Slow steaming – a viable long-term option?

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The slow steaming of merchant ships, particularly container ships, has become a much discussed topic. It is a topic that affects the entire industry, from cargo owners, carriers, ship owners and operators, to equipment manufacturers.

Background for slow steaming

A combination of factors have led to the past two years becoming hugely challenging for certain sectors of the global merchant shipping industry. These factors include:

- The downturn in the global economy, resulting in reduced transportation capacity demand
- The substantial global order book for new tonnage, a legacy from the boom years, resulting in record-high deliveries of new ships
- The global financing crisis
- The sudden fall in ship values
- High fuel costs
- Increasing operating costs (manning, lube oil, maintenance)
- Falling freight rates, which in turn also impacts charter rates.

All of these things have put the entire value chain – starting from cargo owners to the carriers, ship managers, ship owners, financing institutes and equipment suppliers – under big pressure. The industry has had to quickly adjust, which has resulted in a sharp slow-down in new ship orders, cancellations of already confirmed orders, the delaying of new ship deliveries, laying-up and idling of vessels, and all kinds of cost reduction measures.

Fuel consumption

The biggest single cost factor in merchant shipping, particularly for container and other large vessels, is the fuel oil. And the easiest way to reduce this cost is to reduce the ship's speed. The typical propulsion system for larger merchant ships is a low-speed two-stroke main engine, directly driving the fixed-pitch propeller via the propeller shaft. The ship's speed is, therefore, reduced by lowering the speed of the engine and propeller. The power required from the main engine, however, correlates disproportionately with the ship's speed (Figure1). →

For example, reducing the nominal ship speed from 27 to 22 knots (-19%) will reduce the engine power to 42% of its nominal output (CMCR). This results in hourly main engine fuel oil savings of approximately 58%. A further reduction down to 18 knots saves already 75% of the fuel. The reduced speed however results in a longer voyage time; therefore the fuel savings per roundtrip (for example Asia-Europe-Asia) are reduced by 45% at 22 knots, or 59% at 18 knots. These are calculated values, and the actual values depend also on a number of external factors, such as the loaded cargo, vessel trim, weather conditions, and so on.

■ Effect of slow steaming

Such savings cannot, of course, be neglected, which is why carriers have used slow steaming as an immediate means of cutting fuel costs and reducing capacity. Carriers can choose between laying up some of their vessels or applying slow steaming. Slow steaming is preferred because it offers greater flexibility to increase the capacity again when the market situation changes. And there are other big advantages coming as a free side effect of slow steaming, namely that for every ton of fuel saved, the industry reduces its carbon dioxide emissions (CO_2) to the atmosphere by three tons, and the cylinder lubricating oil consumption of the main engine is reduced at almost the same percentages as the fuel, which also reduces solid particle emissions.

General considerations

The change to a long-term slow steaming scenario needs, however, a number of considerations.

■ The cargo owner's perspective

First of all, cargo owners have to accept that the transportation time of their goods will be increased slightly. Reducing the voyage speed from 27 to 22 knots, for example, will increase the time from Asia to Europe by 3–4 days. Similarly, a voyage speed of 18 knots rather than 27 knots will require one week's more sailing time. For some goods this requires changes to the cargo owner's logistics, and might increase the costs for "goods in progress".

■ The carrier's perspective

At the same time, the carrier needs to adapt his trade schedule, and should he want to maintain a weekly service on a certain trade route, he will need to add vessels to his fleet.

However, this has a positive effect on the over-capacity situation of transportation tonnage. Vessels that are idle or laid-up can be utilised for these fleet additions, as too can new ships whose delivery time has been postponed. This is exactly, what we have seen since the beginning of 2010. Since January, the inactive container ship fleet has been globally reduced by approximately 450 ships, and the total merchant fleet by more than 800 ships. The establishment of slow steaming, and the resultant trade and fleet adaptations, have greatly contributed to this reactivation of inactive vessels.

The carriers are definitely the main drivers for the introduction of slow steaming, as they have the most to gain from large reductions in fuel consumption. Of course, the calculated percentages of fuel savings described above do not reflect the overall operational savings to the carrier. The capital and operating costs of the additional ships – or the additional chartering costs – need to be taken into account, as do many other additional and fixed costs. Furthermore, slow steaming is not possible for all services, nor is it appropriate for all times during operations. Several carriers, for example, operate at almost nominal speeds on some legs of a service, while using slow steaming on others. And sometimes ships will have to catch up with delays, or add a port call to its service. All this requires high operational flexibility for both the vessel and its propulsion system. Taking all these considerations into account, it is not possible to make a general statement concerning the overall cost reduction potential of slow steaming. However, a number of industry players have indicated that the overall savings could be in the range of 10–25%, depending on the proportion of vessels in a fleet that are slow steaming, and on the average achieved speed reduction.

■ The ship owner and manager's perspective

Ship owners and their technical managers, who are not the carrier themselves, provide the carriers with fully operated and maintained ships, which the carriers utilise for their shipping business. Under long- or short-term charter contracts, the ship owner and manager basically have to fulfil the carrier's requirements, including instructions relating to ship speed and the introduction of slow steaming. This demand from the carriers was met with concern by many ship owners, and has led to discussions within the industry as to how to address these concerns.

The ship owner's interest is two-fold:

- a) To have attractive ships for the charter market, which fulfil the requirements of a carrier and lead to high utilisation and profitable charter income, and
- b) To keep his assets in good shape with a sustainable value. The ship manager's interest is to fulfil a variety of requirements from the carrier, the owners, as well as from legal and environmental bodies, at the optimal cost.

In this context, concerns have been raised that the owners and managers might end up carrying the potentially consequential costs of slow steaming operations, whereas the carriers reap the benefits. In addition, during the shipping crisis charter rates were severely depressed.

Next to these commercial concerns, owners and managers have mainly expressed technical concerns. These concerns are discussed in the next section.

The commercial perspective

Concluding this general discussion, a scenario whereby slow steaming would continue in certain industry sectors or certain trades has to take into consideration the perspectives and interests of everyone in the value chain. Of course, commercial discussions and negotiations between carriers and their customers, and between carriers, ship owners, suppliers and service providers will be done on a business to business basis. These negotiations will in the long-term lead to a new balance, wherein all players able to cope with the new requirements of high operational flexibility, will benefit from slow steaming.

Technical concerns and recommendations

Ships are designed and built for a certain specified load and speed range, at which the system's total efficiency is optimised. Because of the fixed-pitch propeller's direct drive by the main engine, the main engine itself is then also laid-out for that optimised operating range. →

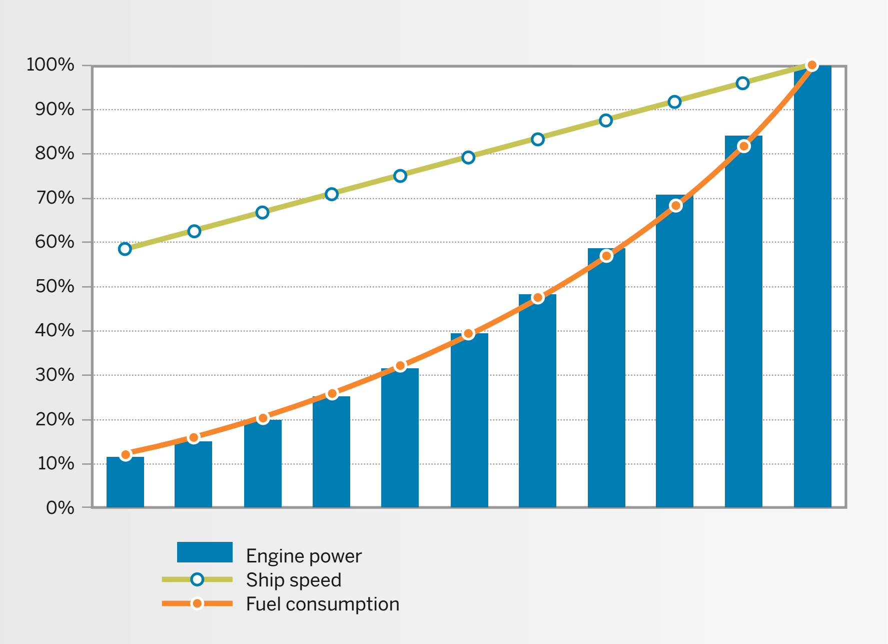

Fig. 1 – Correlation between ship speed, required engine power and fuel consumption.

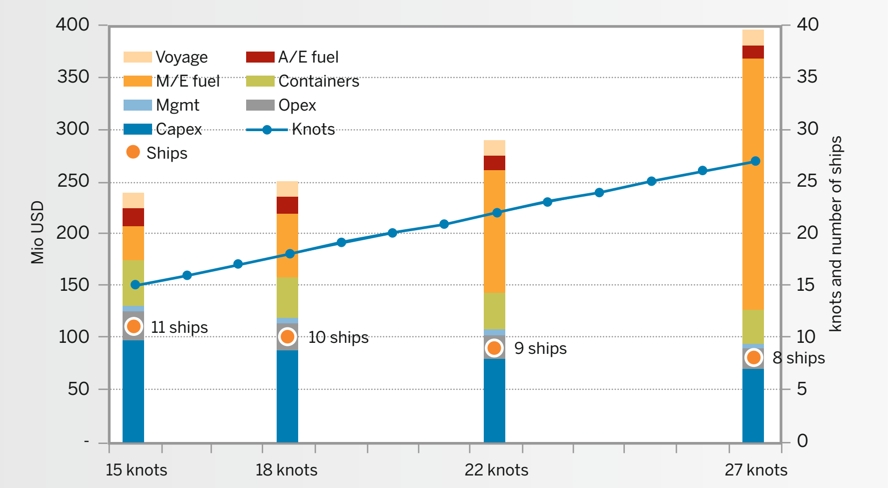

Fig. 2 – Ship operation costs for Europe – Far East trade with different vessel speeds.

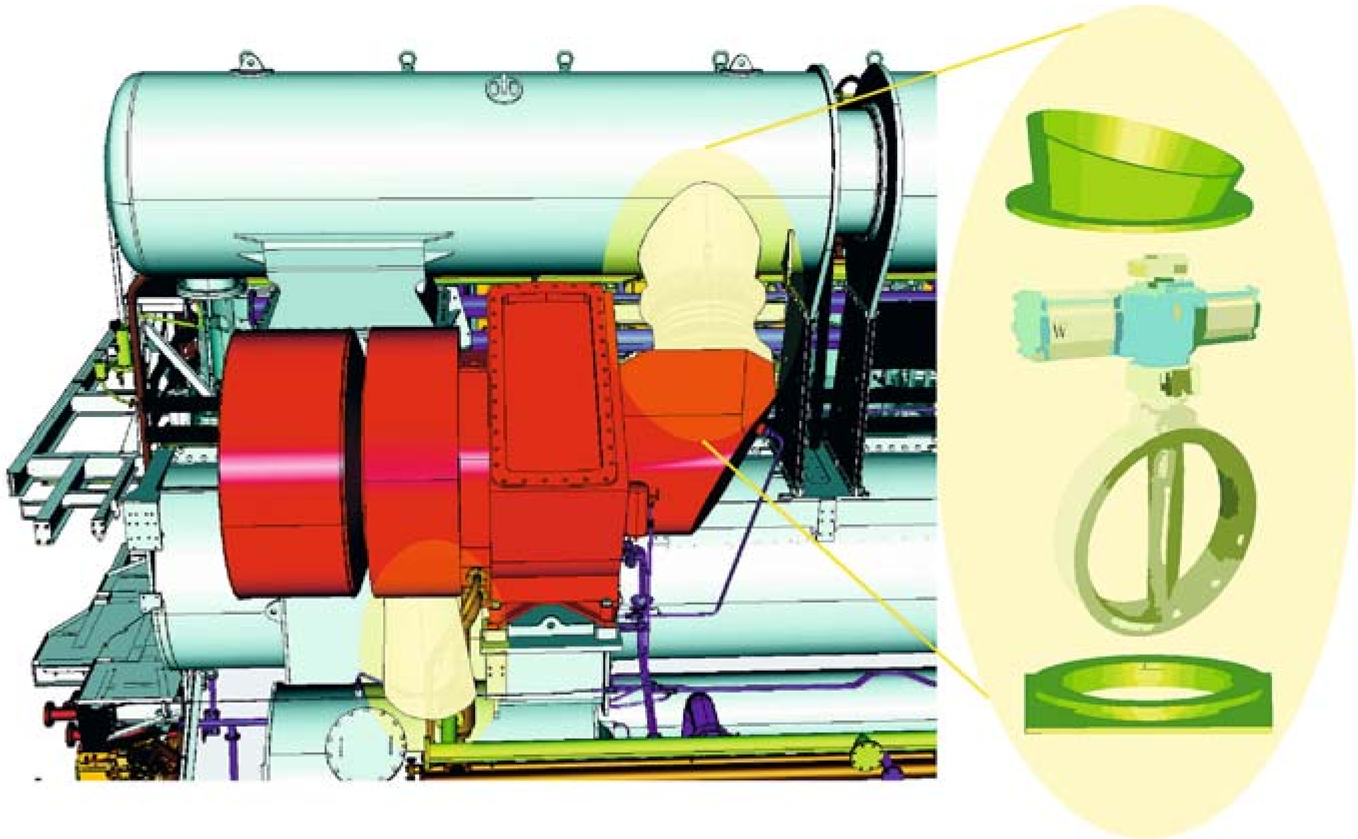

Fig. 3 – The Wärtsilä Slow Steaming Upgrade Kit.

The optimal load range of the two-stroke engine lies between 70-85%. The fuel efficiency of the engine, its operational parameters, the specification of the turbochargers, coolers, auxiliary systems, exhaust gas boilers, and so on, are chosen and optimised for that normal load range. It is natural, therefore, that when the engine is operated continuously in a load range below or even far below 60%, the overall system is no longer fully optimised. As the industry didn't use slow steaming during the previous 20 years, nobody had really good long-term experience with continuous low-load operation of today's generation of new engines. Therefore, marine engineers who daily operate the engines, technical managers, as well as engine builders, were initially reluctant to fully embrace the concept.

Based on requests from carriers and operators, Wärtsilä has investigated the various concerns that have been raised, including concerns on component temperatures, fouling of exhaust systems, turbochargers, etc., and has addressed them in field investigations and through discussions with operators. The conclusions and recommendations were summarized in the beginning of 2009 in a Wärtsilä Service Bulletin about low-load operation.

In general, it was concluded that the modern Wärtsilä two-stroke engines are able to reliably operate in all load ranges between 10% CMCR and 100% CMCR without major modifications, if the operational parameters and precautions, as documented in the Operating Instructions and in the mentioned Service Bulletin, are properly followed. By adhering to these recommendations, the potential risks inherent to such operation will be mitigated.

Expressed technical concerns

To varying degrees across the low load range, different engine conditions can be observed. The possible consequences of continuously operating at reduced load without taking the recommended precautions are:

Lower air flows

- A problematic area after the auxiliary blowers cut out / before they cut in
- The possibility of very high exhaust, and thus component temperatures.

Poor combustion

- Poor atomisation
- Higher sac volume: injected volume ratio, increased likelihood of dripping
- Increased fouling and carbon deposits likely.

Cold corrosion

- Caused by condensation of corrosive vapours
- Possible when observing very low engine temperatures during very low load operation.

Fouling

- Of the exhaust system, turbochargers, exhaust boilers
- Of the scavenging air space due to excess cylinder oil.

Apart from these engine related concerns, concerns have also been voiced about efficiency losses (e.g. propeller, turbochargers, shaft generators, heat recovery systems) and the accelerated deterioration of condition and performance (e.g. fouling of the hull and propeller due to reduced ship speed, stern tube seals, shaft bearings).

Summary of recommendations

Wärtsilä RT-flex engines are better suited

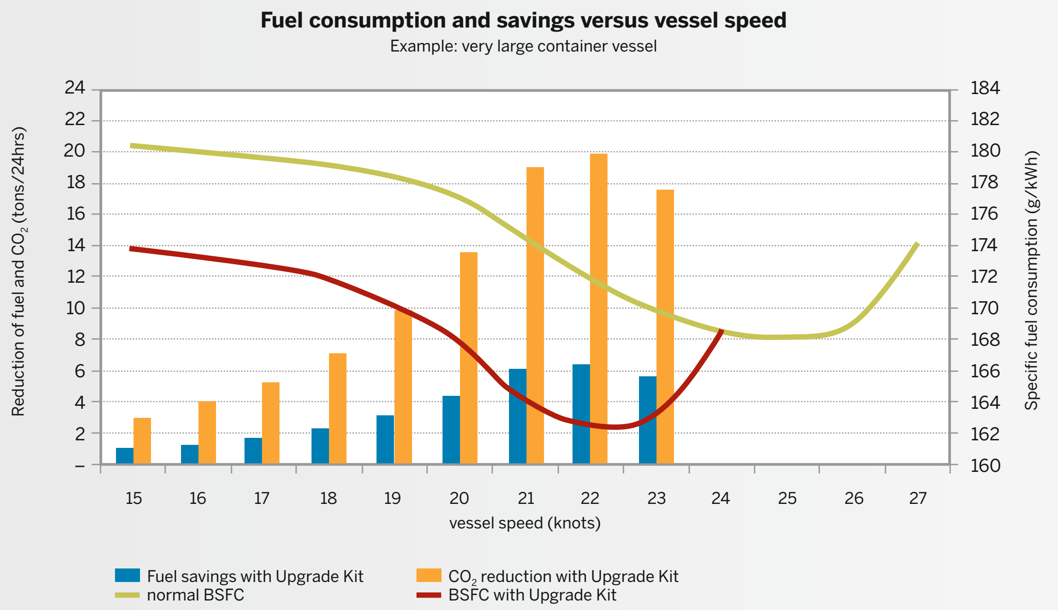

Fig. 4 – Additional fuel savings at different speeds using the Slow Steaming Upgrade Kit.

than the Wärtsilä RTA engines for continuous loads down to 10% due to their unique electronically controlled common rail injection system and flexible exhaust valve control. The selective fuel injector cut-off at low load enables improved injection characteristics, resulting in reduced carbon deposits and, therefore, less fouling of both the exhaust gas boiler and turbocharger.

However, for both engine designs the recommended measures in the Operating Instructions and Service Bulletin have to be implemented and followed to ensure reliable continuous low or ultra low load operation. In short, the recommended precautions are as follows:

- Ensure the injector nozzle condition is correct. This is standard engineering practice but should be given more attention than in normal operation
- Maintain higher fuel temperatures and aim to achieve lower viscosities, 12 / 13 cSt
- Keep the LT cooling water temperature at 36°C in order to maintain the optimum scavenge air temperature, and the jacket cooling water temperature at the upper limit (85–95°C). A high cooling water temperature will reduce condensation and thermal stresses. By-passing of the fresh water generator will most likely be necessary to maintain the cooling water temperatures.
- Normally the cylinder oil feed rate is load dependant, and no adjustment is needed. However, frequent piston underside inspections are recommended to monitor piston running conditions and signs of over- or under-lubrication. In a recently released Wärtsilä Service Bulletin, we have described this characteristic and shown certain observed symptoms on the piston rings during low load operation. When these symptoms occur, a temporary increase in the cylinder lubricating feed rate will help stabilise the situation and recover the reliable piston-running performance.
- It is important that the temperature of the exhaust gas after the cylinders is kept above 250°C in order to reduce cold corrosion. If the exhaust gas temperature drops below this value, the engine load should be increased
- High exhaust gas temperatures, above 450°C, after the cylinders should be avoided during the period following the auxiliary blower cut out or before cut in. This may cause hot corrosion and burning of the exhaust valve seats. As a countermeasure, the auxiliary blower may be switched to "continuous operation".
- Another concern during continuous low load operation is the accumulation of unburned fuel and lubricating oil in the exhaust manifold, as such deposits can ignite after the engine load is increased again. This may result in severe damage to the turbocharger due to sudden over-speeding. Wärtsilä therefore recommends that the engine load be periodically (twice a week) increased to as high as possible (at least to 70%) for a minimum of one hour in order to blow through any accumulated carbon deposits. Whilst operating at these increased loads, turbocharger washing and soot blowing of the economiser should be undertaken in order to reduce fouling

Wärtsilä continues to observe several parameters, by collecting customer feedback, →

service attendance feedback, and through structured field testing. In this way new trends can be detected early, and in depth experience on the long-term behaviour of the engine and components at low and ultra low load operation can be gained. If required, we will publish additional recommendations and solutions via Service Bulletins.

Optimisation solutions

As mentioned above, the Wärtsilä RT-flex engines are better suited for continuous low-load operation, due to their high flexibility in engine control, which allows optimisation of the parameters in the lower load ranges as well. Such features include the selective fuel injector cut-out at very low loads, as well as the Delta-Tuning, which optimises the specific fuel oil consumption below 75% load. For new engines, Low-Load Tuning provides additional flexibility and a further reduction in specific fuel consumption at lower loads by optimising turbocharger efficiency for the lower load range, and through by-passing a part of the exhaust gas flow at high loads.

In addition to these inherent or optional features in new engines, Wärtsilä is also continuously seeking upgrade- and retrofit solutions that fit specific operational requirements, and which provide optimal engine performance and efficiency.

The owners and operators of Wärtsilä two-stroke engines have the following solutions available:

Wärtsilä Slow Steaming Upgrade Kit

This automated flexible turbocharger cut-out solution extends the optimised and reliable load range of the engine for continuous low load operation, and significantly reduces the specific fuel consumption in the low load range. These fuel savings are achieved by cutting-off one of the turbochargers, which in turn leads to increased scavenge air, and thus better firing pressures. The turbocharger cut-off is done in a controlled and fully automated way. The fuel savings, as well as the load at which the turbocharger can be cut-off, depends on the number of turbochargers. For example, for a Wärtsilä RT-flex96 engine with three turbochargers, the load range with a cut-off turbocharger is about 10–60%.

In addition to a major reduction in BSFC (Brake Specific Fuel Consumption) in the low-load range, this solution provides full flexibility (the engine can be operated from 10 to 100%) and decreases the risk of engine fouling and excessive component temperatures. This solution is, therefore, best in a long-term scenario, whereby both slow steaming and nominal speeds are, or might be, required as the engine can operate at any time up to its maximum installed power for full sea speed.

This retrofit is available for ships fitted with Wärtsilä RTA and RT-flex low-speed engines having more than one turbocharger. One such installation of the Slow Steaming Upgrade Kit took place in October 2009 onboard a vessel with a 12-cylinder Wärtsilä RT-flex96C main engine with three turbochargers. The measured fuel savings were 8–12 g/kWh in the optimal load range.

The benefits and operational flexibility of this solution have been recognised by several major operators and carriers, and Wärtsilä has received a number of orders for the Upgrade Kit.

If the operational profile of a vessel is changed for a longer period to slow steaming, and engine loads above 60–70% are not required at all, the blinding of one of the turbochargers can be more cost effective, achieving the same BSFC reductions as the flexible Slow Steaming Upgrade Kit solution. However, this clearly limits the engine's load range (10–60%, upper limit depending on the amount of turbochargers), and the vessel has no possibility to achieve full sea speed if required. Also, the recommended periodical operation at higher loads to blow out any accumulated carbon deposits in the system, cannot be carried out with full effectiveness due to the upper load limits with a blinded off turbocharger.

Permanent de-rating of the engine

If the operational profile of a vessel is changed for long-term operation at reduced speeds and lower engine loads (e.g. 5–15% reduction), a de-rating of the engine might be the best solution considering fuel consumption, reliability and operational flexibility. The scope of the solution depends upon the required de-rating. This solution is applicable for all engine types.

Combination with a propeller modification

When the engine is de-rated or continuously running at low-load, an optimised propeller to better match the new operation conditions might achieve additional fuel efficiencies. The optimal specification can be offered by Wärtsilä Services, combining the support from its two-stroke engine and propulsion experts.

Pulse Lubricating System

Wärtsilä introduced the Pulse Lubricating System (PLS) a few years ago as its standard cylinder lubricating system for all new engines. The system was also introduced as a retrofitting solution – known as the Retrofit Pulse Lubricating System (RPLS) – and was installed widely on large bore engines.

Earlier lubricating systems might have a problem in achieving optimal timing and distribution of the cylinder oil, especially in the lower load ranges when combined with a cut-out turbocharger. The RPLS system ensures precisely timed injection of the lube oil into the piston ring package, which optimises the lubrication, while the piston ring pressure is increased and the speed decreased during low load operation.

In addition, the PLS and RPLS will reduce the specific lubricating oil consumption by 20–40% and in so doing, further increase lube oil savings (low-load operation in itself already saves a substantial amount of cylinder lube oil).

Monitoring and control options

For the continuous monitoring of cylinder liner wall temperatures, Wärtsilä has for many years already offered the so called MAPEX-PR system, which allows the temperature trends of the liners (corrected by actual engine loads) to be monitored. The system also gives early warnings should they exceed the upper or lower limits.

Recently introduced by Wärtsilä, the Intelligent Combustion Monitoring system continuously monitors cylinder pressures and several parameters during the full combustion cycle. It enables the trending and analysis of the monitored data in order to understand the engine's performance, as well as that of the condition of components in the combustion chamber. This system gives additional information about combustion performance, particularly during low load operation.

Wärtsilä offers also an integrated monitoring system, which transmits specified data from ships to Wärtsilä's operation data server; the data is regularly analysed and evaluated by engine experts and reports, together with expert recommendations, are provided to the technical managers of the ships.

For RT-flex engines, Wärtsilä will also introduce the Intelligent Combustion Control system in early 2011, which takes elements from the monitoring system and combines the measured data with an intelligent logic in the Wärtsilä Engine Control System (WECS). This enables optimal cylinder pressures to be controlled and adjusted automatically. Using this automatic control, further fuel efficiency optimisation in the range of 1–2% is possible.

CONCLUSION

Looking at slow steaming from a wider perspective, this article describes several important considerations covering the global shipping industry's view, the drivers for slow steaming, the commercial aspects, and the technical concerns for achieving further efficiency solutions whilst slow steaming. We can conclude that slow steaming has a number of very obvious advantages, and will, therefore, probably continue to be used by the industry for a long time. Conversely, slow steaming throws up several challenges, which need to be properly addressed, and the operational recommendations need also to be followed. Wärtsilä is supporting its customers with all required advice and instructions. Furthermore, Wärtsilä's upgrade and retrofit solutions offer customers the opportunity to further optimise the overall efficiency of the ship's engine and propulsion.

Fig. 5 – Slow steaming of merchant ships affects the entire industry.