, good maneuverability, and fuel consumption rate not far from diesel, but its disadvantages are also obvious. Due to the high temperature of gas, the impeller is made of expensive materials and low durability. Because of its long and large air ducts, this places high requirements on the structural design of the hull. At the same time, its main engine does not have the ability to reverse, and it must be equipped with reversing equipment. It has no self-starting ability and can only rely on starting motors or other motorized machinery.

Ships equipped with AIP power systems, such as the German "214" class submarine and the Japanese "Canglong" class submarine. Its advantages are that the quality and size are small, the structural design requirements are small, the vibration and noise during operation are extremely low, there are no obvious wakes and burn marks, and the endurance is strong. But its shortcomings are also obvious, the power density is low, the output power is small, the technical requirements are extremely high, and the technical difficulty is great.

4. Conclusion
In the process of ship navigation research, the power system is particularly critical as the core technology to promote the progress of the ship industry. Through the comparative analysis of the steam power system, diesel power system, gas power system and AIP power system carried on Chinese and foreign ships, with At present, ships are developing in the direction of large-scale, rapid, specialized and high-speed automation, which requires the power system to have low energy consumption, high single-machine power, strong endurance, long life and good reliability, and high propulsion. Features of efficiency. At present, the widely used steam, diesel, and gas power system technologies are becoming mature and complete, and AIP technology, as a difficult technology that has not yet been overcome, has a long way to go before it is fully applied. The above analysis focuses on the comparative analysis and discussion of various types of domestic and foreign mainstream power systems, and the conclusions and trends drawn are for your reference only.

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