Business efficiency

Ralph E. Lewis of Power Research Inc. argues that improving ships' engine efficiency and cutting emissions makes sound business sense

Bunker prices remain high, charter rates low, and the world economy seems perpetually moribund. Yet vessel owners might find some solace in the words of the late American insurance executive W. Clement Stone, when he said: 'Got a problem? Congratulations!'

Growing up in dire poverty, Stone became one of America's first self-made billionaires. He understood that crisis begets innovation, and innovation begets success. In recent years, many innovations have been introduced in the commercial shipping industry promising a better tomorrow. Some of these advances are now reality – helping vessel owners survive and even prosper. Shipowners may be getting leaner, but they are also getting smarter, implementing innovative strategies for optimum vessel efficiency and profitability.

Many owners have already developed vessel by vessel efficiency improvement plans outlined in the Ship Energy Efficiency Management Programme (SEEMP) guidelines issued in 2009 by the **Marine Environment Protection Committee** (**MEPC**) of the **International Maritime Organization** (**IMO**). Last July MEPC voted to make the SEEMP programme mandatory in January 2013.

In this article we will take a brief look at the SEEMP recommendations, why economic challenges make these recommendations imperative, and the remarkable efforts by engine makers and shipowners to optimise vessel efficiency with innovative technology. We will also evaluate the effect of fuel quality on propulsion system efficiency, and review an inexpensive but highly effective technology now saving millions of dollars annually for savvy vessel owners.

The goal of the MEPC action is reduction of carbon dioxide (CO_2) from marine propulsion systems, by some estimates the source of anywhere from 4% to 6% of so-called 'greenhouse' emissions worldwide. With greater fuel efficiency, CO_2 reductions follow, the thinking goes.

Whether or not the greenhouse theory of 'global warming' holds up over time is anyone's guess. Yet there is no guesswork in understanding that improving vessel propulsion efficiency in order to reduce costs is simply good business, benefiting the owner, the charterer, and consumers who buy goods transported by sea.

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Fuel expense remains the dominant cost for both cruise and container ships, passenger ferries and all vessels trading on the spot market. Charterers bearing the fuel cost burden are also well aware of efficiency benefits - major criteria in the vessel selection process.

While emissions reduction remains a laudable goal, vessel owners in 2012 are far more focused on two daunting and overriding concerns, challenges that threaten their very survival in the turmoil of today's marketplace. These challenges are high fuel costs and low charter rates.

High fuel costs

Economic principles in free markets dictate that with reduced demand, fuel prices should decline. But these rules do not always apply in the petroleum industry. Marine fuel sales in Singapore recently dropped to a two-year low, yet prices remain high. Politicians find easy targets to blame – oil companies, speculators, 'peak oil', **Organization of Petroleum Exporting Countries** (**OPEC**) and so on. Yet the underlying cause is quite simple – US dollar inflation.

Enter the **Federal Reserve System**, the central bank of the United States. Independent of Presidential and Congressional authority – the Fed is essentially a private corporation with limited Federal oversight. The Fed is also the primary lender to the United States government: it now holds more than 61% of US government debt – more than China, Japan,

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Ralph E. Lewis is the Vice President, Technical of Power Research Inc.

Contact:
Power Research Inc.
Tel: +1 713 490 1100
Email: usa@pri.products.com
Web: www.priproduct.com

and everybody else combined. Acquiring such massive debt is an easy process for the Fed. It simply creates the money out of thin air – a process known as 'debt monetisation'.

This sleight of hand was facilitated when President Nixon decoupled the US dollar from the gold standard in 1971. Since that time, the value of the dollar – the world reserve currency used for international oil trading – has declined by more than 83%, thanks to continued Fed increases in the money supply. In fact, the real cost of oil has hardly changed over the years when compared to traditional stores of value – gold and silver.

In 1960, for example, two silver 10 cent pieces (dimes), having a combined composition of 0.18 ounces of silver, could purchase one gallon of gasoline. Today, the same 0.18 ounces of silver, now worth about $5.40 in 2012 dollars – will also buy a gallon of gasoline, with change left over for a soft drink, at least in the United States.

In real terms, oil is still cheap, but this no consolation to vessel owners who must buy bunker fuel in dollars – not gold or silver coinage. Excessive fiat currency creation, likely to continue and even accelerate in years to come, will remain an ongoing challenge for vessel operators, forcing technological adaptation.

Low charter rates

As investor Warren Buffet presciently cautioned in 2007: 'When the tide goes out, we find out who's been swimming without a bathing suit.' That year, spurred on with cheap credit and high charter rates, shipowners were on a ship building spree.

This 'irrational exuberance' (apologies to former Fed Chairman Alan Greenspan) occurred only months before the 2008 economic debacle, resulting in a huge wave of vessel deliveries in the midst of global recession. Charter rates plummeted, and only recently have begun to tick up. In this case, the supply and demand model is working. Some vessel owners have by necessity ceased trade. A few stragglers are struggling to survive, laying up vessels while reducing administrative staff and even crew size. Yet many are boldly moving forward with innovation and improved business practices.

In 2010, total vessel deliveries reached a record high. Deliveries in 2011 were approximately 85% of those the year before, and 2012 deliveries will likely be the same as 2011. Since 2008, the global tanker fleet has grown by an estimated 40%. On the dry bulk side, vessel deliveries are expected to peak this year, but deliveries scheduled through 2013 will likely keep rates depressed through year's end, cautions Moody's Investor Service.

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Not all is gloomy. Solutions are at hand, many of them included in the MEPC efficiency guidelines.

MEPC efficiency guidelines

The basic concepts for efficient vessel operation have been well understood, if not always implemented, for decades. Many of these are reflected in the MEPC guidance memo (MEPC.1 Circ.683) for SEEMP development, including improved voyage planning, speed optimisation, more efficient trim, ballast and propeller design, weather routeing, improved hull maintenance, waste heat recovery and better cargo handling practices – all commonsense measures.

In addressing propulsion system efficiency, the MEPC memo notes that 'the new breed of electronic controlled engines can provide fuel efficiency gains', also suggesting that other methods to improve efficiency 'might include fuel additives, adjustment of cylinder oil consumption, valve improvements, torque analysis and automated engine analysis systems'.

The guidelines almost appear understated in view of the major advances which have been made by engine makers over the past decade. Both **MAN Diesel** and **Wärtsilä** have invested in large bore, two-stroke test bed engines upon which these two dominant players have developed groundbreaking technologies to enhance engine durability and efficiency. In recent years, they have clearly established that with increases in peak firing pressure (pmax), specific fuel oil consumption (SFOC) is reduced.

Reduced fuel consumption

Peak firing pressure is simply the highest pressure attainable in a cylinder during combustion – the optimum efficiency attainable. Achieving this across all load ranges has been a major focus of MAN Diesel in the development of the company's ME series electronic engines.

A first step is a concept known as 'auto tuning'. 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.

The system depends on the capability of varying both fuel injection timing and compression ratio. On conventional engines, this process is somewhat complicated by the fact that the camshaft design determines valve timing. So in the ME series engine, the camshaft functionality is eliminated – replaced by computer-controlled actuators that determine the precise timing of fuel injection and valve opening and closing.

This system permits continued engine balancing at any operational profile, providing optimum pmax pressures while reducing SFOC. MAN Diesel studies verify that pmax improvements of 5-to-10 bar mean a corresponding reduction in SFOC of 1%-2%, a 0.25 decrease in SFOC for every bar pressure increase.

Wärtsilä first experimented in the early 1990s with electronically controlled fuel injection systems. Today, the *RT-Flex* series of engines 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.

Engine design improvements have made major advancements in recent years, but one joker in the deck yet remains to defy all mechanical engineering efforts to optimise combustion.

Reducing fuel consumption

In 2011, **Det Norske Veritas** (**DNV**) and **Viswa Lab** reported a significant increase in bunker fuel quality complaints among operators, some attributable to increased use of cutter stock to dilute heavy fuels to 1.0% sulphur in meeting the Emission Control

Area (ECA) mandate. Among other problems, vessel owners reported increased incidences of poor ignition quality and excessive fuel sludge precipitation. Many of them are now resolving these troubling issues with a series of chemical fuel treatments developed by **Power Research Inc**. Vessel owners quickly discovered that the company's *PRI-RS* and *PRI-27* heavy fuel oil chemical treatments actually boost pmax while reducing SFOC – a benefit now confirmed in stringent, laboratory engine testing. Additionally, both lab and shipboard data confirm the capabilities of these chemistries to reduce fuel sludge precipitation in a range of 30%-45% – recovering lost fuel value. The results are consistent and clear, and the financial savings have been impressive.

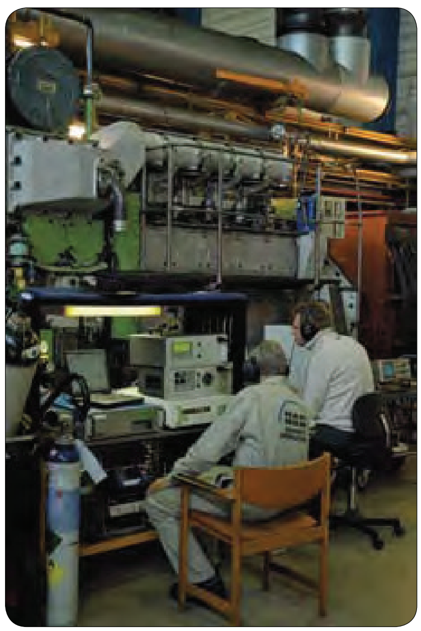
PRI-RS and PRI-27 are formulated with deposit modifier type chemistries specifically designed to elevate the thermal stability of blended heavy fuel oils. The approach is rooted in the reality of petroleum fuel behaviour which dictates that the more thermally stable the fuel – the more completely it combusts. While the concept of thermal stability is a relatively new one regarding marine fuels, petroleum chemists associated with aviation fuels have long recognised the criticality of fuel thermal stability for combustion in aero-derivative gas turbine engines, the focus of decades of research. Prevention of damaging, power robbing deposits with optimal combustion is a primary safety goal for aircraft turbine engine makers, so critical that strict standards have long been mandated to ensure maximum thermal stability in aviation fuels.

While many marine fuel additive makers have developed a wide range of detergents, dispersants and iron-laced catalysts in efforts to 'clean up after the elephant', PRI researchers continue to focus instead on chemistries that optimise thermal stability, a 'proactive' approach that completely negates the need for harsher and less effective measures. The work is yielding impressive results.

In April 2007, just two months after ABB was establishing the relationship between pmax and SFOC in Sweden, the value of the PRI research was verified in testing conducted by MAN Diesel in Denmark on a 5L21/31 engine under the strict MARPOL Annex VI test protocol. At all load ranges, application of PRI-RS to the fuel resulted in reduction of carbon monoxide (CO), total unburned hydrocarbons (THC) and particulate matter (PM) – all markers of improved combustion efficiency.

The PRI-RS effect on pmax in the MAN Diesel test was also pronounced. At all load ranges combined, pmax shot up an impressive 5.2 bars. At reduced load ranges, the increase was as much as 7.5 bars – operating loads now common for vessels at eco-speeds, and loads typical of auxiliary engines. Translated, the results meant a range of SFOC reduction of 1.3% to 1.9% percent, hardly insignificant numbers.

Since then, Power Research Inc. has acquired pmax and SFOC data from a variety of vessels to measure the extent of fuel cost savings with PRI-RS and PRI-27. The results consistently correspond with the MAN Diesel PRI test bed data. For example, a container vessel operating on a fixed schedule consuming 380 centistoke (cst) fuel oil 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%. Translated into dollars – annual vessel fuel costs have been reduced by $147,000. Coupled with recovery in lost fuel value from reduced sludge precipitation with PRI-27, the total saving has been $174,000 annually for the vessel. In another example, a cruise ship operating with six Wärtsilä 46/50DF engines is showing an across the board increase in pmax with PRI-RS. When compared to identical load ranges operating on untreated fuel, pmax increase with PRI-RS is averaging 3.72 bar – resulting in a 0.93% reduction in SFOC. Based on present fuel prices and consumption rates, the vessel is saving $312,000 in annual fuel costs. Sludge data from the vessel also confirms a 30% reduction in sludge with PRI-RS, recovering

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sufficient fuel value to more than cover the overall investment in the chemistry. Spread over a 20-vessel fleet, annual savings with PRI-RS totals $6.24 million.

Similar results have been verified for PRI's thermal stability treatment for distillate fuels, PRI-D. In 2005, PRI-D was evaluated at **Southwest Research Institute** (**SWRI**) in San Antonio, Texas under the **US Environmental Protection Agency** (**EPA**) Heavy Duty Diesel Transient Test cycle. Like the test conducted two years later at MAN Diesel, CO, THC and PM were reduced on the Cummins L-10 engine. Brake specific fuel consumption (BSFC) declined by 1%, and brake specific horsepower increased by 1%. SWRI testing of PRI-D on a larger Cummins KTA 19M3 engine also verified power increase and BSFC reduction across three load ranges.

'These 1%-2% savings may not sound like much at first, but when calculated over time and over an entire fleet, a company can literally save millions of dollars,' says Blake Davidson, PRI chief financial officer. 'On the heavy fuel side, PRI-RS and PRI-27 are also formulated with highly effective sludge dispersants, yet another way to recover lost fuel value. And with low sulphur gasoil, PRI-D contains the most advanced lubricity chemistry available to safely protect fuel pumps from excessive wear and premature failure.'

Cost savings

Additional efficiencies and cost savings accrue. With PRI thermal stability chemistry, the contamination rate of auxiliary engine lube oil has been reduced as much as 30% on many vessels – saving owners considerable expense in lube oil replacement costs. Deposit prevention on auxiliary engines with PRI is permitting engineers to extend overhaul intervals to engine maker schedules. Time between exhaust boiler and purifier cleaning cleanings is increased, and vessels once fined in ports by aggressive smoke police are now getting the all clear.