

September 2013



LAMBOS
MARITIME SERVICES LTD

Marine Efficiency Systems at “Slow Steaming” Conditions

Current and Future developments
that may reduce fuel oil consumption

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1.1 Introduction

The shipping community is focusing more and more these days on mitigating the environmental impact of the world fleet. The Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO) has been working to establish new regulations with respect to several marine pollution issues such as accidental spills, exhaust gases, waste delivery ashore, hazardous materials, ship recycling, ballast water, bilge water, anti-fouling paints and sewage. The significant increase in the world fleet over the past five years combined with the proximity of ship traffic in coastal areas and the general public awareness of global warming has resulted in emissions to air being the single most important item on shipping's regulatory agenda. In the meanwhile fuel prices are very high rendering fuel consumption a major parameter and freight market is at very low level forming an explosive economical mixture.

New technologies with respect to cleaner energy sources are being developed very rapidly, but it will still take some time before some of these innovations become standardized equipment on ships. However, today's designs can be further improved by using existing technology and proven analysis methods. One way to decrease fuel consumption and thus minimize the emissions to air of ships is to optimize the hull shape, propeller, rudder and the interaction between all of them or fit some hydrodynamic and propulsion "boost" appendages to improve the ship's overall fuel efficiency. Fuel efficiency improvements in the hull and propeller can range from 2-3% up to 8-10% but it should be noted that these may vary according to Vessel's design as they are directly linked to the nature of the design and the ship's actual trade.

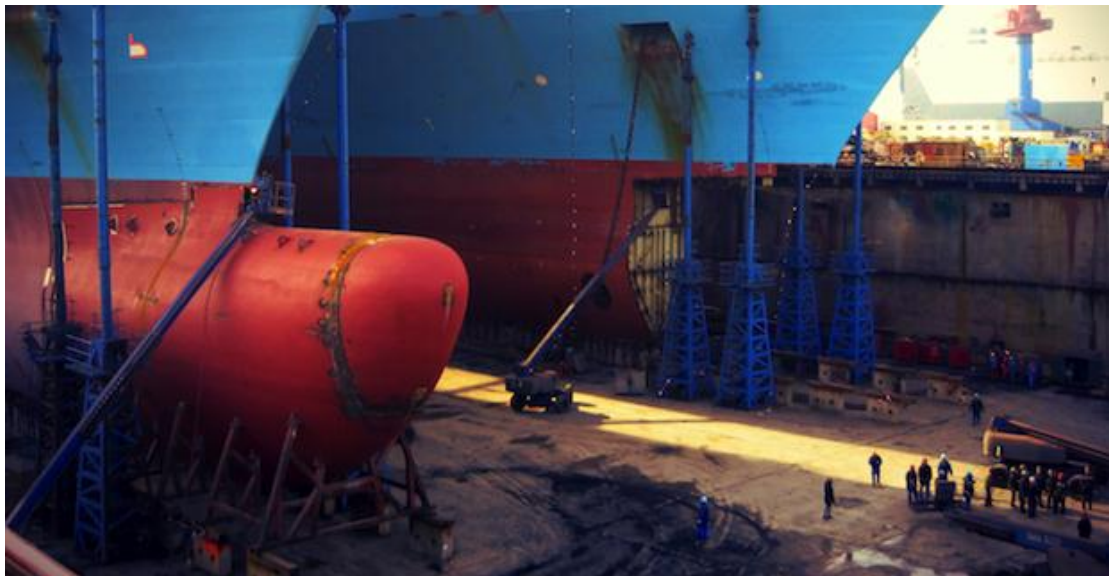
In this report we will try to present the major appendages and methods available in the market until *May 2013* that increase ship efficiency in propulsion and decrease hull resistance leading to higher total ship efficiency. The report is based upon data that is collected mainly from internet and from sources of information such as manufacturers of certain appendages or Universities. As such systems need further examination, data collection from real structures and experience therefore, this report should not be considered as the "Holy Bible of Ship Efficiency" but as a source of collected knowledge that every person in technical department of a shipping company or a technical office should be aware of.

1.2 Hull behavior optimization

Hull lines and smooth surface are very crucial for the resistance of a ship in water affecting numerous parameters. Hull design affects the selection of the type and the Power of the engine, the interaction between hull and propeller varies to hull and propeller design and the behavior of ship at sea which affects the people on board, the machinery, the cargo and generally the integrity of a Vessel.

1.2.1 Bulbous bow re-design

Bulbous bow is installed on ships in order to decrease the wave resistance that is created by hull form when a ship is moving forward. Hydrodynamically, the interference of the primary and secondary wave causes an overall reduction in drag, which is beneficial to the vessel's resistance characteristics. When the water flows over the top of the bulb, it could reduce the pressure above it, thereby reducing the amplitude of the bow-wave. Practically, a bulbous bow creates counter waves that neutralize the waves created by the ship sailing through the water, and thus reduce the amount of energy required to move forward. According to Doust (1961), a good conventional design of bulb can reduce 10 to 15 percent wave making resistance and increase 4 to 5 percent propulsive efficiency.



Over the next several months, Maersk Lines will be giving ten container ships in its fleet nose jobs. They will be cutting off the existing bulbous bows and retrofitting them with new more energy-efficient designs. The actual problem is that the position of the waves created by the bulb and the hull only align under a certain range of speeds and drafts. Slow down or speed up too much and the waves no longer cancel out. In the worst case, the waves become additive and can increase resistance and fuel costs, which is apparently the problem that Maersk has been facing when it slowed down ships originally designed to travel at much higher speed.

This movement has of course to do with slow steaming. Bulbous bows are designed to work at a particular range of speeds and drafts. A well designed bulbous bow can reduce fuel consumption by 10-12%. Many of the Maersk ships were originally designed to operate at around 24 knots. With the dramatic rise in fuel costs and continued container ship overcapacity, many ships are now operating at speeds as low as 12 knots. At such slow speeds the original bulbous bow designs can actually increase hull resistance and increase fuel costs. The new bulbs retrofits should finally save 1-2% in fuel costs in comparison to former service speed.

1.2.2 Hull Coatings

The steel or aluminum hulls of ships need to be protected from the corrosive effects of water so that they don't rust and fall apart. At the same time, these hulls, and also non-corroding hulls such as those made of glass-reinforced plastic, are prone to accumulating biofouling – marine plants and animals which attach themselves to ship hulls as they do to any suitable underwater surface. In the case of hulls, this fouling can greatly increase resistance and prevent the ship from gliding smoothly through the water. This in turn results in greater fuel consumption in order to get the vessel from point A to point B which then causes excessive volumes of emissions of greenhouse gases and other atmospheric pollutants. The biofouling when it becomes severe, can also damage the coating and the hull itself.

Generally the smoothness of the ship hull is determined by a number of factors:

1. Basic 'roughness' (old paint systems attached to hull, even if smoothed over);
2. Hull fouling (starts with slime, then algae, then grass, barnacles); and
3. Propeller friction

For providing optimal hull smoothness there are at present three leading coating technologies available:

Antifouling (AF)

The one in most general use is biocidal antifouling paint which leaches copper and a number of other biocides into the water in order to kill off fouling that attaches to the ship bottom. These paints gradually release the toxic substances into the water over a period of 3 - 5 years, after which time they become depleted and need to be replaced. This method is used years ago and is not broadly used anymore.

Fouling-release (FR)

Another category of hull coating system which has increased in popularity is a "non-stick" type of coating which works on the principle that it is difficult for fouling to stick to it in the first place and easy for it to fall off, wash off or "release" when the vessel is under way, especially at speed. Most of the coatings currently available in this category are silicone-based. They do not work on the principle of leaching biocides,

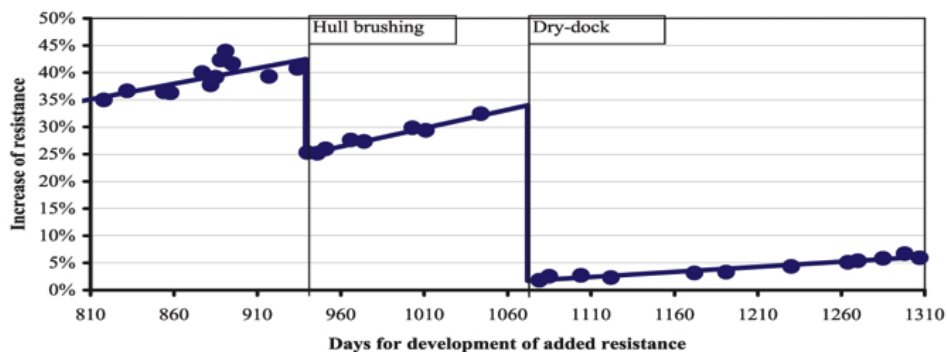
and are advertised as being non-toxic and working mechanically rather than chemically.

Hard, inert coatings

A third general category of hull coating systems can be grouped together under the heading of hard, inert, non-toxic coatings. They are generally either epoxies, polyesters or vinyl esters; some are reinforced with glass flakes.

Nowadays when fuel bunker prices have gone to the roof slow steaming has been a favorite practice to shipping companies. At slow speeds, hull friction becomes a much larger component of hull resistance, thus sleeker new paints have been developed to reduce this skin friction. This attitude resulted to reduction in fuel consumption but inevitably has caused other problems. Besides, ships stay more time in ports and travel with lower speed so biofouling – marine plants are more likely to be attached in the hull surface. This is also the case for the propeller which due to reduced rotation speed the propeller is more vulnerable to fouling as well. *So cleaning of hull and propeller should be performed in shorter intervals.* Furthermore, ship's hull is coated with an antifouling painting designed for a specific range of speed. If the vessel's speed is for prolonged time outside the designed range the protection coating may be not effective. *So the technical Manager should also change the coating which should have such parameters for optimum behavior at lower speed.*

Therefore, in order to present the importance of hull resistance, if a VLCC is consuming 15 more tons per day (in comparison to voyage at design speed and design draft with clean smooth hull and propeller), 5 tons per day could be the basic roughness (all hull coating systems experience some roughening over time, even if no hull cleanings in service), another 7 tons per day could be the fouling of hull and 3 tons per day could be the propeller friction. For another VLCC or for another size and ship type, could be off course completely different proportions of hull roughness, hull fouling and propeller friction. In the graph below the actual reduction in resistance is presented after hull brushing and dry-docking.



1.2.3 Air lubrication

Large Vessels like big container ships, Vehicles carrier etc. have large surface below waterline and thus have increased, comparing to smaller ships and other ship types, frictional resistance. Mitsubishi Heavy Industries few years ago came out with a system named Air Lubrication System, which then was just one of the several energy saving techniques for ships. This system claims to reduce hull friction by blowing out a constant layer of small air bubbles along the bottom of a ship's hull; imaginatively likened to 'a magic carpet' the ship rides on. This reduces the propulsion power demand. The challenge is to ensure that the air stays below the hull and does not escape. With the right ship hull design, the air lubrication system is expected to achieve up to 10-15% reduction of CO2 emissions, along with significant savings of fuel.

An air-lubrication system was installed in each of twin-designed NYK-Hinode Line ocean-going vessels, the 19,800 dwt diesel-engined heavy equipment carriers 'Yamatai' and 'Yamato'; the first in March 2010, and the other in the following November. These two ships are special heavy load carriers with roll-on, roll-off rampways for the transport of



large prefabricated structures. Earlier tank tests and sea trials had suggested a 10% reduction in CO2 emissions was to be expected, but these trials in all sorts of vessel conditions, in a variety of sea and weather conditions confirmed somewhat less – 6% – nevertheless a meaningful energy saving. This system has also been ordered by Germany's AIDA Cruises ordered MALS to be installed in its two new 125,000 GT cruise ships now under construction at MHI's Nagasaki Shipyard & Machinery Works. MHI say that the system is expected to reduce fuel consumption by 7% and will be the world's first such installation in a large cruise ship. Deliveries are scheduled for the spring of 2015 and 2016.

This system propagates a decrease in fuel consumption depending on the ship type:

	Type of Ship	Reduction Level
1	Tanker	~15%
2	Container	~7.5%
3	PCTC	~8.5%
4	Ferry	~3.5%

1.3 Propulsion maintenance and appendages

The selection of a propulsion system is very important for a new ship design. The propeller should have optimum design for the operation demands characteristics of a new vessel. It is also very important to carefully design the stern part of the hull which is the part of the ship which mostly interacts with propeller. So in the phase of the design redesigning the hull, appendages and propeller together will at low cost improve performance and propulsion efficiency. Besides the selection and the design of a propulsion system operation is very important to keep the marine structures functional and safe in their “trip” to oceans. In this part we will examine some of the commonly used propeller arrangements and their operational characteristics.

1.3.1 Propulsion maintenance - Clean/Polish the propeller

When a ship manager was monitoring some years ago ship operations, ship performance was associated with the condition of the ship hull while the effect of the propeller surface condition was often overlooked. Nevertheless, the effect of the rough surface of a propeller can be significant. The effect of the propeller surface condition is less important than the hull condition, but significantly more important in terms of energy loss per unit area. In fact, relative to the total surface area involved, the effects of marine growth on the propeller have a *much greater* impact on a vessel's performance - and this applies equally to all vessels.

When considering the propeller surface condition a distinction has to be made between fouling and surface deterioration coupled with an increase in propeller roughness. The reasons that cause a propeller to have a rough surface are:

- Mechanical damage
- Erosion
- Cavitation
- Marine Fouling



A rough propeller results in a fuel penalty for the ship. How large that penalty depends on the degree of roughness. Based on information available, it can be

conducted that propeller surface roughness from fouling and surface deterioration can cause a fuel consumption increase of somewhere between 5 and 15 per cent. Nowadays during slow steaming period Vessels stay longer time in ports and travel with lower speed so living organisms are more likely to be attached to ship surface. So even if a Vessel continues to trade to same ports her propeller should be cleaned in closest intervals in order to have propulsion efficiency and fuel consumption with little deviation. The frequency between propeller maintenance cleanings is defined by the actual trading route, the ports the Vessel uploads/offloads and the time the ship is layed-up at the ports or trading in areas of warm sea waters like Caribbean, Red Sea, Persian Gulf and generally tropical climates. It is clearly understood that the trading pattern influences the fouling of the propeller and *the only can be concluded is that the shipping company should monitor the fuel consumption and the ship resistance and schedule the propeller cleaning accordingly.*

1.3.2 Propulsion maintenance - Monitoring the propulsion

Monitoring Vessel Performance is very important for a Ship Operator in order to accurately schedule of docking and optimization of vessel routing. Using in service performance monitoring, the ship owner can make a comparison between the ship's design conditions and the actual ship performance, including the environmental conditions it encounters on its voyages.

Nevertheless, ever soaring fuel prices make ship performance an important issue in shipping. Coming regulations on ship emissions furthermore stimulate operators to reduce the ships fuel consumption. Using in service performing monitoring trends to become visible of the ship performance. From fleet comparisons it is known that the fuel consumption of sister ships on the same trade may vary up to 10%. Optimum trim, routing, speed control, autopilot and propeller pitch setting and propeller cleaning can reduce fuel bills by more than 5%. Therefore, besides detailed monitoring of vessel performance, detailed analysis is required to compare the performance of individual vessels and draw conclusions.

In detail, the motivations to develop and implement such a system to ship management are:

1. Fouling problem

During service the ship will experience fouling on hull and propeller. The degree of fouling depends on many factors; the length of port stay and the service speed at sea; the nature of water in different areas of the world, e.g. salinity, temperature, pH, salts and oxygen concentration.

2. Performance Prediction

Various methods and systems have been developed to estimate the performance of a ship. General methods for estimating this are developed on the basis of the results of a large number of model and full-scale tests which are collected and described statistically in graphs and empirical formulas.

3. Performance Systems

There are a vast number of performance evaluation systems on the market while there are different approaches to log data and to evaluate the performance of a ship. These systems are using manually logged data in the analysis of performance.

4. Logging of Data

Performance evaluation of ships has existed for several years. Several Companies have described the need for developing instruments for the logging of parameters during service.

The basic purpose of a propulsive performance system on board a ship is to provide feedback of how the ship performs during a voyage or a period in the ship's life. By use of a performance system the goal of making the most efficient voyage may be achieved. It not only indicates how the ship performs at the moment of measurement, but also, on the basis of data collected over a period, monitors the condition of the ship while in service. The overall purpose will normally be to gain information on how to make the most economical or environmentally efficient voyage. An evaluation of the ship's performance must comprise a comparison of two or more conditions. As the sailing conditions, e.g. the environmental and loading conditions might be of great importance during the time of operation, a performance index taking this into account must be used. A suggestion is to compare the present condition with a model condition defined by some given standard circumstances.

Conclusion is that the Vessel Operator should develop a ship model in which will have as input data the measurements of a number of sensors installed to ship structure and mechanical equipment. These sensors are usually amidst the following:

1. Speed Log
2. Echo Sounder
3. RPM and Torque Meter
4. Shaft Motor
5. Thrust Meter
6. Rudder Indicator
7. Stabiliser Fins
8. GPS
9. Gyroscope
10. Air temperature and Pressure
11. Gyrocompass
12. Motion Sensor
13. Sea water temperature
14. Draught

This integral system of sensors will constantly monitor and log the parameters of the ship voyage and then compare the main parameters to those of the model. Afterwards ship Operator can take countermeasures to improve ship performance aiming of course to lower the operational costs of Vessel. These systems have been developed by many companies and organizations such some of the prestigious Classifications Societies of IACS and big companies like ABB, Wartsila, MAN etc. The propulsive performance system is also a compulsive part of SEEMP regulations in order to achieve certain environmental and economic goals.

1.4 Introduction to Propeller appendages

Various energy saving devices can be applied onboard, but the practically applicable devices should be simple, relatively cheap to install, easy to maintain and most importantly, the design should have a solid scientific background. Here find below, the most commonly used energy saving devices in shipping sector, currently available in market with their features, indicative costs, and contact details when already available. This study should be considered only *as an estimation and collected knowledge in paper* since all data are mostly gathered from *internet sources* and websites of manufacturers of those devices. A company that will decide to install such a device **should not base on this study and should cross check** all the decisive factors and contact the manufacturer for precise data before taking a decision regarding the installation of such an appendage.

1.4.1 Becker Mewis Duct

The Becker Mewis Duct, a highly-efficient energy-saving device, was named after the inventor Friedrich Mewis and is developed, manufactured and retailed by Becker Marine Systems. The duct is placed in front of the propeller with the purpose of improving the water flow to the propeller. The advantage of the Becker Mewis Duct is that it combines two positive devices: a pre-swirl stator and a duct. The stator blades are non-movable fins that create a pre-swirl. This means that they change the angle of the flow towards the propeller in such a manner that it operates as a counter-rotated device with a more favourable angle of attack. The effect of the duct is to increase the velocity of flow towards the propeller, which is again an improvement in the propeller's working condition. The duct itself creates a forward directed thrust due to its foil section shape. Becker Marine Systems delivers each Becker Mewis Duct individually adjusted for the actual hull form and propeller after a thorough design phase using Computational Fluid Dynamic (CFD) computations.



The achievable power savings from the Becker Mewis Duct® are strongly dependent on propeller thrust loading, from 3% for multi-purpose ships up to 8% for tankers and bulkers. The power savings is virtually independent of ship draught and speed.

The Becker Mewis Duct® is ideally suited to both new-build and retrofit applications (e.g. Tankers, Bulkiers and MPCs) and has the below mentioned characteristics:

- Improved propulsion efficiency
- Proven fuel savings up to 8%

- Reduced greenhouse gases (GHG)
- No moving parts, no service necessary
- Reduced vibrations & pressure pulses
- Return on investment in approx. 1 year (based at an actual bunker price of 600 \$/t)
- Installation time approximately 4 days
- The Mewis Duct can be retrofitted without changes to the propeller
- The Mewis Duct is suited to vessels with High block coefficient Speeds lower than 21 knots

Mewis Duct®- Case study

Installation of a Mewis Duct® on a 45,000 DWT Multi Purpose Vessel

Indicative Costs

- **Price** about 220,000 \$
- **Installation** about 30,000 \$
- **Capital costs** about 25,000 \$
- **Sum of costs** about 275,000 \$

Saving in costs by MD

- **6% power reduction** abt. 1,000 \$ / day*
- 220 days / year abt. 220,000 \$ / year
- Saving after 15 month abt. 275,000 \$
- Payback of investment after abt. 1¼ years

The data which is presented above is from internet sources and may not be valid. The costs and efficiency depends on ship size and design. Do not base on the above data.

The Contact details of Company which produces this energy saving device are :

Becker Marine Systems

Head Office

Hamburg, Germany

Neulander Kamp 3

21079 Hamburg

Service

During Office hours

Tel. +49 40 24199 23

24/7 Hotline

Tel. +49 173 9229311

Tel. +49 40 24199 0

Fax. +49 40 2801899

<http://www.becker-marine-systems.com>

1.4.2 Schneekluth Wake Equalizing Duct (WED)

Schneekluth WED which stands for *Wake Equalizing Duct* is an energy-keeping gauge proposed by Prof. Schneekluth in 1985. WED is assigned to flatten out velocity field of nominal wake. Design of this gauge was worked out by German firm “Schneekluth Hydrodynamik”. More than 1.500 ships have been equipped with the WED and are effecting an amount of savings as the direct advantage.

The Schneekluth duct has the below mentioned characteristics:

- Fuel saving up to 12 %
- Vibration-reduction up to 50 %
- Improvement of steering qualities from more straightened flow to the rudder.
- No constructional changes and no modifications in propeller design are required



Schneekluth Wake Equalizing Duct (WED)-Case Study

Installation of a **Schneekluth** Wake Equalizing Duct (WED) - on a 30,000 DWT BC

Indicative Costs

- **Price** about 70,000 \$ - 80,000\$
- **Installation** about 20,000 -30,000 \$ (depends on shipyard)
- **Sum of costs** about 90,000\$ - 110,000 \$

Saving in costs by **Schneekluth** WED

- **4% minimum power reduction** abt. 670 \$ / day
- 220 days / year abt. 147,400 \$ / year
- Saving after 7 month abt. 86,000 \$
- Payback of investment after abt. 7 months

The data which is presented above is from internet sources and may not be valid. The costs and efficiency depends on ship size and design. Do not base on the above data.

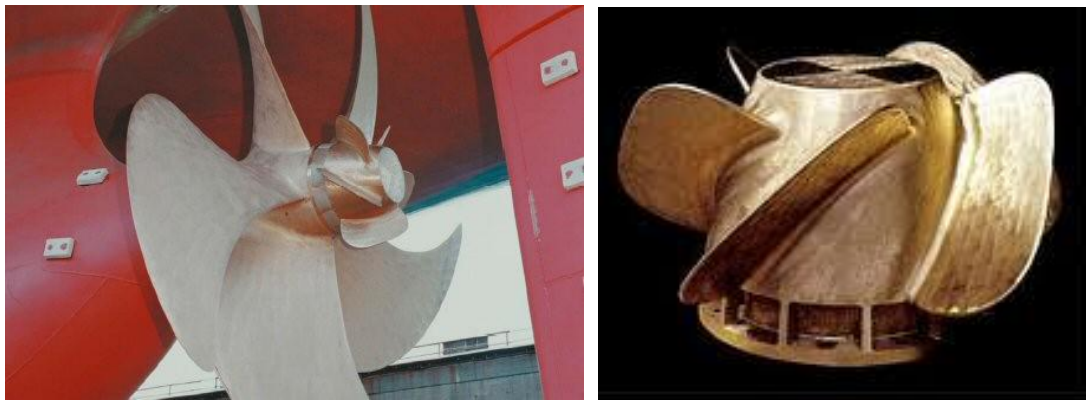
The Contact details of Company which produces this energy saving device are :

**Schneekluth Hydrodynamik
Entwicklungs- u Vertriebs GmbH**
Amtsgericht Duisburg HRB 9757

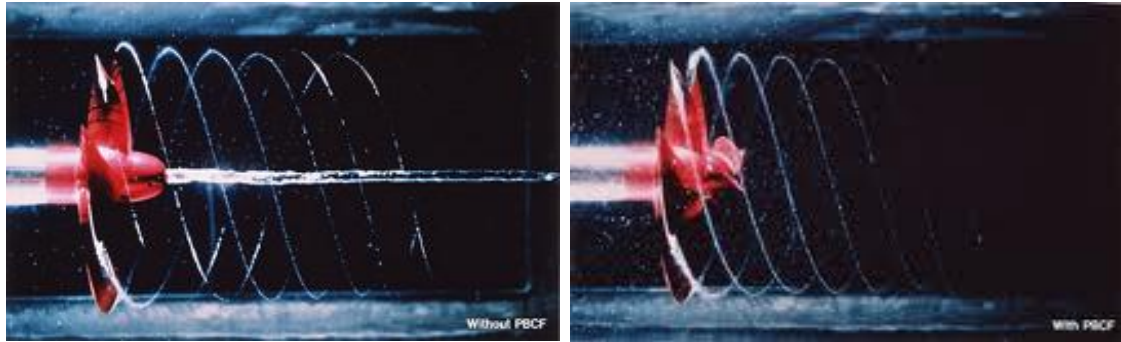
Attention Mr. Peter Ostra, Eckhard Ostra
Tel. +49 (0) 2064 54127
Fax. +49 (0) 2064 58434
www.schneekluth.com

1.4.3 PBCF – Propeller Boss Cap Fins

The PBCF – Propeller Boss Cap Fins has been developed and commercialized in 1987 by the corporate group centered in Osaka Shosen Mitsui Senpaku KK (currently Mitsui O.S.K. Lines, Ltd.). In 2011 it has achieved the record of installation of 2000 vessels.



PBCF is the originated device to be focused in the recovery of energy from the flow out energy in propeller hub vortex. Its fundamental mechanism and effects have been repeatedly verified through numerous series of model tank tests and actual ship measurements from the first stage of the development. The 5% energy saving effect has been presented on numerous occasions at academic association meetings both in Japan and overseas, and this has been well accepted both in Japan and overseas. As results, these development works have won the Japan Institute of Marine Engineering Award, Society of Naval Architects of Japan Award and Outstanding Energy Conservation Award of the Japan Machinery Federation. At the same time, patents have been acquired in twelve countries around the world as unique technology from Japan. Under the current importance of the global environmental problems, the demand for the PBCF has been continually growing up from not only as an energy saving device but also as an environment-friendly product.



The PBCF Device consists of a modified propeller boss cap (hub cone) with fins. The number of fins are the same as the number of propeller blades, and it rotates together with the propeller. Installation of a PBCF device is relatively simple and easy to do. The device is bolted onto the propeller boss using the existing bolt holes for the normal propeller bonnet, the bonnet being replaced by the PBCF device. No modification of the vessel or the propeller is required. This means that the PBCF is an effective and inexpensive fuel saving device for application to existing vessels.

Features of PBCF

- 3-5% reduction in fuel consumption and a corresponding reduction in CO₂ emissions
- A reduction in propeller torque
- Reduced vibration in the stern less underwater noise
- Reduced rudder erosion
- Installation is simple and straightforward, requiring only the removal of the propeller boss caps and replacement with the PBCF. No hull modification is needed.
- The PBCF is an integral part of the propeller, with no other moving parts. The PBCF system is custom made, with design optimized for the shape of the vessel's propellers. Lead time is three to four months from order to delivery.
- It is maintenance free after installation, requiring only inspection and polishing when the vessel is in drydock, and performance does not decline over time.

Ship type	Utilization	Fuel Oil Consumption	Estimated PBCF Cost	Payback Period
	%	t/d	US \$	Months
Containership	75	210	185.000 \$	2.2
VLCC	85	100	165.000 \$	3.6
Capesize Bulk Carrier	75	60	105.000 \$	4.4
Handy Bulk Carrier	70	30	65.000 \$	5.8
General Cargo Ship	55	10	40.000 \$	13.7

The data which is presented above is from internet sources and may not be valid. The costs and efficiency depends on ship size and design. Do not base on the above data.

The Contact details of Company which produces this energy saving device are:

MOL Techno-Trade Ltd

Tel: 81-3-6367-5480

Fax: 81-3-6367-5525

<http://pbcf.motech.co.jp>

1.4.4 Pre-swirl stator

Daewoo Shipbuilding and Marine Engineering Co. Ltd (DSME) has developed the pre-swirl stator (PSS) in cooperation with SSPA. SSPA tested most of DSME's designed PSS over the past 10 years. The PSS is a device mounted on the boss end of the hull in front of the propeller and is designed to generate pre-swirl flows in order to gain a favorable interaction with the propeller action that improves propulsive efficiency and results in power reduction.

Three to six blades have been investigated in various configurations on single screw ships over the years. The Optimization Investigation showed that PSS typically has four blades with a diameter equal to the propeller diameter. This has become the standard configuration for a wide range of hull types including VLCCs, tankers, Bulkers, RO RO ships and Containerships. The DSME PSS has been successfully applied to various ship types, with an average gain of 4 % on propulsion power achieved in model tests and confirmed in sea trial tests.

The Pre-swirl Stator, which has four blades, improves the inflow angles to the propeller by being well placed in front of it. It can minimize operational costs by maximizing propulsion efficiency. The Pre-swirl Stator was first installed on H.5297, a Kristen owned VLCC with a capacity of 320,000 TDW. After conducting a sea trial of this vessel with this energy saving device, significant improvement in performance has measured. Indeed it accelerated Vessel's speed performance by 0.2 knots and reduced fuel consumption by 4%.



The Contact details of Company which produces this energy saving device are:

Daewoo Shipbuilding and Marine Engineering Co. Ltd (DSME)

DSME Seoul

Tel. 221290114

1, Possidonos Ave., 174 55

Alimos, Greece

Greece Office

Tel. 30 210 422 6786-7

athens@dsme.gr

<http://www.dsme.co.kr>

1.4.5 Counter rotating propellers



Counter rotating propellers consist of a pair of propellers behind each other that rotate in opposite directions. The aft propeller recovers some of the rotational energy in the slipstream from the forward propeller. The propeller couple also gives lower propeller loading than for a single propeller resulting in better efficiency. CRP propellers can either be mounted on twin coaxial counter rotating shafts or the aft propeller can be located on a steerable propulsor aft of a conventional shaft line. CRP has been documented as the propulsor with one of the highest efficiencies. The power reduction for a single screw vessel is 10% to 15%.

1.4.6 Rudder Bulb Designs

Wärtsilä Energopac



Image by Wärtsilä Corporation

The efficient design of the rudder bulb, particularly when integrated with the propeller and the rudder profile, streamlines the flow and significantly reduces separation losses from the propeller hub. The impact is most noticeable when a large part of the rudder bulb is behind the propeller hub. Thus, the highest fuel savings are achieved when the vessel is in transit, since the rudder angles required for maintaining course are minimal. This device claim to have a gain 2-9% comparing to conventional propeller-rudder arrangements.

Wärtsilä Greece S.A

Pireaus, Akti Miaouli 25 Str.

Tel.+ 30 (2) 10 4135 450

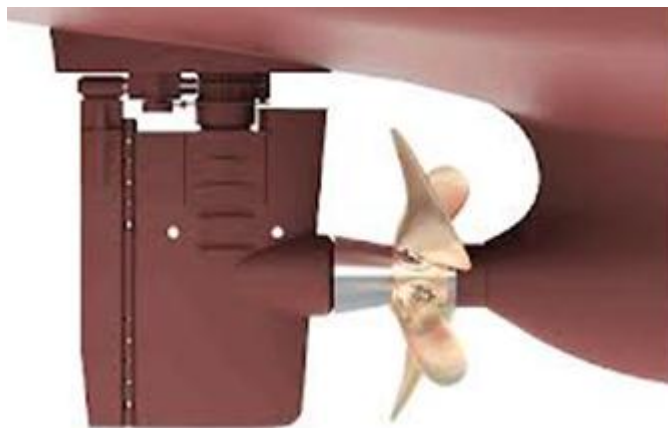
Fax.+ 30 (2) 10 4117902

24hrs Phone: +30 69 44594562

<http://www.wartsila.com>

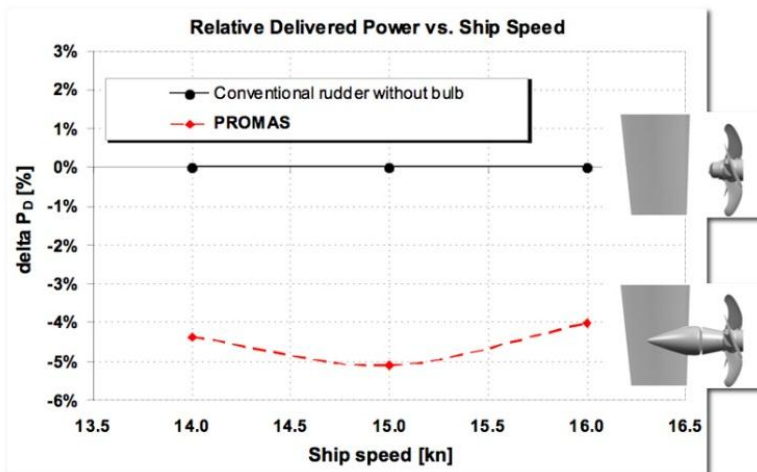
Integrated propeller and rudder Promas Lite by Rolls-Royce

Promas Lite is a version of the successful Rolls-Royce Promas integrated propeller and rudder system, designed specifically for vessels already in service. With the advances in propeller design, it is well known that propeller blade changes, or the fitting of new propellers, can have a significant effect on propulsive efficiency, fuel consumption



and, therefore, emissions. With Promas Lite these improvements can be maximised, as the propeller and rudder are treated as a complete system which can lead to further increases in efficiency which parallel will lead to improved manoeuvrability for only a

small increase in cost. Each Promas Lite system is custom engineered to an individual vessel and its specified operating profile.



Promas Lite integrates the propeller and the rudder into a single system. Behind a normal propeller hub there is a strong low pressure vortex (hub vortex) that acts on the propeller hub, increasing drag and reducing propeller thrust. A special hubcap is fitted to the propeller which stream-lines the flow onto a bulb that is added to the rudder, effectively reducing flow separation immediately after the propeller. The result is an increase in propeller thrust, as previously

wasted energy is recovered from the flow. In Addition, the bulb on the rudder also streamlines the flow aft of the rudder, further reducing drag. The hubcap is mounted outside of the propeller hub and acts purely as a hydrodynamic fairing. No special hub design is needed, thus cost and technical complexity is kept to a minimum.

The characteristics of this propulsive arrangement are:

- *Reduced fuel consumption*
Improvements of between 5-15% is possible, depending on the vessel's operating profile
- *Reduced environmental impact*
Proven corresponding reduction in emissions with lower emission taxes
- *Short payback period*
It depends on vessel operating hours, but the return on investment is often less than two years.
- *Increased propulsive efficiency*
Integrated rudder and propeller design, reduced pressure pulses for improved comfort
- *Simple and quick installation*
The device can be normally fitted within a week
- *Lower maintenance costs*
Reduced engine loads means less oil consumption and potentially reduced engine wear

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1.4.7 Costa Propulsive Rudder Bulb

Limited to single screw vessels (usually) the bulb is a simple but effective device for recovering energy from losses aft of the propeller. It consists of a fabricated stream lined steel shell, manufactured in two halves and welded onto the rudder immediately aft of the propeller boss with its center line continuous with the tail shaft. The bulb eliminates vortices created due to turbulent flow and sudden contraction of the water which trails from the boss. This contraction is caused by the sudden release of the very large volumes of air released under normal operational conditions when the water passes through the propeller. It has also a tranquillizing effect on the flow of water behind a propeller. Reduces prop vibration, stiffens rudder, increases buoyancy and improves steering.



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