

topics

Electric Propulsion Systems for Ships

Yoshifumi Ajioka Kiyoshi Ohno

OVERVIEW: The number of electric propulsion ships being built is expected to rise due to their ability to do an excellent job in meeting societal demands such as simplifying the running of a ship, increasing fuel efficiency during travel, and reducing CO₂ emissions. Hitachi is applying power converter and electric motor-driven control technology to its development of an electric propulsion system for ships, which was adopted for use in the icebreaker “Shirase.”

INCREASING USE OF ELECTRIC PROPULSION SYSTEMS ON SHIPS

AS is the case with general automobiles that are driven on land, the main type of engine used on ships is the internal combustion engine (motors such as diesel engines and gas turbines). It is a well-known fact that as a societal demand for reductions in carbon dioxide (CO₂) emissions has arisen, electric motor-driven systems have been introduced for use in automobile engines, thereby greatly improving fuel efficiency in hybrid or electric vehicles (which decrease CO₂ emissions by reducing the consumption of fossil fuels). For the same reason, the number of electric propulsion ships being built has also been increasing (based on research by Hitachi, Ltd.), and this trend is expected to continue accelerating in the future.

The introduction of electric propulsion systems for use in ships offers the following four advantages:

- (1) Simplification of the propulsion system, including the complicated reduction gear used to run the ship (frequent shifts between forward and backward movement or acceleration and deceleration; crush astern)
- (2) In the case of ships that consume extremely large amounts of power, a reduction in the financial burden of maintenance and repair including life cycle costs, due to the integration of propulsion motors with power generation motors for use in supporting general internal electrical load
- (3) Silencing of onboard noise
- (4) Improved fuel efficiency during travel due to the ability to constantly maintain a rotational speed that offers good fuel efficiency in the motors used for producing propulsive electric power

Disadvantages include a higher initial cost when compared to propulsion systems based on internal combustion engines, increased energy conversion loss

from fuel to propulsion, and a larger system volume due to the large number of component parts.

Electric propulsion systems are often used on ships such as icebreakers or oceanographic research vessels that take advantage of the aforementioned operational benefits, or large passenger cruise ships and others that emphasize cost and silent operation.

Hitachi is working to develop electric propulsion systems for ships based on these advantages and disadvantages.

SOLUTIONS FOR PROBLEMS AFFECTING ELECTRIC PROPULSION SYSTEMS ON SHIPS

The utilization of industrial technology is being pursued as a strategy for conquering the initial cost disadvantage of electric propulsion systems. The electric propulsion system for icebreakers described below had to have a high-power electric motor that offers load characteristics that can provide a great deal of torque at low speed, and so it was developed by applying electric motor technology for industrial steel mills, which provide similar torque characteristics. Hitachi is also considering size-reduction solutions that apply smart grid technology, an area in which it is focusing a great deal of product development efforts.

EXAMPLES OF ACTUAL USE OF ELECTRIC PROPULSION SYSTEMS

Icebreaker “Shirase”

Since icebreakers must repeat a process of breaking ice then moving forward, their propulsion systems must be able to support sudden movements both forward and backward. This is why the icebreaker Shirase uses an electric propulsion system with electric motor variable speed control. This electric

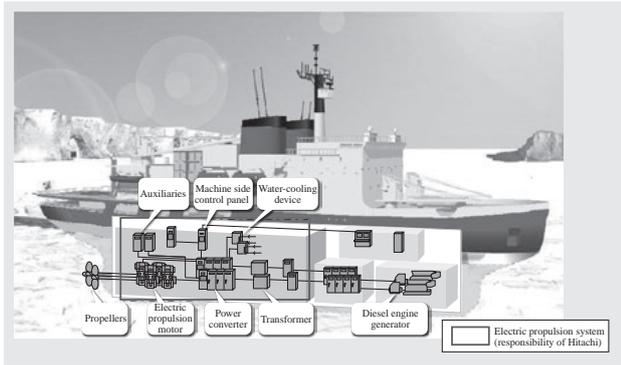


Fig. 1—Devices Related to Icebreaker Electric Propulsion Systems.

propulsion system is comprised of an electric motor, power converter, transformer, initial charging panel, back power absorption resistor, water-cooling device, machine side control panel, and other parts (see Fig. 1). During icebreaking, a steep torque curve (around 170%) is required so that the chunks of ice are smashed as they come into contact with the propellers, and since generator power and electric motor power are around the same level, if there is a precipitous change in load on the propeller, the generator may have trouble keeping up, which can cause the generator's motor to cease up. This electric propulsion system, on the other hand, prevents the motor from ceasing up by outputting the large amounts of torque necessary for icebreaking while maintaining a maximum torque limit, thereby satisfying two conflicting requirements at the same time.

A water-cooled power converter was adopted from a unit used in steel mill motor drives and the environmental resistance required for use on a ship (vibration resistance, shock resistance, heat and cold resistance, humidity resistance, and so on) was achieved through means such as reviewing parts, changing part support structures, and using a rigid structure for chassis.

Bow Thruster Devices for New Cable-laying Ships

Cable-laying ships lay cables on the seafloor. Since this cable-laying work requires a fixed location to be maintained by the ship, in addition to the main propulsion system at the stern, a small propulsion system is also installed on the bow of the ship (bow thruster). This small bow thruster is an elevation/turning bow thruster drive device with electric motor variable speed control, and is comprised of an electric motor, a power converter panel, a transformer, a back power absorption device, and a machine side control panel (see Fig. 2). Since this small bow thruster offers

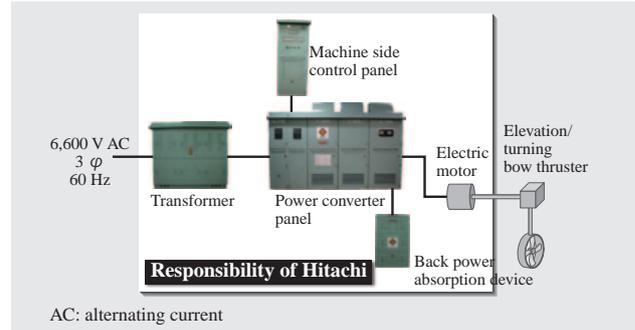


Fig. 2—Configuration of Elevation/Turning Bow Thruster Drive System.

superb responsiveness to rotation speed commands, it is used to maintain the ship's position by changing the running speed of the electric motor based on factors such as the state of ocean currents.

The air-cooled power converter was adopted from a unit used in steel mill motor drives and repurposed by equipping it with the environmental resistance required for use on a ship (shock resistance, heat and cold resistance, humidity resistance, stabilization, and so on) by reviewing parts and chassis.

UTILIZATION OF INDUSTRIAL TECHNOLOGIES

Electric ship propulsion is an effective means of helping to achieve the low-carbon society required by global societal needs. Hitachi is promoting systemization for the same purpose by developing technologies that utilize information systems and other basic technologies that are applied in smart grids and electric vehicles, and these technologies are used to support the ship power network control technology necessary as internal ship power requirements increase, as well as other implementation technologies. Hitachi will continue contributing to the spread of electric propulsion systems for ships by utilizing these technologies.

ABOUT THE AUTHORS



Yoshifumi Ajioka
 Joined Hitachi, Ltd. in 1987, and now works at the Integrated Fleet Systems Office, Electronics & Systems Integration Division, Defense Systems Company. He is currently engaged in the creation and promotion of business plans regarding electric propulsion and power supply systems.



Kiyoshi Ohno
 Joined Hitachi, Ltd. in 1991, and now works at the Electrical Systems Planning Department, Electronics & Systems Integration Division, Defense Systems Company. He is currently engaged in the development and design of electronic systems for use on ships.