HULL AND PROPELLER

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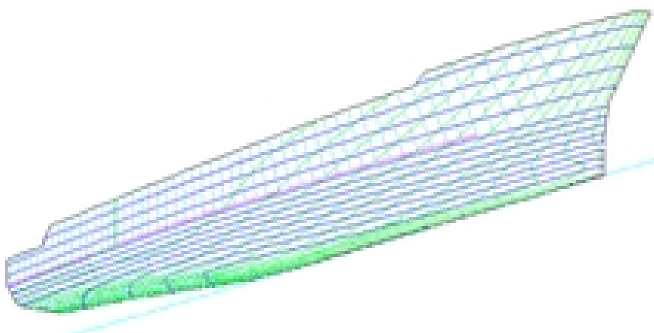
ABSTRACT

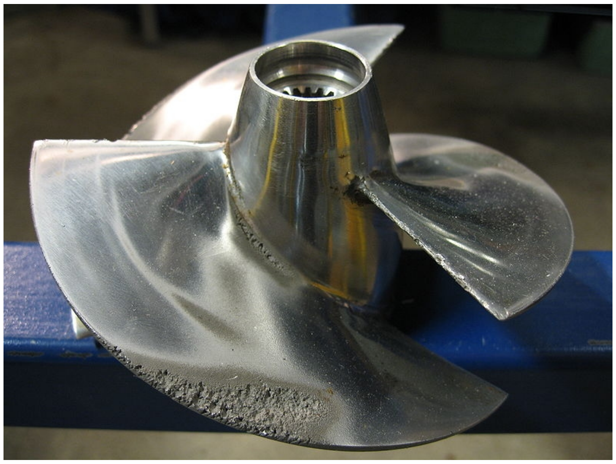
As we all know our mother planet earth is covered with 70% of water and the ship being a major means of transport. Our talk will be on hull and propeller one of the very important part of the ship. A propeller when rotated it screws or thrusts its way through the water by giving momentum to the column of the water passing through it. It must therefore be solidly constructed and mounted onto a rigid seating or framework to perform its task.

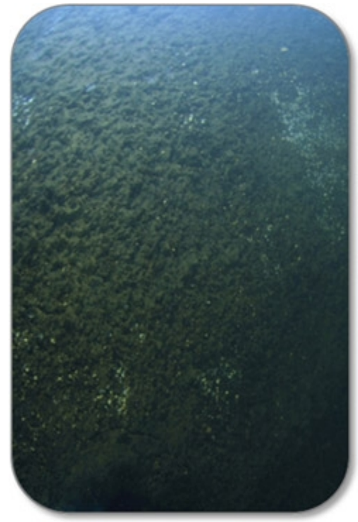
In our talk (presentation) we will talk briefly about the different propellers, propeller mounting and along with this we will discuss different issues related to Hull and Propeller and remedies to improve it we will also talk about how to reduce dry-docking span for maintenance, alternative hull cleaning technology to reduce dry docking ROV for underwater hull cleaning and Russia's use of cavitation in water for erosion of fouling.

INTRODUCTION

Transportation with the help of ships is one of the most convenient ways of transporting. Ships and boats have developed alongside mankind. In major wars, and in day to day life, they have become an integral part of modern commercial and military systems. Fishing boats are used by millions of fishermen throughout the world. Military forces operate highly sophisticated vessels to transport and support forces ashore. Commercial vessels, nearly 35,000 in number, carried 7.4 billion tons of cargo in 2007. So one of the most important part of the means of transport are Hull and Propeller.in this paper our main aim is to concentrate on how to reduce the fouling on hull and cavitations on propellers and how to reduce the dry docking span so that the money can be efficiently used for the research and development purposes.







PROPELLERS

PROPELLERS: A **propeller** is a type of fan that transmits power by converting rotational motion into thrust. A pressure difference is produced between the forward and rear surfaces of the airfoil-shaped blade, and air or water is accelerated behind the blade. Propeller dynamics can be modeled by both Bernoulli's principle and Newton's third law. A propeller is often colloquially known as **screw** both in aviation and maritime.

A propeller is the most common propulsor on ships, imparting momentum to a fluid which causes a force to act on the ship.

The ideal efficiency of any size propeller (free-tip) is that of an actuator disc in an ideal fluid. An actual marine propeller is made up of sections of helicoidal surfaces which act together 'screwing' through the water (hence the common reference to marine propellers as "screws"). Three, four, or five blades are most common in marine propellers, although designs which are intended to operate at reduced noise will have more blades. The blades are attached to a boss (hub), which should be as small as the needs of strength allow - with fixed pitch propellers the blades and boss are usually a single casting.

An alternative design is the controllable pitch propeller (CPP, or CRP for controllable-reversible pitch), where the blades are rotated normal to the drive shaft by additional machinery - usually hydraulics - at the hub and control linkages running down the shaft. This allows the drive machinery to operate at a constant speed while the propeller loading is changed to match operating conditions. It also eliminates the need for a reversing gear and allows for more rapid change to thrust, as the revolutions are constant. This type of propeller is most common on ships such as tugs[citation needed] where there can be enormous differences in propeller loading when towing compared to running free, a change which could cause conventional propellers to lock up as insufficient torque is generated. The downsides of a CPP/CRP include: the large hub which decreases the torque required to cause cavitation, the mechanical complexity which limits transmission power and the extra blade shaping requirements forced upon the propeller designer.

For smaller motors there are self-pitching propellers. The blades freely move through an entire circle on an axis at right angles to the shaft. This allows hydrodynamic and centrifugal forces to 'set' the angle the blades reach and so the pitch of the propeller.

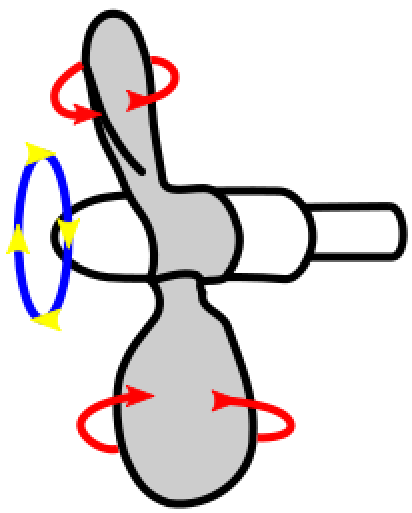
A propeller that turns clockwise to produce forward thrust, when viewed from aft, is called right-handed. One that turns anticlockwise is said to be left-handed. Larger vessels often have twin screws to reduce heeling torque, counter-rotating propellers, the starboard screw is usually right-handed and the port left-handed, this is called outward turning. The opposite case is called inward turning. Another possibility is contra-rotating propellers, where two propellers rotate in opposing directions on a single shaft, or on separate shafts on nearly the same axis.

Contra-rotating propellers offer increased efficiency by capturing the energy lost in the tangential velocities imparted to the fluid by the forward propeller (known as "propeller swirl"). The flow field behind the aft propeller of a contra-rotating set has very little "swirl", and this reduction in energy loss is seen as an increased efficiency of the aft propeller.

TYPES OF MARINE PROPELLERS

CONTROLLABLE PITCH PROPELLER

At present, one of the newest and best type of propeller is the controllable pitch propeller. This propeller has several advantages with ships. These advantages include: the least drag depending on the speed used, the ability to move the sea vessel backwards, and the ability to use the "vane"-stance, which gives the least water resistance when not using the propeller (e.g. when the sails are used instead).



•SKEWBACK PROPELLER

An advanced type of propeller used on German Type 212 submarines is called a skewback propeller. As in the scimitar blades used on some aircraft, the blade tips of a skewback propeller are swept back against the direction of rotation. In addition, the blades are tilted rearward along the longitudinal axis, giving the propeller an overall cup-shaped appearance. This design preserves thrust efficiency while reducing cavitation, and thus makes for a quiet, stealthy design.

•MODULAR PROPELLER

A modular propeller provides more control over the boats performance. There is no need to change an entire prop, when there is an opportunity to only change the pitch or the damaged blades. Being able to adjust pitch will allow for boaters to have better performance while in different altitudes, water sports, and/or cruising.

HULL

A hull is the watertight body of a ship or boat. Above the hull is the superstructure and/or deckhouse, where present. The line where the hull meets the water surface is called the waterline.

The structure of the hull varies depending on the vessel type. In a typical modern steel ship, the structure consists of watertight and non-tight decks, major transverse and longitudinal members called watertight (and also sometimes non-tight) bulkheads, intermediate members such asgirders, stringers and webs, and minor members called ordinary transverse frames, frames, or longitudinals, depending on the structural arrangement. The uppermost continuous deck may be called the "upper deck," "weather deck," "spar deck," "main deck" or simply "deck." The particular name given depends on the context--the type of ship or boat, the arrangement, or even the area where it sails. Not all hulls are decked (for instance a dinghy).

In a typical wooden sailboat, the hull is constructed of wooden planking, supported by transverse frames (often referred to as ribs) and bulkheads, which are further tied together by longitudinal stringers or ceiling. Often but not always there is a centerline longitudinal member called a keel. In fiberglass or composite hulls, the structure may resemble wooden or steel vessels to some extent, or be of a monocoquearrangement. In many cases, composite hulls are built by sandwiching thin fiber-reinforced skins over a lightweight but reasonably rigid core of foam, balsa wood, impregnated paper honeycomb or other material.

HULL SHAPES:

Hulls come in many varieties and can have composite shape, (e.g., a fine entry forward and inverted bell shape aft), but are grouped primarily as follows:

- Moulded, round bilged or soft-chined. Examples are the round bilge, semi-round bilge and s-bottom hull.

- Chined and Hard-chined. Examples are the flat-bottom (chined), v-bottom and multi-bottom hull (hard chined).

HULL FORMS:

Smooth curve hulls are hulls which use, just like the curved hulls, a sword or an attached keel.

Semi round bilge hulls are somewhat less round. The advantage of the semi-round is that it is a nice middle between the S-bottom and chined hull. Typical examples of a semi-round bilge hull can be found in the Centaur and Laser cruising dinghies.

S-bottom hulls are hulls shaped like an s. In the s-bottom, the hull runs smooth to the keel. As there are no sharp corners in the fuselage. Boats with this hull have a fixed keel, or a kielmidzwaard. This is a short keel which still sticks a sword. Examples of cruising dinghies that use this s-shape are the yngling and Randmeer.

CHINED AND HARD-CHINED HULLS

A chined hull consists of straight plates, which are set at an angle to each other. The chined hull is the most simple hull shape because it works with only straight planks. These boards are often bent lengthwise. Most home-made constructed boats are chined hull boats. Benefits of this type of boating activity is the low production cost and the (usually) fairly flat bottom, making the boat faster at planing. Chined hulls can also make use of a daggerboard or attached keel.

Chined hulls can be divided up into 3 shapes:

- V-bottom chined hulls
- Flat-bottom chined hulls
- Multi-chined hulls.

FOULING

Fouling refers to the accumulation of unwanted material on solid surfaces, most often in an aquatic environment. The fouling material can consist of either living organisms (biofouling) or a non-living substance (inorganic or organic). Fouling is usually distinguished from other surface-growth phenomena in that it occurs on a surface of a component, system or plant performing a defined and useful function, and that the fouling process impedes or interferes with this function.

Other terms used in the literature to describe fouling include: deposit formation, encrustation, crudding, deposition, scaling, scale formation, slagging, and sludge formation. The last six terms have a more narrow meaning than fouling within the scope of the fouling science and technology, and they also have meanings outside of this scope; therefore, they should be used with caution.

Fouling phenomena are common and diverse, ranging from fouling of ship hulls, natural surfaces in the marine environment (marine fouling), fouling of heat-transfer components throug h ingredients contained in the cooling water or gases, and even the development of plaque or calculus on teeth, or deposits on solar panels on Mars, among other examples.

TYPES AND CATEGORIES OF FOULING.

The types of fouling are separated into soft, hard, and composite categories. Soft fouling typically algae, slime and grasses, have a minimum effect on the coating systems and the performance of the ship. Hard fouling is more tenacious having a calcareous structure which may become detrimental to the performance of the ship and coating systems. Composite fouling includes both hard and soft fouling organisms and is extremely detrimental to the ship's performance and coating and machinery systems.

- SOFT FOULING. The dominant organisms in this stage of fouling are slime and grass.
- SLIME. Formation of slime is the first step in the fouling process. Almost any object immersed in seawater rapidly accumulates a coating of slime, consisting of bacteria, fungi, protozoa, and algae. Bacteria frequently are attached within one-half hour of wetting the surface, and slime can often be felt by hand within an hour. The coating of slime is smooth and generally follows hull contours.
- GRASS AND OTHER SOFT FOULING. Grass is a form of multicellular green and brown algae. It forms most heavily near the water-line, where adequate light is available for photosynthesis. It is less evident as depth increases, and the dominant color changes from green to brown.
- HARD FOULING. The dominant forms of hard biofouling are barnacles (usually acorn) and tubeworms (serpulids). Some underwater components, such as the bare metal of a propulsor, can experience severe conditions where a combination of biofouling (hard and soft) and calcareous deposits can form.
- BARNACLES. Acorn barnacles have conical hard shells with jagged tops.
- TUBEWORMS. Tubeworms form intertwined tubes lying along or projecting out from the hull.
- CALCAREOUS DEPOSITS. A result of an active cathodic protection system is the deposition of magnesium and calcium carbonate on bare metal surfaces. The bare nickel-aluminum-bronze-surfaces of a propulsor are highly susceptible to a uniform accumulation of calcareous deposit. The thickness will depend upon the time from the last cleaning and the functionality of the cathodic protection system and although usually more fragile than biological hard-fouling, can still be tenacious and difficult to remove.
- COMPOSITE FOULING. In advance stages of fouling, mature barnacles and tubeworms may be present along with calcareous bivalves organisms such as mussels or oysters, or hydroids with calcareous cellular structure such as coral or anemones. In advanced stages of fouling, the ship will be affected by slime, grass, barnacles, and tubeworms. In addition, this stage of fouling will include soft shell-less animal forms, such as hydroids, anemones, and tunicates (sea squirts).

Underwater ship hull cleaning -- advantages and tools

For over 130 years people have thought about machines or robots for cleaning ship hulls. Various devices and technology has been developed and tested. Only few developments have found wider application, an example could be hydraulic brush system operated by diver (BrushCart). In recent years, we are observing growing interest in robotic system that are developed to cope with the bigger ships and eliminate diver's presence underwater. Important issue is stress on marine ecology requirements. Robots are able to cope with that case using suitable tools. However, the investment in robotic system may be substantially high, such system will be able to work continuously underwater and possibly above the water where divers do not have access. Plug in sensor modules could allow to conduct detailed inspection of the almost whole hull during the same mission.

Brush technology

Brushes are used in cleaning carts, handheld polishers and some robotic systems and are able to cope with almost all types of fouling. Most systems consist of one or more rotating brushes pneumatically, or hydraulically driven. This requires the minimum of equipment beyond the cleaning device itself thus reducing the cost of the system. Before the ban on tributyltin (TBT) came in, brush technology was preferred to underwater jetting systems, as it was easier and more economical to use. However, the increase in use of environmentally friendly low friction coatings can cause a problem, as these coatings are less durable and more easily damaged by the abrasive action of the brushes. Research has shown that bristle density, angle and gauge have a greater effect on shear and normal forces produced by brushes, while the brush speed and stand-off distance has little or no effect. The main point demonstrated by the research was the selection of the brush cleaning system and forces involved is dependant on a number of factors and their relationship is very complex. The major problems in cleaning using heavy duty brushes could have place when dealing with calcerous forms of fouling.

Water jetting technology The use of high pressure water jets has become an accepted alternative to brush cleaning systems. Unlike the brush-based systems, water jets can be easily controlled by reducing or increasing the pressure from the pump. A water jet's effectiveness is dependant on the surface, pressure of water, jetting angle and distance from the cleaning surface. Jet nozzles, such as CaviJet or SwirlJet have been developed to enable effective cleaning of the hull underwater.
Tests using cavitating water jet nozzles showed that the cleaning process can remove various types of fouling from hull coatings, while at the same time, minimizing the damage to the coating. Although jet washing provides increased control of the cleaning process, the perceived increase in the cost of the equipment is still thought to be prohibitive. In hase of the HISMAR system low pressure jetting will be sufficient to remove effectively and safely the layer of slime from the hull surface.

CAVITATION OF MARINE PROPELLER

Every naval architect or propeller designer knows what a propeller cavitation is. Cavitation happens when the pressure in the fluid flowing around the propeller blades drops and causes some fluid to change into water vapor. When cavitation of marine propeller happens, it changes the homogeneity of the fluid flow. This causes the racing of propeller shaft but the speed of the ship drops. Cavitation on propeller also causes the erosion of material particularly on the surface of the propeller blade. Read my other article Erosive Effect of Cavitation on Propeller to know more about it.

The phenomenon of propeller cavitation was first noticed by Thornycroft and Barnaby on their destroyer, *Daring*. When the ship was being tested, they expected it to reach a speed of more than 27 knots. In reality, it could only reach 24 knots. Finally, Thornycroft and Barnaby solved this problem by increasing the surface area of the blade up to 45%. They concluded that the loss of the propelling force in high speed propeller had been caused by the high loading of propeller blade. According to them, the phenomenon happened when the thrust/inch^2 of the projected surface of the propeller was more than 11.25 lbf (77.55 kN/m^2). After modifying the propeller, finally, *Daring*'s speed could reach more than 29 knots.

High loading of propeller will create high negative pressure at the back of the propeller which forms cavities that will be filled by air and water vapor. It was then R.E. Froude who suggested Thornycroft and Barnaby that the phenomenon be called "cavitation."

When designing the propeller of a ship, we have to check whether the propeller, at the service speed of the ship, will experience cavitation or not. The tool that we usually use to check the cavitation is the Method of Burril.

This method is also my basis for determining the developed area ratio or A_D/A_0 of the ship's propeller. Before determining the ratio we have to calculate, according to Burril method, some such cavitation parameters as, thrust coefficient, the conversion factor of resultant speed at radius blade fraction of 0.7, static pressures at shaft axis, and static and dynamic pressures at the shaft axis of the propeller.

After determining the propeller blade area ratio, We then can continue the process of designing the ship's propeller by performing the strength calculation of the propeller's blade.

In theory and in practice, the thinner the propeller the better will be its efficiency. But, the chance of it to experience cavitation will be higher. In addition, the thin blade may fail or brake due to high stress during operation. But if the blade is too thick, it will be uneconomical and inefficient.

EROSIVE EFFECT OF CAVITATION ON PROPELLER

Cavitation of marine propeller creates negative effect on the blades of a propeller. Besides reducing the thrust power, it also erodes or wears the surface of the blades. Not all of the propellers in cavitation condition experience this erosive effect.

Experts in marine propellers and ship propulsion explain that cavitation erosion is caused by the traveling of bubbles around the surface of blade aerofoil. When these bubbles collapse, they generate pressures that are harmful to the surface of the blades and at the same time these bubble turn into smaller bullets usually called microjets whose speed is very very high. When the microjets hit or travel along the surface of the propeller blades in very high pressure, they cause erosion on the blade surface. Continuous microjets impacts (or also called (bombardment) of the bubbles on the surface of the blades of the propellers is the cause of fatique failure of the blade surface that triggers the beginning of propeller erosion.

To prevent erosion of the propeller, naval architects and marine engineers perform cavitation testing of propeller which they have designed before they are manufactured. When the tested propeller model shows the phenomenon of cavitation, usually they will reanalysis the propeller to find the solution. Propeller designer might increase the blade area ratio of the propeller and adjust the pitch ratio. Another alternative is changing the RPM which will eventually effect the selection of main engine of the ship whose rpm greatly influences the RPM of the propeller. If the RPM of the engine is too high, a reduction gear can be installed. But naval architects will prefer to find another engine whose RPM is lower without reducing the specified power which has been determined previously from resistance calculation or ship resistance model test.

In recent years, the need for high speed marine vehicle is increasing. This is answered by ship designers by the introduction of catamaran. This type of twin hull ship still uses marine diesel engine as its driving power. To fully support the high speed, propeller designers work hand in hand with marine engineers and naval architects to design an integrated propulsion unit that has high propulsion efficiency with low risk of cavitation on the propellers. by Charles Roring

PROPULSION IMPROVEMENT

Fuel prices have risen considerably in the past few years, resulting in higher ship operating costs. To maintain the economic profi tability of the vessel, Wärtsilä can provide a number of solutions to save fuel. Propellers of more modern design along with grinding and repair, and modifi cation of heavy running propellers offer considerable hydrodynamic improvement and an attractive return on investments. Ducted propellers, and especially the Wärtsilä high effi ciency nozzle, can increase free running propeller effi ciency by 15%, with a payback period of 1 to 1.5 years. Fuel saving devices are categorized on percentage of effi ciency improvement:

UP TO 5% IMPROVEMENT

• Propeller polishing and/or repair of edge damage
• Propeller of more modern design

UP TO 10% IMPROVEMENT

• Propeller of more modern design with increased diameter and low speed
• Effi ciency rudder

• Propeller - engine interaction

UP TO 15% IMPROVEMENT

• Conversion of an open propeller to a ducted propeller.

UNDERWATER PROPELLER REPAIRS

Wartsila offer a full range of underwater repairs, an option that decreases the vessel's downtime and eliminates the need for dry-docking. We can perform comprehensive shop-quality propeller repairs underwater, including cold straightening of bent blades, removing damaged blade sections, calculating propeller mass balance in accordance with ISO class standards and establishing hydrodynamic edge profi les. Repairs comply with classifi cation rules and all major repairs are supervised by an experienced propeller repair specialist or under the direction of the hydrodynamic propeller design department.

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Environmental and legal aspects

There is ongoing discussion at International Marine Organisation (IMO) with regard to Marpol Annex V (Regulations for the Prevention of Pollution by Garbage from Ships). IMO has already defined the residue from hull scrubbing as ships waste and it is therefore covered by the convention. As a consequence of this, it is likely that restrictions will be introduced as to where and how ship hulls may be scrubbed. The scrubbing of hulls by divers is forbidden within many European harbours. Fouling on a hull increases a ship's drag through the water, thus increasing the amount of power required to maintain the same speed or reducing the speed of the vessel for a given power. Fundamental data on that subject can be found in reference . It is estimated that serious fouling can increase the drag on a ship by up to 40%, reducing the speed by up to 2 knots and increasing the fuel consumption by 10÷20% . For the shipping industry, this means increased costs and time delays. The extra fuel consumption also increases greenhouse gas emissions, being composed of NOx, SOx and CO2 from ships by up to 20 million tonnes per annum. Although shipping produces the least amount of greenhouse gases annually when compared to other modes of transportation, under the Kyoto agreement the EU is committed to a 5% reduction in emissions by 2012.

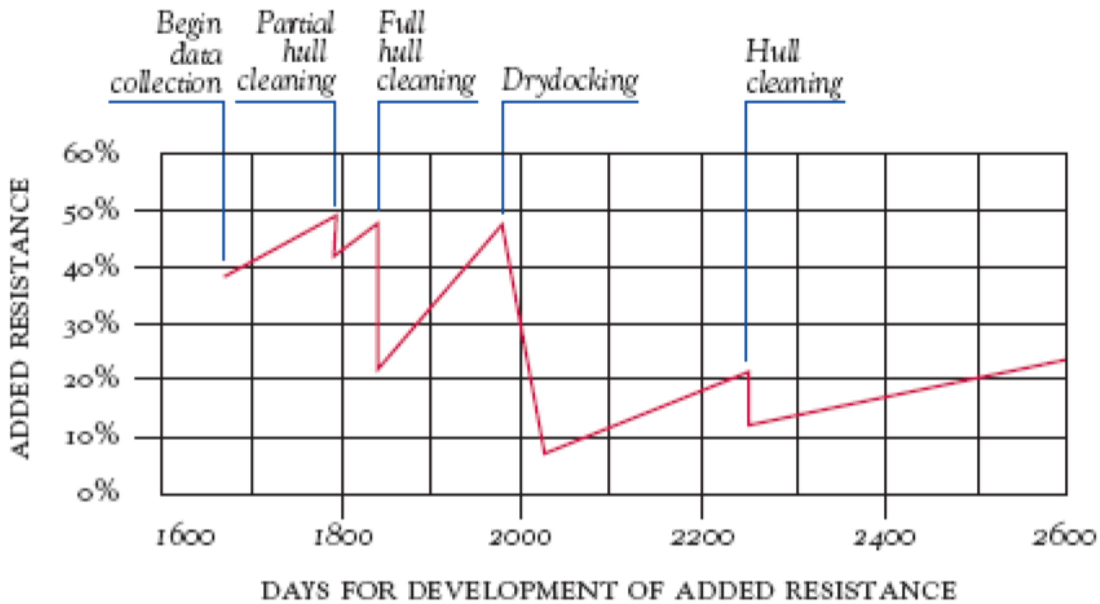
Table 1. Estimated savings due to selected measures applied to various types of ships

Ship Type	Tanker	Container	Ro-Ro	Ferry
Efficiency measures				
Hull clearing	< 3%	< 2%	< 2%	< 2%
Propeller clearing and polishing	<10%	<10%	<10%	<10%
Modern hull coatings	< 9%	< 9%	< 5%	< 3%
Propeller efficiency measurement	< 2%	< 2%	< 2%	< 2%
Constant versus variable speed operation	< 5%	< 5%	< 5%	< 5%

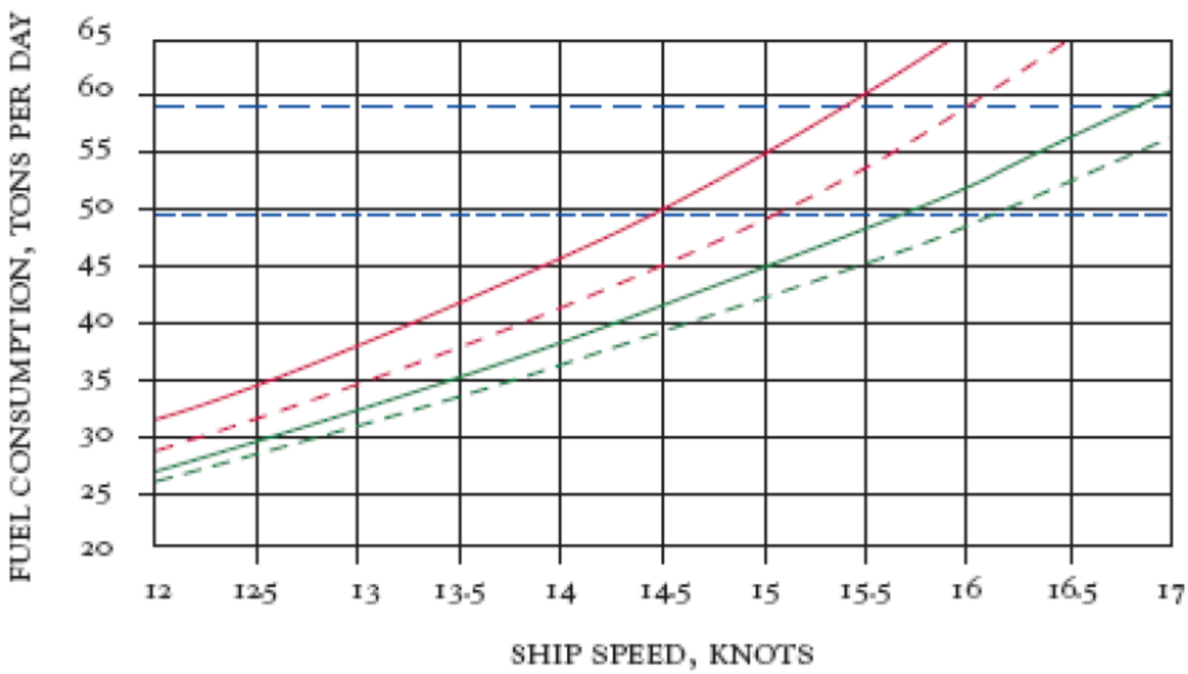
Conclusion

It is obvious, that machinery that operates for longer time and at higher power and loading is more susceptible to failures. Lower engine loading in general means lower wearing of certain components of ship drive system that could lead to longer operational life of the ship propulsion. Furthermore, it results in better reliability of the main propulsion and resulting ship safety improvement

When speaking about the increasing efficiency of the propulsor system there is a number of another opportunities like new highly efficient diesel engines, advanced propeller designs as well as promoted by some companies propeller coating techniques that prevent biofouling.



Long term development of hull and propeller resistance



– – – –	Engine max. power (MCR)	– – – –	Max engine power w/o overload, loaded condition
- - - - - -	85% MCR	———	Fuel consumption, ballasted condition
———	Fuel consumption, loaded condition	– – – –	Max engine power w/o overload, ballasted condition

Vessel performance in comparison to sea trials