Euronav's 'Cap Guillaume' is one of seven sister tankers to feature Propulsion Analytics' Engine Hyper Cube model of its MAN B&W 6S70MC-C7 main engine

The race for remote diagnostics

While makers of medium and high-speed engines have offered remote analytics for several years now, the major two-stroke engine designers have only recently announced plans to launch their own diagnostics programmes. **Gavin Lipsith** reports.

THE EMERGENCE OF greater satellite connectivity, reliable sensor technology and more powerful data analysis capabilities are bringing many changes to the marine industry. Among them is the ability for both crew and shore-based personnel to monitor engine performance in real time. The benefits accruing from such operation are great, ranging from quicker troubleshooting to the ability to move from time-based to condition-based maintenance. But to date only the makers of four-stroke engines have offered the service.

There are many reasons why two-stroke designers have been slow to the party. First is the relatively high number of four-stroke installations, meaning investment there is more easily justified. From ABB's integrated operation centres for example, the compny monitors an installed base comprising 3,600 vessels. It is currently monitoring the condition of propulsion equipment – its electric Azipod units – on 350 vessels, while providing other advisory services (such as route optimisation) for a further five hundred.

There is also the fact that many four-stroke vessels, in the cruise and offshore sectors for example, are more technologically advanced and often boast better connectivity than two-stroke driven bulk carriers and tankers. Operators of those ships have also historically had a much acuter interest in monitoring their vessels' performance: a lost day on a cruise vessel can cost more than a million dollars, while according to GE the typical drillship loses up to US$12 million a year in downtime.

The incentives to reduce unplanned time off-charter and to more efficiently schedule planned downtime are great. An example from Rolls-Royce's health management service illustrates the point. In September 2015 following the end of a contract in the US, Norwegian owner Eidesvik's multi-purpose offshore vessel *Viking Poseidon* was making its 24 day voyage back to Norway. Eidesvik had asked the Rolls-Royce service centre in Finland to keep a careful eye on a previously identified thruster fault and report if the situation worsened.

Fifteen days into the journey, Rolls-Royce's health management team contacted the vessel. Unknown to the crew – there were no vibrations, smell or heat that the engineers could detect – the sensors were picking up significant changes in the vibration readings and it was now impossible to predict how long the bearing would last. Left unaddressed the thruster could have broken down entirely costing its owner time and money. Instead, a new bearing was ordered and waiting quayside, ready to change, when the vessel reached Norway.

> 'The ship intelligence products we can deliver right now are already taking us beyond our traditional customer portfolio, and we hope to do the same with health management systems'

According to Marco Camporeale Christoforo, general manager intelligent asset management, Rolls-Royce, the example highlights the progress since the company installed its first energy management systems in 2012. "Then it was about giving the crew onboard an awareness of fuel consumption," he says. "Since then the frequency at which sensors log data has increased, offering a better insight into equipment condition. Connectivity now means that the data can be transmitted to shore. And the way we collect and analyse the data also enables further opportunities."

Data transmitted and processed onshore can now allow operators to benchmark the performance of vessels against either their own earlier performance or against other vessels in the fleet, notes Christoforo. And Rolls-Royce's growing experience of remote diagnostics – driven by the collection of anonymised data from monitored equipment – means that it is continuously strengthening both the operational knowledge of its equipment and the advisory service it can offer to operators.

Perhaps spotting the market gap left by the two-stroke designers, Rolls-Royce believes it can now leverage that experience on bigger vessels. Due to its product portfolio, in particular the absence of two-stroke engines, Rolls-Royce has little exposure on such vessels at present (although it does have some deck machinery and automation equipment installations). But that is changing as the company focuses on new technology areas.

BEYOND DATA

"The ship intelligence products we can deliver right now are already taking us beyond our traditional

Remote diagnostics, such as that provided by ABB's integration operations centres, is already common for four-stroke and electric propulsion applications

customer portfolio, and we hope to do the same with health management systems," says Christoforo. "We are already expanding health management to cover four-stroke engines from other makers and would like to go further. It is ambitious, but what gives us confidence is the technology we are using – not only data but the way we are processing it with machine learning and artificial intelligence so that we will be able to pick up failure modes not just in our equipment but in any company's equipment."

Rolls-Royce is not alone in that aim. ABB's integrated operation centres already have near real-time access to equipment on vessels it is monitoring, and is developing its already extensive condition monitoring expertise. So too is Wärtsilä through its Genius portfolio of digital services, recently boosted with the acquisition of performance monitoring specialist Eniram.

Although MAN Diesel & Turbo does not yet offer remote diagnostics for its two-stroke customers, it is already monitoring around 200 four-stroke installations. Among the most recent ship owners to sign up for the service, under MAN's PrimeServ Online brand, is Stena Line. The company's *Stena Hollandica* and *Stena Britannica* ro-pax ferries are each powered by four MAN 48/60CR engines.

Constant monitoring of four-stroke engine and turbocharger data will enable Stena to optimise inefficient operation modes and maintain the availability and reliability of the MAN hardware. The information can also be made available to PrimeServ specialists, who can provide further recommendation for maintenance and repairs. Since 2000, all MAN Diesel & Turbo engines have been delivered with integrated data interfaces, which can be upgraded to complete local systems for engine monitoring. In the second phase of the digital strategy the company will introduce its online service for two-stroke engines.

Meanwhile, two-stroke engine users must rely on third-party providers to satisfy their needs for connected condition monitoring. One such company is Piraeus-based Propulsion Analytics, which used the CIMAC World Congress in Helsinki last June to show its approach to condition monitoring.

The core of Propulsion Analytics' methodology involves the use of a thermodynamic simulation model for each specific shipboard engine. This model is tuned to be an exact replica of the actual engine in operation, reflecting the physical relationships of all primary parameters (temperatures, pressures, rpm) and resultant values including torque, fuel consumption and emissions. Once tuning is performed, the model predicts engine performance as influenced by ambient conditions, load, speed and fuel at any operating point.

Several simulations are then performed for combinations of all possible engine settings, ambient conditions and fuels, allowing an engine performance hyper-map – which the company calls an Engine Hyper Cube – to be generated. This map can provide the expected values of performance parameters at any engine operating condition.

These values are then compared to the measured values, offering diagnostics based on the residual differences between the two.

ADVANCED MODELLING

Tanker operator Euronav installed Engine Hyper Cube models for seven Suezmax sister ships, each powered by a MAN B&W 6S70MC-C7 main engine. To ascertain the accuracy of the methodology and the predictive potential, a single blind validation was performed where the engine settings from service performance reports for some years in the past were input into the Engine Hyper Cube software. Any observed swings in residuals (the difference between measured and expected outputs) were then compared with the known engine maintenance events. The results indicated recognisable shifts in performance following maintenance events in the ship's records, confirming the accuracy of the methodology.

> "The engine diagnostic system is something that the industry has been expecting for a long time"

Euronav later used the system to investigate a fuel injection problem. An in-depth analysis using measured cylinder pressure diagrams compared with pressure trace predictions and the use of heat release analysis pinpointed the cylinder with fuel injection issues.

The methodology also allows the company to perform optimisation studies as well as execute a number of 'what-if' scenarios for examining how the vessel engine performs in regimes it had not operated in the past. The shipping company is also using these methodologies and technologies for monitoring and evaluation, aiming at optimum vessel operation.

Propulsion Analytics' case study was clearly noticed – early this year WinGD announced that it would be partnering the company to develop an advanced diagnostics programme for its range of two-stroke engines. The system will be capable of connecting to shore-based stakeholders, with securely held data enabling fleet comparisons if required. It will also offer a virtual and interactive tuition tool for shipping companies and crew. A prototype of the system is expected to be running in the field by mid-2017, with full release across the WinGD range forecasted for 2018.

The jointly developed system will acquire and analyse data on the performance and condition of engines and subcomponents in real time and provide live troubleshooting and diagnostic advice to the crew. The data will be used to improve performance based on load profiles acquired over complete voyages, as well as enabling ship owners to diagnose and troubleshoot abnormalities and integrate maintenance planning and spare parts purchasing.

Andrew Stump, vice president operations, WinGD, notes: "With real-time data collection and exchange across a shipping company's vessels, WinGD's new engine diagnostic system will be the first advanced product on a two-stroke engine that will not only optimise and monitor performance but will also track the condition of key engine components. It will be able to predict future malfunctions and provide troubleshooting support to shipping companies to prevent failures and fix technical problems faster and more economically."

Propulsion Analytics will develop software for processing and evaluating data gathered from on-engine sensors in a digital controlling, monitoring and diagnostic system. "The engine diagnostic system is something that the industry has been expecting for a long time," says Panos Theodossopoulos, CEO, Propulsion Analytics.

One way or another, it seems that two-stroke engine users will not have to wait much longer before engine developers address their need for remote diagnostics. MS