Gas turbines ready for merchant sector revival

In a presentation to the recent Motorship Gas Fuelled Ships Conference, held in September onboard the dual-fuelled cruise ferry Viking Grace, Mr Barnes described GE’s combined gas turbine, electric and supercritical CO2 (COGES) propulsion option for gas fuelled ships

In the 1990s it looked as if gas turbines – which have always been a popular option for naval vessel propulsion - could have found a home in niche passenger ship markets. GE and other manufacturers collected several references in fast ferries and cruise ships, with GE’s LM2500 aero-derivative gas turbine proving the most widely-adopted engine. Although gas turbines are unmatched in power density, provide low emissions and quiet, vibration-free operation, and enjoy simple maintenance thanks to the modular construction and small size, they have never been able to compete with diesels in fuel consumption terms. They and lost ground once again to the reciprocating engine once fuel prices began climbing sharply over the last decade or so.

LM2500 packaged for marine propulsion applications

Nevertheless, GE claims to have delivered more than 1,200 LM2500s for marine use, including naval vessels, which added to the 1,900-plus delivered for industrial applications, provides a considerable amount of market experience. Signs of a revival are already here, with the Incat-built fast ferry Francisco now in service with Buquebus in South America, powered by two LM2500s running on LNG fuel – the first gas-fuelled high speed ferry. In fast ferries the advantages are obvious; high power equates to high speed, and with a capability of over 58 knots Francisco is the fastest ferry of its type afloat. The low weight of the engines means a lighter ship displacement, which in turn leads to reduced draught and reduced drag. And the compactness of the engine allows flexibility in positioning, fitting comfortably in the catamaran hull form.

Similar benefits have been demonstrated in the LM2500 cruise ship installations. The small volume permits more space to be used for revenue-earning cabins and public areas onboard, while flexibility offered by the small size and light weight allows the engines to be placed in such a location as to maximise the ship’s revenue-earning capacity. As an example, in the Queen Mary 2, the gas turbines are sited in the otherwise dead space in the base of the funnel.

As more ECAs are established, and generally NOx, SOx and particulates are limited by tighter emissions regulations, both nationally (as in the US EPA) and globally (by IMO), the industry is looking for engines that can burn cleaner fuels, but retain a degree of flexibility in fuel choice. Here, the LM2500 with its dry low emissions (DLE) system offers an alternative. Burning LNG, a sulphur-free fuel, produces negligible SOx emissions, while the engine meets 2016 NOx limits without the need for SCR after-treatment. Moreover, GE adds that the DLE system is dual-fuel capable, allowing the use of diesel fuels where gas is not available.

Mr Barnes believes that as well as emissions regulations, rising and uncertain fuel oil price trends, the uncertainty over HFO availability after 2018-2020 and the expected downward price trend for LNG in relation to oil, especially in North America, could all add up to making gas turbines running primarily on LNG a realistic option. Around 2016 the combination of emission regulations and the spread between
the cost of gas and distillate fuels will offer gas turbines an opportunity to re-enter the market on economic grounds. Further benefits can be gained from reduced maintenance. Costs, says Mr Barnes, for a gas turbine running on LNG, are halved compared with using liquid fuel.

So, given the timescale for ordering new tonnage, GE considers that now is the time to give gas turbines another look. The benefits of gas turbine for passenger vessels can, in GE’s opinion, be leveraged to cargo ships, and in particular LNG carriers. The COGES system used in cruise ships is equally suited to an LNG carrier power plant.

According to GE, the advantages of the so-called supercritical CO2 power cycle, otherwise known as the exhaust energy recovery option, which recovers waste heat from the gas turbine exhausts, are that its is safe, using non-flammable, non-toxic, non-corrosive, thermally stable working fluids. It employs a simple, in-stack waste heat exchanger, with no boiling. The cycle is flexible, integrating with either diesel or gas turbine power and allows a choice of fuel. The closed-loop system is compact, and incurs minimal operation and maintenance costs. The thermal-to-electric power conversion efficiency is claimed to be competitive with other technologies, while the capital cost is typically lower than steam or organic Rankine cycle (ORC) technologies.

The system would employ two LM2500 (or other gas turbine) powered generators, feeding, via the switchboards, the propulsion load and the ship’s other electrical loads. The LM2500s have dual fuel (gas or MGO) capability. Heat produced by the gas turbines would be recovered to produce steam, some of which would supply the ship’s steam loads, and the rest used to power a steam-driven generator set which would supply additional electrical power to the switchboards. An auxiliary boiler, powered by gas or MGO, could provide additional steam, and a small diesel generator could also feed into the system. The benefits of this arrangement, beside the afore-mentioned compact size, light weight and low maintenance costs, include:

- Design flexibility, offering the capability to use multiple sources of electrical power and steam;
- Dual fuel gas (LNG) and MGO capable

Over 1,200 examples of GE’S LM2500 have been delivered for marine use
• For LNG carriers, when power requirement is in excess of available boil off gas (BOG), the system can use forced boil off gas to supplement BOG or switch to MGO.
• The auxiliary diesel genset provides 'black start' capability
• The use of twin gas turbine plant ensures redundancy
• In normal operation one gas turbine with heat recovery system and the steam generator would provide sufficient power.
• If one gas turbine is unavailable, operation would not be affected.

GE’s predictions for low maintenance costs are based on the fact that using condition-based maintenance, overhaul is only performed when the engine condition warrants this. Routine maintenance would include changing fuel filters and regularly checking fluid levels. Preventive Maintenance would be employed, using gas turbine borescope inspections and system inspections to assess engine condition.

Predicted maintenance requirements allow for 15,000 hour intervals between hot section refurbishments when burning MGO; this can be extended to 25,000 hours-plus on LNG. Maintenance intervals can thus be planned for every three years, or to coincide with survey with MGO, longer on LNG.

Engine removal for maintenance, or swapping gas turbine modules for repair, is a comparatively simple task, taking 24 hours or less depending on arrangement, so the vessel availability is enhanced compared with normal drydocking. GE says that actual engine life frequently exceeds these predictions.

Looking at a typical LNG carrier of 170,000m³ capacity, GE compares certain costs - fuel burn and lube oil, capital expenditure, maintenance, operating expenses, and availability - between dual fuel diesel electric (DFDE), low speed engine with mechanical drive, and gas turbines.

The results indicate that:
• low speed mechanical drive has highest efficiency, DFDE lowest;
• low speed has higher first cost, DFDE lowest;
• gas turbine maintenance costs are lower;
• the gas turbine uses very little lube oil; and
• the gas turbine plant can be easily and quickly replaced.

GE's COGES sytem as proposed for LNG carriers

Meeting these performance requirements, says Mr Barnes, enables users to take advantage of other gas turbine benefits, such as high power density, emissions compliance, high reliability, and low fuel gas pressure (compared to low speed engines).

With the key COGES advantages, namely:
• Emissions: Tier III IMO compliance today, without exhaust after-treatment;
• Maintenance: 24 hour swap-out, high availability; and
• Small footprint: ship design flexibility, extra room for cargo

Gas turbines could well provide a viable alternative to conventional propulsion plants in the merchant shipping sector.

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