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Attracting optimal efficiency

Tugs and OSVs need to balance commercial viability with environmental standards. Mika Koli from Finnish technology company The Switch writes that permanent magnet technology is one tried-and-tested way to increase efficiency, decrease maintenance, and reduce emissions

► *Mika Koli, marine business development manager, The Switch*

As cost pressures mount and environmental regulations become more stringent, the need for a smart and innovative approach is becoming increasingly apparent. This is particularly true for tugs and OSVs that primarily operate at partial load. Instead of modifying conventional technology, such as induction motors, results prove that there is a much better way to save on operational costs.

Using permanent magnet (PM) motors and generators as key elements in advanced drive trains allows ship owners to take advantage of a more flexible, modular, efficient and lightweight propulsion system.

Although new to marine applications, PM technology has in fact been a game changer for many years in other industries, such as wind power, where it ensures the highest energy efficiency and lowest cost of operation. As a bonus, this technology helps future-proof ships when it comes to even the strictest environmental legislation.

For electric propulsion, drive trains based on PM technology are ideal for vessels such as tugboats, OSVs, research ships, icebreakers and more. The technology enables ships to lower their operational costs by optimising fuel consumption through superior efficiency, reliability and design flexibility.

A synchronous PM machine contains neodymium-iron-boron (NdFeB) magnets, which are materials with a very high flux density. This makes them ideal for variable-speed motors and generators throughout the entire speed range. The magnet field is created with almost zero rotor losses.

A PM machine gives high-efficiency performance over the entire operating range, significantly cutting back on fuel consumption. A PM is typically 2-4 per cent more efficient at full load and 10 per cent more efficient at part load when compared with induction machines. These efficiencies result from a lack of current losses in the rotor, the absence of an exciter, and reduced winding losses.

PM propulsion motors and their inverters efficiently turn available energy into thrust. Although standard induction motors can reach high efficiency in a narrow band around their nominal working area, PM motors are designed to deliver even higher efficiency in a much wider speed and torque range, which is so important to cutting back on total fuel consumption.

In a recent study of two 1,250kW diesel-electric propulsion trains, PM motors achieved annual fuel savings of more than 3 per cent with the same Z-drive thruster. PM motors also make it possible to use an L-drive thruster, which results in fuel savings of more than an extra 1 per cent, along with length and weight savings thanks to the stacking ability.

A frequency converter offers the accurate and adjustable speed control needed for dynamic positioning and demanding load cycles in offshore and special vessels. The high-energy density of PM technology and the resulting decrease in rotor inertia are both beneficial when the ship needs high manoeuvrability and a DP-class propulsion system. This results in optimum fuel efficiency and lower levels of exhaust.

Highly-pulsating power demand also poses a serious threat to the lifetime of a vessel's engine. The ability to deliver a combination of short, full-power bursts with longer periods of low power can lead to wear.

To handle highly-fluctuating load cycles, guarantee longer engine life, cut back on fuel consumption and reach lower exhaust values, adjustable speed control is ideal. This avoids the low or no-load running of generators, which minimises engine heat stress, reduces fuel consumption and eliminates undesired start/stop engine cycles.

PM machines have proven their high reliability and durability under extremely harsh operating conditions in many industrial applications. For example, they have even been used in wind turbines, which operate in a much harsher environment than the challenging marine market.

In direct propulsion systems, no gearbox or accompanying slip rings and brushes are needed, as with other synchronous machines. Therefore, the PM propulsion line machine experiences fewer failures and requires significantly less maintenance.

The Switch frequency converters are optimised to work with PM machines for the best overall system efficiency. The electricity produced is of better quality with low electrical noise emission and total harmonic distortion of less than 1.5 per cent. Additionally, PM drive trains have always demonstrated superior grid connection behaviour, even in distributed environments.

The frequency converter features a rugged IP54-class cabinet, which is a higher class to withstand the harsh sea environments. It can be easily accessed for installation and maintenance.

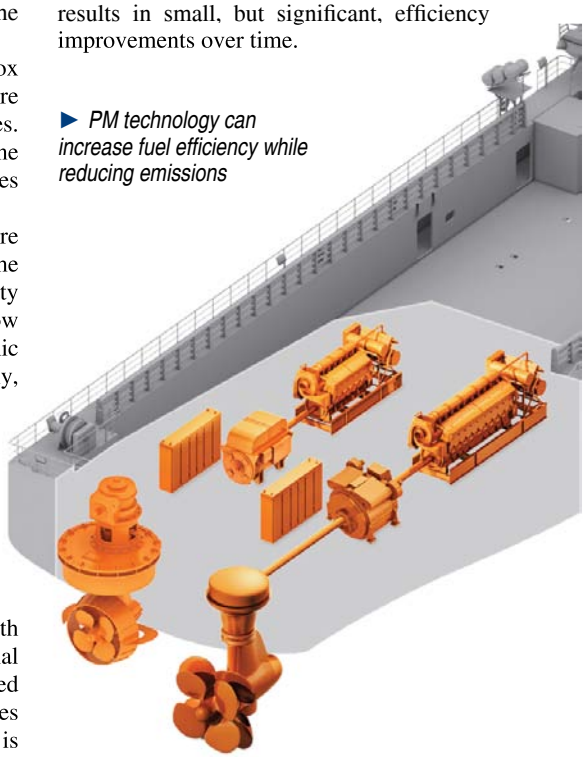
PM drive train solutions are compact, with less weight and volume than conventional drive trains. They offer unsurpassed flexibility and a smaller footprint for all types of configurations, especially when space is a factor. Additionally, PM solutions comply with low environmental footprint rules.

By using a PM generator as part of a generator set, significant weight savings can be achieved, and the total length of the generator set can be reduced. On the propulsion side, using a PM machine as a propulsion motor combined with an inverter can lead to weight savings and switchboard length reductions.

In all, this radically changes a typically packed machine room into an easily accessible space for machines, crew and maintenance personnel.

During dynamic positioning, a low speed with constant acceleration and deceleration is needed to keep the ship in place when adapting to weather and sea conditions. PM machines have the ability to function efficiently at low speeds and throughout the entire load range. In vessels where all energy is produced by fuel, a lower consumption leads to an improved operational range and lower operational costs.

Constantly varying speeds and loads can benefit from the active motor cooling, which keeps operating temperatures low. This results in small, but significant, efficiency improvements over time.



► *PM technology can increase fuel efficiency while reducing emissions*