Options for LNGC power flower

After holding a virtual monopoly over the LNG carrier propulsion system market for over 35 years, steam turbines look set to encounter some serious competition. Furthermore, the world's two remaining steam turbine manufacturers are fearful that, in light of recent developments, once the dam is breached, they might quickly be forced to pack up shop

A good indicator of the extent to which liquefied natural gas (LNG) shipping is a conservative industry is given by the fact that steam turbines remain the propulsion system of choice for LNG carriers, virtually without exception. LNG carriers are the only commercial ships where steam turbines are still utilised, oil tanker owners having switched their ships over to diesel engines back in the 1970s.

LNG owners favour steam turbines for several reasons, most notably their dual-fuel capabilities and their reliability. All the gas that boils off from the liquefied cargo during the course of an LNG carrier voyage can be burned in the boilers as readily as fuel oil to generate steam.

Engine reliability is a key factor because gas producers and consumers depend on a steady flow of product, and the restricted availability of alternative ships means that vessel downtime has to be kept to a carefully planned minimum.

New conditions apply

The arrival of the new century coincides with growing concern about the environment, a greater awareness of the benefits of clean-burning natural gas and a global LNG traffic volume that is set to double within 10 years.

While the traditional LNG trading pattern, characterised by ships shuttling back and forth between nominated load and discharge ports over the 20-year life of a gas sale and purchase contract, will continue to predominate, the rapid growth in LNG shipments means that opportunities for more short-term contracts, multiport load and discharge arrangements, backhaul cargoes and inter-route trading are expanding.

The need to consider additional levels of ship flexibility to accommodate more diverse trading patterns has coincided with an industry push to cut costs and improve efficiencies along the transport chain in order to improve the economics of gas projects.

Steam turbines, whether burning heavy fuel oil or natural gas boil-off, make for a comparatively inefficient power delivery system. As a result, ship propulsion has been identified as a key area for potential savings, and investigative work on alternatives to steam turbines on LNG ships has intensified in recent years.

Strength in steam

The alternatives to steam turbine propulsion under review are low-pressure, dual-fuel diesel engines; high-pressure, gas-injection, dual-fuel diesel engines; dual-fuel, slow-speed diesel engines; dual-fuel, medium-speed diesel engines mechanically coupled; dual-fuel, medium-speed diesel electric propulsion; and gas turbines.

Some of these engine options have been considered in single-fuel mode in tandem with an onboard reliquefaction plant to cool down LNG boil-off and redirect it back to the cargo tanks. Differences in the prices of oil fuel and natural gas will be a factor in any decision on whether to opt for onboard reliquefaction.

Engine builder MAN B&W points out that the use of onboard reliquefaction in tandem with two-stroke, heavy fuel diesel engines will yield savings of $2.5m per year on overall propulsion system costs of $5m, when compared to the dual-fuel steam turbine alternative. These savings, which would have to be offset against the capital cost of the reliquefaction plant, stem from delivery of that cargo which would normally boil off and be consumed as fuel in the steam turbine ship's boilers.

Irrespective of what happens in the future, however, for the moment the inherent conservatism which pervades the high-stakes, capital-intensive LNG supply chains currently in operation underpins the dominant position of steam turbines. All 128 tankers in LNG service are powered by steam and, of the 61 deepsea LNG carriers on order, all but one are to be supplied with steam turbines by either of the two remaining turbine manufacturers, Mitsubishi and Kawasaki.

The one non-steam turbine newbuilding - a 75,000 cu m ship under construction at Chantiers de l'Atlantique in France, which will be powered by diesel-electric propulsion (see accompanying panel) - represents a brave decision by the shipowner and a major step for the LNG industry. The ship has also served to intensify worries about where the additional steam engineers needed to run the other 60 newbuildings are to come from.

Boil-off in port

One investigator of alternative LNG carrier propulsion systems is a joint venture initiative comprising personnel from the Isle of Man-based Dorchester Maritime Ltd (DML) and Tractebel Gas Engineering (TGE) in Germany.

"One of the key considerations with dual-fuel engines is what to do with the boil-off gas when the ship is at anchor or tied up in port," states Chris Clucas, DML gas projects manager. "In turbine ships the boil-off gas can be burned in the boilers, with re-condensation of the steam. However, for dual-fuel diesels either a reliquefaction plant or a thermal oxidiser to dispose of the excess boil-off gas are probably the most practical solutions.

"Having said that, with an installation cost of approximately $850,000, thermal oxidisers are a relatively expensive alternative. Our investigations with TGE have tended to focus on options featuring a dual-fuel diesel engine in combination with a reliquefaction plant."

Amongst the options being considered are designs for a highly flexible ship based on dual-fuel diesel electric propulsion, with either a single or duplicated reliquefaction plant or a thermal oxidiser, according to customer preference. The DML/TGE team believes that the use of a pair of azimuthing pods to propel the gas carrier would also overcome this boil-off problem when the dual-fuel option is chosen.

When the ship is at anchor, the two pods would be set to face each other and, if there is the need to run the dual-fuel engine to consume the boil-off gas, the pods would simply work in opposition to each other. In this way the ship would be kept stationary and the cargo boil-off would be disposed of. This idea, which would provide a backup to the ship reliquefaction plant, has been patented by DML.

"Although pods are relatively expensive, they have the further advantage of providing the LNG carrier with a high degree of manoeuvrability," comments Chris Clucas. "This capability will be crucial when and if the LNG industry moves to floating production systems or offshore loading/discharging buoys."

Gas turbines in view

Also on the horizon is the use of gas turbine propulsion systems for LNG carriers. Rolls Royce, Alstom and GE are pressing ahead with development work on gas turbines for LNG ships, using their extensive experience of land-based plant, aero engines and the first generation of marine gas turbines.

The manufacturers claim that their second generation designs make ideal propulsion units for LNG carriers due to their improved fuel consumption, well-developed maintenance regimes, low emission levels and the ease of dual-fuel operation, especially when linked to an electric transmission system. Also, it is possible to run the new marine gas turbines as dual-fuel engines on heavier grades of oil, a capability which makes them more competitive with diesel engine alternatives than previously.

Steam turbine plant, with its requirement for two large boilers, is most demanding of engine room space, while gas turbines are the least. Gas turbines are comparatively small and can be positioned virtually anywhere, attributes which allow that portion of the ship hull to be given over to cargo to be maximised.
On the downside, gas turbines can be expensive to repair if things go wrong and their propulsive efficiency drops when ambient temperatures are high. Also, gas turbines provide optimum fuel efficiency when running at continuous high load. It may be possible to overcome this problem by running the turbine continuously at full power and using a diesel genset as a booster to provide peak power when required.
Taken on balance, gas turbines, like steam turbines, should prove reliable in LNG carrier service and the concept has potential in the longer term. Those gas turbine configurations showing the most promise are those provided with a low-pressure steam plant which is used to convert the thermal heat of the exhaust gas into electric power.

Pods ready to open out?
As outlined above, podded drive systems have the potential to overcome the problem of how to dispose of unwanted cargo boil-off when non-steam, dual-fuel LNG tankers are tied up alongside in port. Having gained acceptance in the cruise ship industry, both the Azipod system from Finland's ABB Industri and the Mermaid system from Kamewa/Alstom are finding that new markets are opening up.
Another, similar system - the Siemens-Schottel SSP - has been specified not only for a cruise ship, but also onboard a chemical carrier, two ro-ro ferries and two heavy lift ships. The latest design to enter the podded drive market is the Dolphin, jointly developed by STN Atlas Marine Electronics of Hamburg and John Crane-Lips of Drunen in the Netherlands.
Amongst other applications, the Azipod system is being considered for use onboard a large LNG carrier. In a base case study Wärtsilä is investigating the extent to which Azipods could service a 138,000 cu m carrier with an operating speed of 20 knots and a power requirement of approximately 26 MW at the propeller and a further 6 MW for electrical requirements, if electric cargo pumps are utilised.
In one of the study scenarios for a twin-screw ship, the requirements are met by a low-speed main diesel engine driving a single, fixed pitch propeller and a complementary podded drive which replaces the rudder. The main engine, which would operate on heavy fuel oil, would supply approximately half of the power requirement, while the podded drive would provide the other half.

More non-steam testbeds
Meanwhile, the non-steam turbine trickle continues. Last month Knutsen OAS ordered a 1,100 cu m tanker to deliver up to 40,000 tonnes of LNG a year along the Norwegian coast from a depot near Bergen. This vessel, which will be the smallest LNG carrier ever built, will have four diesel electric engines driving two azimuthing thrusters.
Two independent engine rooms will be provided, one with two gensets powered by LNG cargo boil-off and the other with two gensets for running on diesel fuel as back-up. The ship is being built at the Bijlsma yard in the Netherlands at a cost of $11.7m for October 2003 delivery.

Non-steam future
In practice, steam turbines are well-established in the LNG sector and it is unlikely that such machinery will be abandoned overnight simply because one non-steam-powered LNG carrier has been ordered. There are a number of perceived problems for which industry will want to be assured of solutions before changing the habits of a lifetime.

For example, whether or not dual-fuel diesel electrics can be effectively scaled up for the more common size of 135,000 cu m LNG carrier to provide the required constant, low power supply is one question that needs answering. There are also concerns about the high level of nitrogen oxides emitted from diesel engines due to high combustion temperatures, and the capital and operating costs associated with the use of reliquefaction plants;
Nevertheless, the disadvantages of steam - inferior fuel efficiency and high fuel costs - are becoming more critical. No doubt, the industry will be watching the performance of the new LNG carrier propulsion technology in the Gaz de France ship, once commissioned. Because continuous technological advances are being made with the alternative propulsion systems, it is likely that before the end of this decade diesels, and possibly gas turbines, will be specified as the power plants of choice in a growing number of LNG carrier newbuildings.