# Hybridized horizon

Advances in permanent magnet technology are speeding up the introduction of electric propulsion system hybridization in marine applications

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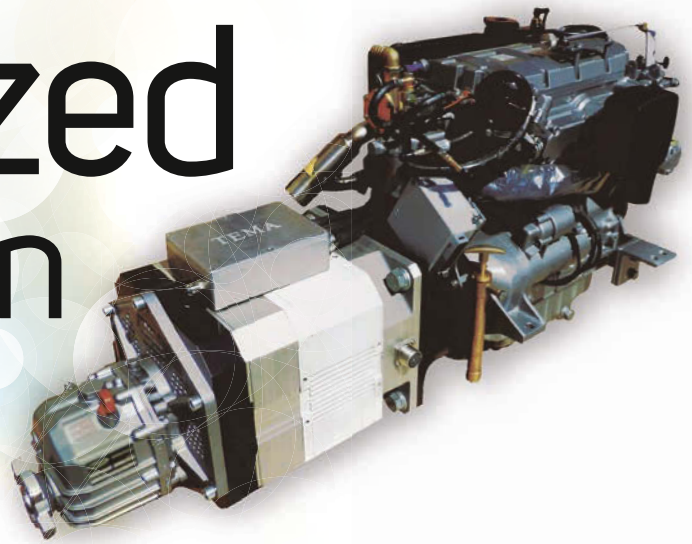


There are three factors that affect the development of marine propulsion systems: fuel savings, maintenance costs, and legislation dealing with environmental protection. The integration of an electric drive in marine propulsion systems harmonizes propulsion power needs; optimizes operating resources; reduces fuel consumption, time and maintenance costs; increases redundancy, robustness and operational safety; and reduces greenhouse gas emissions.

There are differences between vessels that operate as passenger ships, working units and local transportation ships, and those that navigate environmentally protected waterways. However, the owners of all these vessels like to maximize comfort and minimize service costs. And whenever electric drives are used, the advanced technology premium or super premium efficiency (IE4) categories should be used. Hence, permanent magnet (PM) technology must be applied. Motors and generators with PM technology are always accompanied by power electronics and advanced digital controls. These make the system more complex yet unbeatable in terms of comfort, user-friendly operation, and energy transfer efficiency.

Compared with conventional diesel engine propulsion systems, today's electric equivalents offer much better performance, but are hindered by a lack of adequate energy source capacity. This means comparing up-to-date battery energy capacity with a fuel tank-concentrated chemical energy, and as such, the ship owner has to invest much more money at the beginning to enjoy long-term fuel savings and get a return on their investment.

Practical applications today use conventional fuel-like energy sources, but propulsion energy control is achieved by electric systems via a process called hybridization.

When a diesel engine is connected to a generator and when an electric motor is connected to a propeller shaft, an electric shaft, referred to as a serial hybrid system, is installed between the power source and propeller shaft. The propeller is always driven by an electric motor.

In this system, a common DC bus solution is the best choice. When a genset supplies a DC bus, there is no need for constant frequency operation. Here, a diesel engine can operate in variable speed and generator frequency mode (VSGS), offering maximum efficiency. By controlling the engine speed through measuring the output voltage and current, VSGS can operate as a battery charger, or control the engine speed separately. It can also use a step-down converter to stabilize the output voltage. The best solution is offered by using a diesel engine speed controller to optimize fuel consumption and an active front-end solution for voltage buck and boost control. The system requires more investment, but it makes a return on the investment much faster than conventional systems, reduces fuel consumption, and offers the best common DC bus performance.

An electric motor and diesel engine connected on the same shaft is referred to as a parallel hybrid system. The propeller can be driven by the electric motor and/or diesel engine. The mechanical connection between the diesel engine, electric motor and propeller can be achieved in different ways.

Small ships and boats usually use an in-line configuration. Here, it is important to operate the propulsion shaft in both directions with the diesel engine and electric motor. The diesel engine should be able to drive the propeller for maneuvering and navigation. The same applies to the electric motor, giving users a choice of which system to use and which to have on standby.

The battery should be charged by the electric motor running as a generator and driven by the diesel engine, or by batteries charged from a shore connection point. A coupling control between the diesel motor and propeller shaft should be as simple as possible, and should be robust and engaged for low torque and low power systems.

## The core of electric propulsion

Advanced technology and innovation in PM electric machine design are making significant steps toward the introduction of electric propulsion system hybridization.

A serial hybrid solution offers the best marine propulsion system efficiency. It is usually used in more powerful marine propulsion systems. Combining several variable speed gensets with an electric propulsion motor connected over an active front-end and inverters to a common DC bus generally provides flexible maneuvering and navigation features with improved efficiency.

Meanwhile, a parallel hybrid solution makes for a good compromise between navigation autonomy, space usage and investment. It offers redundancy, compact installation, and optimizes the overall system efficiency. Such a configuration is usually selected for boats and small ships, as well as speedboats and yachts, to boost the main engine before vessel planing.

Above: Parallel hybrid solutions offer a good compromise between navigation autonomy, space usage and investment, and can optimize system efficiency