MOL Rotating Equipment Consultant

Marine power goes diesel-electric.

Why are electrical drives popular today? What is their added value? What will the future bring?
At first let us place two events in their historical context.
Ever since railway transportation commenced over a 100 years ago the mechanical transmissions have been powered by electric motors. Locomotives house diesel engines to produce electricity not mechanical power.
In marine transportation it is all the other way round: diesel engines take care of propulsion and bow thrusting.
Why such a difference in approach whilst the prime objective is obviously the same: take stuff from A to B? Isn't it because in railway engineering the electrical guys are leading whilst in the world of marine power the mechanical millwrights have always been dominant? But what to do when it comes to fuel efficiency, comfort on board, asset reliability, maintenance costs control, modular design and environmental care? Which of the two engineering cultures is best equipped to meet the challenges of tomorrow? Which principles will be thrown overboard in the scramble to get best economy? Or is a clever mix or a novel third approach the answer?

The floating locomotive.

Today there is a clear tendency to go for the design of so-called 'all-electric' ships. Featuring electric power generation by diesel-gensets or gasturbine-gensets and mechanical drives driven by electric motors only, not by diesel engines. Also the position of hydraulic motor applications is under pressure. Various novel electrical-mechanical designs, often using variable frequency converters have already been constructed and put into operation. These designs are known as 'hybrid drives' or 'diesel-electric drives'. Some designs are patent pending. However most of them are basically classical as they make use of 'slipringless' slipring motors or slip recovery drives to get a variable speed. This is making marine transportation more and more the domain of electrical engineers with their 'floating locomotives'. Will the electrical guys rule the seven seas tomorrow?

Electrical drive setup.

The basic design difficulty with diesel engines driving propellors or centrifugal pumps is the natural mismatch of torque - speed characteristics of both machines. That is why a gearbox is inevitably incorporated. Electric motors however are a better match for propulsion, winches, cranes, bow-thrusters, etc. Using an electric drive comprising electric motor and variable frequency converter overcomes this inefficient mismatch. Such an electric motor will be a standard multi-pole - low speed induction motor directly connected to propellor shaft, a 'direct-drive' arrangement. The shaft direction of rotation can easily be reversed eliminating the need for a bi-directional mechanical clutch. A gear box is also eliminated making the propulsion drive 'oil-free'. Reliability increases and maintenance costs decrease simply because components that are not there shall never run to failure.
The noisy and vibrant diesel engine can be containerised and located anywhere on board providing better noise and vibration isolation hence improved comfort for crew members and often providing more room for payload. Such an electric power plant with gensets in parallel-redundant operation generate all the electric power needed on board. Genset output frequency can be adjusted to cope with the required demand of power. Depending on application this option may open fuel efficiency opportunities. The increased simplicity allows shipyard to reduce installation and commissioning time line.

Permanent magnet technology.

A new development is using a synchronous permanent magnet motor instead of a standard asynchronous induction motor. Such a permanent magnet (PM) motor has a rotor with permanent magnets instead of a squirrel cage rotor. Stator and bearing design are similar. The availability of powerfull magnets enable the construction of motors up into the MW power ratings.

Design features compared to induction motor are:
- High torque per weight, increased kW/kg ratio. Using water-cooled motors reduce overall dimensions further.
- Higher efficiency as rotor slip losses are eliminated. But considering the total chain from diesel fuel injection to propellor vortex such an efficiency claim should not be overestimated as the kW losses in electric motors are only a fraction of the total energy losses.
- Two propellors can run in synchronism and in anti-phase when driven by synchronised frequency converters eliminating the annoying interference in noise and vibration. Anyone who ever tried to get to sleep on a North Sea Ferry knows how annoying this slowly fluctuating noise and vibration can be (unless this is masked by the late night disco beat!).
- A frequency converter is usefull to set speed to desired value however mandatory to start-up a synchronous motor.
- The absence of a squirrel cage results in absence of magnetic noise, a PM motor is basically a low noise motor.
- As a synchronous motor is self-commutating the design of a frequency converter can be reviewed which may lead to simplified designs resulting in reduced di-electric stress on winding insulation materials. And in reduced chance for bearing failure as a result of electrical current passage.
- When equipped with a damper cage located in the rotor poles the PM motor can provide torsional stability. With absence of the many vibration excitation frequencies that come with a diesel engine it is anyway so much easier to control torsional vibrations. This eliminates associated problems like reduction of lifetime of torsional flexible couplings.
- Delivery times for electrical machines are shorter than for diesel engines.

PM technology is on the brink of large scale application in power drives. On shore and at sea. Potential reliability threats like corrosion sensitivity will be eliminated. Mechanical shops need to be prepared to handle PM machines as these machines can not be handled in the traditional way. Each of the design features mentioned may not be considered to be an outstanding advantage. But it is the sum of them all that makes electrical (PM) drives favourable in so many respects.