Powerful Options

PROPULSION MANUFACTURERS USE STATE-OF-THE-ART TECHNOLOGY TO CREATE AND UPGRADE ENGINES THAT ARE BOTH POWERFUL AND EFFICIENT.

BY HENRY CANADAY, CGF CORRESPONDENT

Options for upgrading the performance, reliability, environmental characteristics, life and maintainability of engines on Coast Guard boats and cutters abound. But complicated choices must be made, costs taken into account and tradeoffs among important objectives resolved.

Current engines may be upgraded or replaced. The Coast Guard may seek to meet new environmental regulations, even if not necessarily required to do so. Improvements on well-proven technologies may be best, or new technologies may be sought with bigger potential gains. Always, operating profiles of vessels must be well predicted if optimum choices are to be made. The choices are not easy, but complex, expensive and long-lasting in their effects.

Richard Partridge

There are currently 65 Fairbanks Morse ALCO 251 engines installed on Coast Guard cutters, and the company is launching an upgrade kit for the engine. One of the key benefits of the upgrade kit is improved efficiency, reducing fuel costs by up to 5 percent. In addition, the kit delivers lower emissions, meeting EPA Tier 2 levels for nitrogen oxide (NOx), total hydrocarbons, particulates and carbon monoxide.

Matt Wisniewski, director of engineered solutions, said, "The upgrade kit costs far less than a complete engine re-power." Upgrade costs depend on configuration, but when installed during overhaul, upgrade and center-section overhaul can be completed for less than half the cost of a replacement engine. Center-section overhauls are typically completed every three to five years.

The kit includes a more efficient turbocharger, new piston-bowl geometry and an enhanced cam profile providing increased partial load efficiency and lower brake specific-fuel consumption. About 80 percent of the kit is common to most ALCO engines and 20 percent must be tailored to specific engine configuration. Fairbanks Morse Solutions works closely with operators to ensure each upgrade kit matches the specific engine model and application configuration.

The kit is currently available for quoting, and Fairbanks Morse Solutions is initially focusing on commercial vessels that will have to meet California Air Resources Board requirements, similar to EPA Tier 2, and the Canadian Coast Guard, which sought the upgrade. In addition, vessels operated by the Coast Guard can also benefit from this upgrade kit.

Entirely new engine choices are also available. Richard Partridge, chief of Naval Systems at Rolls-Royce, argues that his firm's new third-generation hybrid system technology, derived from commercial-offshore vessels, has strong advantages for large Coast Guard vessels that operate most of the time below top speed, such as the offshore patrol cutter.

Rolls-Royce's Hybrid Shaft Generator (HSG) can operate in several modes—diesel-only propulsion, diesel-electric propulsion, assisted trailing mode, transit mode and diesel HSG boost mode—providing plenty of flexibility. In each mode, propeller and main engine operate at optimum revolutions and pitch, maximizing propulsive efficiency over the vessel's speed range.

When in generator/power take-off mode, HSG's induction machine supplies power at constant voltage and frequency, regardless of main engine and propeller revolutions. This maximizes propulsive efficiency and fuel economy, vessel range, endurance and life cycle economy. HSG also supports prolonged low-speed or loiter operations very efficiently, with low vibration levels to optimize crew conditions.

HSG reduces dependence on diesel generator sets, resulting in lower fuel consumption and engine running hours. Also, patrol vessels may need fewer installed diesel generator sets or less power capacity. Fewer engines should mean less maintenance costs and may mean reduced manning requirements. Better fuel efficiency means reduced carbon dioxide (CO2) emissions.

Partridge believes Rolls-Royce is well ahead of other manufacturers in achieving advantages of third-generation hybrid systems. HSG entered sea-going service in 2012 on Norwegian ferries, demonstrating operational flexibility and fuel economy and raising HSG to Technology Readiness Level 9.

For the polar icebreaker, Partridge recommended consideration of the MT30 gas turbine generator (GTG), an engine derived from the power-plant on the Boeing 777. The Rolls-Royce exec expects the icebreaker to use full electric propulsion that will support top ship speed and efficiently support prolonged low-speed operations, be highly reliable and re-configurable, produce low vibrations and be compact, proven and affordable in terms of initial acquisition and lifecycle cost.

Partridge believes modern aviation gas-turbine technology has achieved new levels of power output with ultra-high reliability. "The MT30, derived from the same parent-engine technology as the 777 power-plant, enables new choices for the naval architect and system designer." He said that MT30 GTG for high-power operation and medium-speed diesel generators for low-speed would be a great fit for the icebreaker.

The MT30 is a two-spool engine that supports sudden changes to electrical load, as often experienced in icebreaking, in GTG configuration. "It can be considered the world's most power-dense marine gas turbine," Partridge stressed. MT30 has been selected for five naval programs and has been at sea since 2008 on the USS Freedom Class littoral combat ship (LCS).

Tognum America, now MTU America, has been using high-pressure, common-rail fuel injection and other internal-engine technologies for several years to maximize performance and fuel efficiency while reducing emissions, noted spokesman Gary Mason. In September 2013, MTU Series 8000 marine engines were given Naval Vessel Rules certification, a requirement for the Navy's LCS and Joint High Speed Vessel, by the American Bureau of Shipping.

Certification came after 1,500 hours of testing, including extensive run times at 110 percent of rated power in a variety of extreme environmental conditions. The Series 8000 joins the 8V 396 in MTU's portfolio of engines with ABS NVR certification. Bernard Bentgen, director of government sales for MTU America, believes the latest NVR certification will help his firm strengthen its relationship with the Coast Guard.

Cummins Engines offers a full range of propulsion and auxiliary engines, from 6.7 to 60 liters, that satisfy EPA Tier 3 requirements. Cummins's Tier 3 engines use advanced combustion technology to reduce emissions in-cylinder without need for after-treatment. These engines will also serve as platforms for the future, as even more stringent emission regulations are put in place in the United States and world.

For example, the QSB6.7 has exceptionally low cold-start smoke levels and significant sound reduction at cruise and rated speeds. This 6.7-liter engine is calibrated for optimal fuel economy at cruising speeds, which is how the engine is most often used, rather than at wide-open throttle. Its high pressure common rail fuel system is compatible with low-lubricity fuels. With ultra-low sulfur diesel, this engine offers extended oil-change intervals. Another notable feature is power take-off capability. Power steering and hydraulic pumps are gear-driven, more reliable than belt-driven systems. Commercial propulsion and military ratings range from 247 to 542 horsepower, making QSB6.7 ideal for workboats, special vessels, military vessels and high-speed rigid inflatable boats.

The QSC8.3 also meets Tier 3 and is rated at 493 to 593 horsepower.

Cummins's QSL9 has an Xtra-High Pressure Injection fuel system, enabling faster, smoother power delivery with minimal impact to fuel consumption. Engine management has been upgraded, with Cummins's CM2250 electronic control module providing three times faster processing power and double the memory capability of previous modules. The QSL9 is Tier 3-certified, rated at 281 to 400 horsepower, making it ideal for pilot boats and workboats.

Available in late 2013, Cummins's QSM11 is rated at 602 to 705 horsepower. Early testing shows NOx emissions 10 percent below Tier 3 limits, with up to 3 percent better fuel economy.

The Tier 3-certified QSK19 features the same premium base engine hardware and footprint as its Tier 2 predecessor. Rated from 660 to 800 horsepower, the QSK19 is suited for offshore support, towing, cargo and passenger transport, ship's service power and diesel-electric propulsion. The Tier 3-certified QSK60 is rated at 2000 to 2700 horsepower and suited for high-hour, demanding applications, including ship-service power and diesel-electric propulsion.

Cummins has announced its path to compliance with International Maritime Organization Tier III and EPA Tier 4 regulations. It is a fully integrated solution featuring Cummins Quantum Series engines, which meet particulate limits in-cylinder, combined with Cummins's Selective Catalytic Reduction (SCR) clean exhaust system to meet NOx requirements. By using the Quantum Series, Cummins preserves exceptional power output and in-service dependability.

All key EPA Tier 4 technologies are designed, manufactured and integrated by Cummins. The new SCR system is highly robust, fully passive, fully integrated compact aftertreatment package specifically developedby Cummins for high-horsepower applications. Cummins said it has experience with SCR not available to other diesel-engine manufacturers.

Volvo Penta has two new advances it believes are suitable as a package for Coast Guard vessels.

In June 2013, the D13 diesel engine was certified for EPA Tier 3, offering improved environmental properties while retaining low fuel consumption. The D13 operates in more than 450,000 heavy-duty applications, maritime and non-maritime. The new version achieves a 40-percent reduction in particulate matter and 20-percent reductions in NOx and hydrocarbons. Yet performance, fuel efficiency, design, size and installation remain the same. The D13 is available as a propulsion engine and as a marine generation set.

Also last summer, Volvo launched its IPS900 inboard performance system with Rating 3 for commercial boats. Coast Guard boats can now exploit IPS benefits such as improved fuel economy, better maneuverability and lower operating costs.

The IPS900 package uses a D13 diesel engine with 700 horsepower. Volvo believes this is ideal for boats that get medium-duty

use of about 2,000 service hours per year. This usage means reduced load, lower oil temperature, lower engine temperature and reduced stress on components, leading to longer life. And service intervals are also longer, for both engine and IPS unit. The manufacturer estimates IPS yields a 30 percent saving in fuel and CO2, 40 percent longer cruising range, 50 percent less noise and 20 percent higher top speed.

Other innovations are also available. Used on a wide variety of vessels, HamiltonJet's waterjet propulsion systems are particularly suited to vessels operating in the 25- to 45- knot range, according to Acting Marketing Communications Manager Tony Kean.

A waterjet is essentially just a specially designed water pump that picks up water from beneath the hull, accelerates the water through an impeller and stator system and then ejects it as a high speed jetstream from an outlet/steering nozzle. "By accelerating that water and throwing it backwards, a powerful forward thrust force is generated to drive a boat through the water," Kean explained.

Waterjet has several benefits compared with conventional propulsion. Obvious is shallow-draught capability. Less obvious is high-speed efficiency. Waterjet units sit flush with hull bottoms and do not have protrusions below the waterline, so increasing boat speed does not increase hull resistance as much as with conventional propulsion, which adds resistance from rudders, propeller shafts and struts. "In general, from 25 knots and faster a waterjet-propelled boat becomes more and more efficient compared to a conventional propeller-powered vessel," Kean said. He believes waterjets are ideal for vessels that operate regularly at high speed, such as patrol boats and rescue vessels.

Waterjet propulsion transfers engine power to propulsive thrust more efficiently, bringing performance benefits. "Waterjets can operate efficiently over a wider speed range than propeller systems," Kean said. And waterjets are affected by changes in hull weight or hull resistance differently as well. Propeller-driven vessels do not significantly change speed when lightly loaded, but a waterjet-propelled vessel travels several knots faster when lighter. "This allows the operator to complete a trip faster or to reduce engine power to maintain speed with greater fuel economy." Vessels that experience wide fluctuations in weight thus benefit from waterjets.

Kean said waterjets also yield better maneuverability at all boat speeds. "Waterjet propulsion produces thrust for both ahead and stern operations so the vessel is able to maneuver with far more agility than with conventional propulsion. Tighter turns at high speed, more rapid steering and reverse control at low speed and the ability to maintain precise control when a vessel is stationary are three aspects of this." The HamiltonJet spokesman argued that improved maneuverability is a key advantage for rescue craft, pilot boats and vessels that operate in close proximity to obstacles or other vessels.

Another inherent advantage of waterjets is that crucial pumping components are out of the main flow of water beneath a vessel. Vessels can thus travel through shallow or debris-laden water, and propulsion systems are not easily damaged from striking bottoms or objects, a common cause of damage to conventional propulsion. This in turn reduces maintenance burdens.

Kean said that waterjets have many inherent environmental advantages, including no exposed moving parts to harm marine life, restriction of turbulence to water surface only, and reduced underwater noise and vibration. And HamiltonJet equipment is designed with inboard hydraulic control components to reduce risks of leaks and contamination.

The MTU engines on the Sentinel class fast response cutters give the power to get where it needs to go. [Photo courtesy of U.S. Coast Guard]

HamiltonJet has developed computational fluid dynamics software that models water-flow patterns using different intake and impeller designs to find the most efficient combinations. And improvements continue to be made in steering and reverse performance. Kean acknowledged that some waterjet designs suffer loss of thrust when turning. Manufacturers are incorporating interceptors and other systems to avoid this loss. HamiltonJet uses a steering system to maintain high thrust during turns, and the company continues to develop steering nozzles to allow for sharper turns and better control.

HamiltonJet is also developing control systems to make control easier and more precise for skippers, to reduce risks of operator error and to closely link in with other vessel systems such as dynamic positioning.

The firm is now looking at improvements that will further minimize environmental effects. For example, most noise and vibration are due to flow of water through the jet and are affected by the number and shape of impeller blades. "As we improve impeller designs, acoustics will change and this is taken into account in performance criteria," Kean said.

HamiltonJet waterjets have been used in boats from 6 to 70 meters in length in every maritime sector. Kean said the technology is not just an alternative, but should be considered a major option for any new re-powered vessels where waterjet benefits count. ✭

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