ADVANCING PROPULSION EFFICIENCY

Ralph Lewis looks at official efforts to codify measures for more efficient marine propulsion including an advanced petroleum technology

Faced with continued high fuel prices amidst depressed rates in a withering global economy, owners are keen to adopt strategies which keep balance sheets from hemorrhaging red ink. Most, if not all of these common sense measures are outlined in the IMO's 2009-issued Ship Energy Efficiency Management Program (SEEMP) guidelines that become mandatory for all vessels on January 1, 2013 and aim to reduce fuel consumption rates, which in turn, reduces CO_2 emissions. Interestingly, although less CO_2 is generated per one ton of cargo per mile from shipping compared to all other forms of transportation, large marine vessels still account for anywhere from 4- 6% of so-called 'greenhouse' emissions globally.

The key to a successful SEEMP, the memo states, is planning on a vessel by vessel basis, followed by management improvements on the company level and the setting of specific, albeit private internal goals to achieve specific fuel consumption reduction targets.

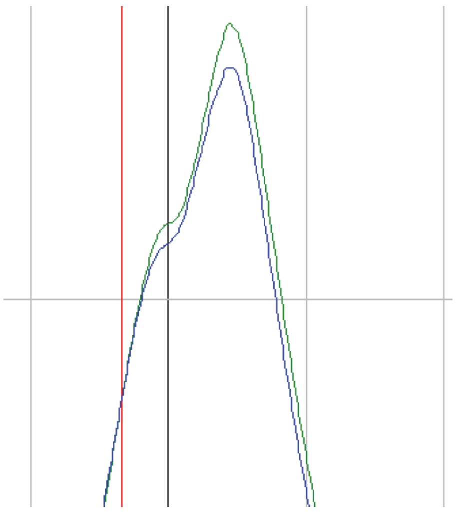
Most of the recommendations are imminently practicable, such as: weather routing, 'just-in-time' scheduling, speed optimisation (better known as eco-speed), optimum trim, ballast and propeller configuration, proper hull cleanliness and improved cargo handling.

Buried in section 4.25 of the memo is the statement, 'in particular, the new breed of electronic controlled engines can provide efficiency gains' - a phrase grossly understated in view of decades of development and advancement made by the engine makers MAN Diesel and Wärtsilä.

Increased pmax for reduced fuel consumption

The primary objective of electronic engine control is to achieve optimum firing pressure with reductions in fuel consumption rates per unit of power produced. In their research efforts, MAN Diesel and Wärtsilä have determined that for every bar increase in peak firing pressure (pmax), specific fuel oil consumption (SFOC) is reduced approximately 0.25%. Hence, with a pmax increase of 6 bars, SFOC is reduced by 1.5% – a number that can mean significant savings annually for fleet operators.

First introduced in February 2003, MAN Diesel's ME engine was–essentially an electronic version of the MC series that aimed to optimise peak firing pressure (pmax) at all load ranges thereby reducing SFOC and CO_2. A first step is 'auto tuning', where firing pressure from each cylinder is monitored by a sensor, the data sent to an onboard processor with software that interprets the results and formulates an appropriate response which makes operational adjustments to achieve greater engine balance and improved thermal efficiency.



Pmax Increase with PRI Technology
The measurement of two combustion curves on a MAN Diesel S70MC-C shows the improvement in peak combustion pressure when the engine is operating on PRI-27 treated fuel. For both measurements, the engine was running at identical speed and loads

A key functionality of the ME system is the capability to vary both fuel injection timing and compression ratio using computer controlled actuators to determine the precise timing of fuel injection and valve opening and closing. This permits continued engine balancing at any operational profile, providing optimum pmax pressures while reducing SFOC.

Wärtsilä's RT-flex series use a common rail system that permits complete control of fuel injection timing, rate of fuel flow, fuel pressure and timing of valve operation. An option for the company's electronic two-stroke engine, the RT-flex series, is an Intelligent Combustion Monitoring (ICM) system which continuously evaluates firing pressure data from all cylinders in order to properly time fuel injection and valve operation and provide ongoing engine balancing to optimise reduced fuel consumption. The good news is that ICM system can be retrofitted to any older mechanical two-stroke engine.

The ICM system incorporates technology originally developed by ABB as the Cylmate system, pioneered in the early 2000s. In two-stroke engine testing conducted in February 2007 to verify the relationship between pmax and SFOC, ABB incorporated a highly accurate, KRAL fuel mass flow meter. The test verified that with a 10 bar increase in pmax, SFOC was reduced 2.2% – a relationship later mirrored in test data reported by MAN Diesel.

Fuel degradation trend threatens efficiency gains

Rugged as they are, modern two-stroke marine engines remain subject to the capricious whims of fuel quality; with quality exponentially deteriorating in recent years - the outlook is not hopeful. A survey con-

In April 2007, MAN Diesel engineers conducted a test of PRI-RS thermal stability fuel treatment on a Holeby 5L21/31 engine under the Marpol Annex VI protocol. The test verified that PRI-RS reduces CO, THC and PM, and established combustion efficiency improvement with an elevation in peak combustion pressure (pmax)

ducted by DNVPS in early 2011 confirms fuel quality issues are rapidly on the upswing. Of those responding to the survey, 80% complained of 'off-spec' fuel, and of those, 44% classified the problems as 'serious'. The greatest complain was 'filter clogging', reported by 64% of respondents. This was followed by excessive sludge issues (48%), fuel pump sticking and seizures (40%) and broken ring problems (19%).

Speaking before the International Bunker Conference in Copenhagen in April 2011, DNVPS Managing Director Tony Morten Wetterhaus warned of more problems ahead: 'Over the next two or three years, we are expecting more fuel quality cases due to increased blending activities in the supply chain to meet the greater need for low sulfur fuel oil (LSFO) products. Unregulated blend components will remain a key cause to such problems.'

Ironically, the increased use of lower quality, 'waste' distillates as cutter stock is an unintended consequence of laws mandating ultra-low sulfur diesel (ULSD) fuel production for onshore automotive use. The fuel is produced through a method known as hydro-desulphurisation – one that also uses aluminum/silicon catalysts in the fuel cracking process. Also known as 'hydro-treatment', this process yields lower end distillates of little commercial value - light cycle oil and slurry oil.

These distillates can also become heavily contaminated with spent cat fines that have sloughed off during the refining process – with a 20+% increase in cat fine content in marine fuels over the past three years as the number of hydro-treatment units has grown to meet ULSD demand. 'So far this year, issues with excessive cat fines have been our greatest challenge,' says Soeren Esbensen, MAN Diesel Head of Operations for low speed diesels.

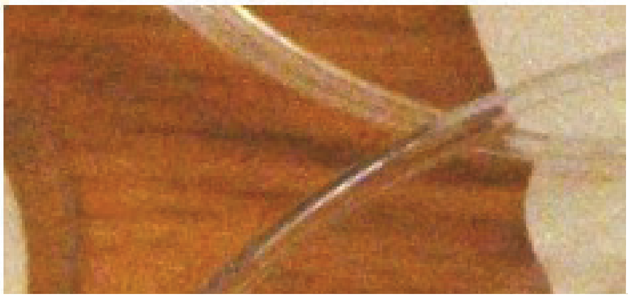
Further aggravating the problem is the expansion of ECAs requiring use of 1.0% low sulfur fuel oil (LSFO) that is complex to extract and very expensive. Consequently, far too few of these units exist to begin to meet the requirements for marine consumption – a reason why use of inferior distillates as cutter stock for LSFO will predominate for years to come.

Many vessel owners have attempted to overcome these issues with marine fuel treatment additives. Section 4.27 of the MEPC memo even suggests the use of fuel additives to improve propulsion system maintenance. However, among the wide range of offerings from marine fuel treatment manufacturers, only one product has emerged that has actually been verified by an engine maker to safely improve combustion and reduce emissions under the very strict testing protocol of Marpol Annex VI.

Advanced Fuel Treatment Technology

PRI believes that its thermal stability chemistry provides the answer – with results proven over just two days of testing at the MAN Diesel engine emissions certification facility in Denmark in April 2007. The test on a MAN Diesel 5L21/31 engine verified that with PRI treatment of the fuel, average pmax for all loads (100%, 75%, 50%, 25% and 10%) averaged a dramatic increase of 5.2 bars. At loads of 75% and less, average pmax increase with PRI increased 5.8 bars – a reduction in SFOC of 1.45%.

Combustion improvement was clearly verified in the emissions data. At all load ranges, application of PRI chemistry resulted in significant reductions in carbon monoxide (CO), total unburned hydrocarbons (THC) and particulate matter (PM).



The capability of PRI fuel treatment technology to significantly reduce particulate matter from marine engines is evident in photos of particulate filters used during a 2007 MAN Diesel test of the product. At left is a filter used during the untreated fuel portion of the test. At right is a photo of a filter used during the PRI treated portion of the test – both readings taken at identical loads.

The version of the PRI fuel treatment chemistry for distillate fuels, PRI-D, had previously been verified in testing by the Southwest Research Institute in Texas, under the rigorous EPA Heavy Duty Diesel emissions testing protocol. In this testing, the chemistry provided an increase in horsepower with a reduction on brake specific fuel consumption, and reductions in CO, THC and PM.

Manufactured by Houston-based Power Research Inc, PRI technology is incorporated into three products – PRI-RS and PRI-27 for heavy marine fuels – and PRI-D for marine distillate fuels. The technology can be found onboard the vessels of close to 200 commercial shipping clients worldwide, with continued shipboard application re-confirming the test stand engine results.

In one example, a container vessel operating on a fixed schedule consuming RMG 380 fuel has been continually monitoring PRI-27 performance on a two stroke MAN Diesel 7S70 MC-C. With the PRI-27 thermal stability additive, pmax has increased an average of 3.89 bar, providing an SFOC reduction of almost 1% – $147 000 annual savings in fuel cost. Coupled with recovery in lost fuel value from reduced sludge precipitation, total annual savings total $174 000.

In a four-stroke engine application, a diesel electric cruise ship operating with six Wärtsilä 46/50DF engines is showing an across the board average increase in pmax of 6.2 bars with PRI-RS, resulting in an SFOC reduction of 1.55%. Based on present fuel prices and consumption rates, the vessel saves $312 000 annually. Sludge data from the vessel confirms a 40% reduction in sludge with PRI-RS, recovering sufficient fuel value to more than cover the overall investment in the chemistry.

The functionality of PRI-RS, PRI-27 and PRI-D relies on product capability to elevate the thermal stability of fuels. In basic terms, fuels with high thermal stability are less prone to producing unburnable, high carbon weight structures that form during the coke ignition phase of combustion. PRI products for heavy fuel oil are also formulated with industrial sludge dispersants which help recover lost fuel value with sludge reductions in the 35-to-50% range.

Although the concept is new to the marine industry, producers of aviation fuel have been researching thermal stability issues for decades. Aviation fuels with moderate or poor thermal stability can create hot spots on the combuster wall of jet engines, leading to cracks and premature engine failures – not a good thing at 30 000 ft. Carbon deposits from fuels with moderate to poor thermal stability can also impinge on turbine blades and stators, causing erosion.

In the onshore automotive sector, the first thermal stability additives began to appear following passage of the US Federal Clean Air Act in 1977 – a law which mandated the use of the technology in all gasoline sold in the US. The EPA justification for the mandate was clear – cleaner engines optimise combustion efficiency, minimizing emissions products.

No such mandate exists for marine fuels. Worse yet, the ISO 8217 standard is a shadow of the much tougher standards mandated for refiners of onshore automotive fuels. 'Fueling an innovative electronic marine diesel engine with an inferior quality fuel is like fueling a Formula One car with 87 octane gasoline,' says Blake Davidson, cfo of Power Research Inc. 'It is one step forward in marine propulsion technology, but two steps backward in efficiency gains.'

'When we launched Power Research Inc. in the mid-1980s, we saw a situation where fuel standards in commercial shipping lagged far behind those of onshore industries,' Davidson says. 'We also realised that the existing fuel treatment 'remedies' for marine fuels were grossly insufficient compared to those developed for automotive fuels. PRI thermal stability technology not only dramatically addresses these issues – but it is saving our clients millions of dollars annually at a time when they need these efficiencies the most.' MER