An empirical investigation of hull and propeller vessel performance under the ISO standard 19030

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Abstract: *Inefficient energy utilization is intolerable amongst ship operators and regulatory authorities especially in the current era. When the condition of a ship's hull and or propeller-s degrades, in order to maintain speed, there is a need for more power thus more fuel. A byproduct of the increased fuel consumption is increased Green House Gas emissions that are strictly regulated by international authorities. In the present paper the Hull and Propeller performance will be assessed in terms of fuel consumption reserves and CO2 emissions based on the required levels environmental footprint as indicated by the ISO Standard 19030 created by the International Maritime Organization.*

1. Introduction

Degenerative energy utilization is intolerable amongst ship operators and regulatory authorities especially in the current era where fuel prices are continuously increasing, and the environmental footprint is amongst the most important aspects of regulatory authorities. Losses in the performance of a vessel due to deterioration of the propeller and or the hull sometimes are substantial, but it is proven that it is difficult or time consuming assuming all the means are available to quantify them.

Altering vessels and environmental conditions results to a large degree of variability in the performance data that making the separation of hull and propeller data a challenging task. A good example beside the propeller and hull condition, is that the performance of the ship will change when there is a change in the draft, trim, rudder activity, wind, waves, currents, water depth and other factors.

Hull and propeller performance allude to the relationship between the state of a ship's submerged hull and propeller and the power required to move the ship through water at a given speed. Estimation of changes in ship explicit hull and propeller performance after some time makes it conceivable to show the effect of hull and propeller support, fix and retrofit exercises on the general energy efficiency of the ship being referred to. The increase cost of fuel, the maintenance cost of the hull and the mounting environmental regulations make the monitoring of hull conditions an important tool for prudent ship operators, in order to decrease energy waste when it comes to hull and or propeller malfunctions has been regulated from the International Maritime organization with the creation of the ISO 19030.

In the context of the initial part of the ISO19030 it describes the basic principles that exist in order to measure the changes in the performance of the hull and the propeller. It also outlines some performance indicators for hull and propeller maintenance and repair. Further in the next part the basic method that help measure the changes in the performance of the hull and the propeller are described. Other than that, it helps calculate the indicators of performance and provides guidance on the accuracy to be expected by each performance indicator.

The last part outlines some substitute methods that result in lower accuracy but can assist the application of the standard methods. Some can give same or higher accuracy but elements which are not yet broadly used in commercial shipping may be included.

2. Resistance

The resistance of a ship at a given speed is the force required to tow the ship at that speed in smooth water, expecting no impedance from the towing ship. On the off chance that the hull has no extremities, this is known as the bare–hull or towing resistance, and albeit close to, it isn't equivalent to the drive resistance because of hull/propeller collaborations [1]. This absolute resistance is comprised of various components, which are brought about by an assortment of elements and which interface with one another in a somewhat mind-boggling design. So as to manage the inquiry all the more proficiently, it is standard to consider the all-out quiet water resistance as being comprised of four principle components [2].

(a) Frictional resistance, because of the motion of the hull through a viscous fluid.

(b) Wave making resistance, because of the vitality that must be provided persistently by the ship to the wave framework made on the free surface.

(c) Eddy resistance, because of the vitality diverted by vortexes shed from the hull or limbs. This is particularly extreme at the stern where the water might be unfit to pursue the bend and will split far from the hull, offering ascend to vortexes and partition resistance.

(d) Air obstruction experienced by the above water some part of the essential hull and the super structures due to the movement of the ship through the air

In a genuine liquid, the limit layer modifies the virtual shape and length of the body, the weight appointment at the stern is changed and its forward part is reduced. For this circumstance there is a net power on the body acting against the movement, offering rise to an obstruction which is distinctively implied as structure drag, or thick weight drag. The body moreover experiences frictional opposition and perhaps whirlpool obstruction too. The liquid rapidly in contact with the outside of the body is passed on close by the surface, and that in the adjacent locale is gotten going a comparative path as that where the body is moving. This result in a limit layer which gets gradually thicker from the bow to the stern, and in which the speed changes from that of the body at its surface to that reasonable to the potential stream design at the outside edge of the layer [3].

The power gave to the water in the limit layer by the hull is an extent of the frictional opposition. If the body is to some degree blunt at the after end the stream may seclude eventually, called the parcel point, along these lines diminishing the total load on the afterbody and adding to the opposition. This division obstruction is demonstrated by an example of twirls which is a channel of essentialness. A ship continuing forward the outside of the sea experiences most of the above kinds of opposition also as finishes a submerged body. Regardless, the closeness of the free surface incorporates a further part. The ensuing weight flow on the hull results really taking shape of a wave structure which spreads out toward the back of the ship and should be industriously recreated. This looks at to a channel of imperativeness given by the ship and is named the wave making resistance [2].

The frictional obstruction is commonly the most vital fragment of the outright ship opposition. For modestly moderate ships with high square coefficients it adds to about 85% of the full-scale obstruction, while for quick streamlined dislodging hulls it may drop to about half. These characteristics may finish up higher in time due to the extended disagreeableness of the ship surface. Froude's theory was imperative as in he had the choice to part the supreme opposition coefficient in two segments that are weakly dependent upon each other. The dependence of frictional opposition on the Re number was not known during Froude's time and he was experiencing some difficulty extrapolating his model tests to full scale. Before long, his backslide results were particular, and they were being utilized for a long time.

The wave making obstruction of a ship is related to the net power upon the ship due to the normal liquid loads following up on the hull, correspondingly as the frictional opposition is the delayed consequence of the digressive liquid powers. In case the body is going on or near the free surface this weight assortment causes waves which transmit a long way from the body and pass on with them a particular proportion of essentialness that is dispersed in the ocean. The wave making obstruction would then have the option to be in like manner depicted by the imperativeness utilized by the ship that is critical to keep up the wave structure. Theoretical affirmation of the wave making opposition requires learning of the wave structure delivered by a moving ship.

The principle real speculative undertaking towards estimating the ship wave system was a result of Lord Kelvin in the late nineteenth century. He considered a singular weight point going in a straight line over the outside of the water, passing on waves which join to outline a trademark design. This involves a course of action of transverse waves following behind the point, together with a movement of one of a kind waves transmitting from the point, the whole example being dominatingly contained inside two straight lines starting from the weight point and making edges of around 19 degrees on each side of the line of movement. The Kelvin wave example speaks to and explains tremendous quantities of the features of the ship wave structure. The whole wave example moves with the ship, and for an onlooker on the ship the waves appear, apparently, to be stationary. In spite of the way that at first it may give the idea that replacing the ship by a singular weight point is unnecessarily unraveled, it should be borne as a top need this is a far field surmise significant a long way from the body where the geometric qualities of the hull are not self-evident. Kelvin had the alternative to meet up at his model using a general procedure in asymptotic examination, called the method for stationary stage, which he developed unquestionably for the wave obstruction issue. The system allows the unpleasant appraisal of explicit integrals of rapidly influencing limits and it produces two wave frameworks [2].

If frictional drag was the main segment of concern, the pontoons would be exceptionally short to keep the surface territory contacting the water (the wetted surface) to a base. On the off chance that wave-production drag was the main drag, the vessels would be exceptionally long to keep them thin and the waves they produce little. The reality is in the middle of these two, yet streamlining the length requires a somewhat definite information of the estimation of each kind of resistance. A correlation of various producer's items in your boat storage can indicate varieties of a meter or more long, all intended for a similar class and weight of rower. Various hypotheses and fluctuating background levels have prompted various ends.

2.1 Hull resistance

A ship's calm water resistance is especially impacted by its speed, displacement, and structure of the vessel. The absolute opposition RT comprises of many source-protections R, which can be partitioned into three principle types, frictional resistance (RF), Residual resistance (RR) and air resistance (AR) [2].The impact of frictional opposition relies upon the wetted surface of the body, while the size of lingering obstruction depicts the vitality lost by the ship setting up waves, whirlpools and by the gooey weight obstruction, which all rely upon the structure lines. For moderate moving boats, for example, tankers and bulkers, the frictional friction and resistance is frequently of the best impact (70-90%) though for quick going boats, for example, panamax compartment transporters, the frictional obstruction may represent as meager as half of the joined obstruction [4]. Air resistance ordinarily speaks to about 2% of the absolute opposition, be that as it may, with a noteworthy increment up to approx. 10% for boats with huge superstructures, for example, holder ships with compartments stacked on deck. On the off chance that breeze opposition is considered; the figures may increment.

Thusly, if water is all things considered ceased by a body, the water will react outwardly of the body with the dynamic weight, realizing a dynamic power on the body. This relationship is used as a reason when figuring or evaluating the source-assurances R of a ship's structure, by techniques for dimensionless resistance coefficients C. As such, C is related to the reference control K, portrayed as the power that the dynamic load of water with the ship's speed V applies on a surface which is comparable to the structure's wetted region AS. Eventually, the induced tally of a particular ship's resistance, which is required for the hidden dimensioning, is normally affirmed and streamlined by testing a model of the ship in a towing tank (Kusuma et al., 2018). In research issues worried about the partition of obstruction into its segments, techniques for extrapolation to the ship, model–ship connection remittance and so forth, the all-out opposition coefficient $C_T = \dfrac{R_T}{0.5\rho S V^2}$ s generally utilized, plotted to a base of the logarithm of Reynolds number Rn = V L/ν. Bends of this sort have been utilized in before areas. In any predictable arrangement of units, both CT and Rn are dimensionless [2].

3. *Propeller factors*

The operating conditions of a propeller according to the propeller law are described for free sailing in calm weather. The influence of the propeller size and speed is considered along with different philosophies for optimizing hull and propeller interactions [4].

Propeller configuration is the specialty of orchestrating multi-disciplinary prerequisites and restrictions into a strong last item that proficiently meets the requirements of a ship. It is an iterative strategy that can by and large be partitioned into three collaborating stages: I) the issue portrayal, ii) the starter plan and iii) the structure investigation and improvement stages [1]. In like manner building structure issues, there is a fourth stage where the plan is assessed, generally with a model. Be that as it may, this is occasionally conceivable in propeller propulsion situation, because of the uniqueness of the planned propeller and on the grounds that the assessment happens utilizing full-scale ocean preliminary tests with the last item. This way, propeller configuration requires specific consideration in the structure examination and improvement stage. Mechanized enhancement methodologies can bolster the creator in discovering better plans quicker [5].

Early endeavors to clarify the instrument which is utilized by the propeller to drive the ship centered around the force hypothesis. In this the propeller is viewed as a "circle" fit for granting an expansion of weight or speeding up to the liquid going through it, the instrument by which it does as such being out of sight. Energy hypotheses depend on right essential standards, however, give no sign of the propeller structure which would create the required push. Later advancement pursues the course hypothesis. In its most direct structure, this yields the bleeding edge segment theory of propeller movement, where the propeller is seen as made up of different separate edges, which therefore can be detached into dynamic strips over the edges, from provoking trailing edge [6]. The powers following up on each strip can be surveyed from a data of the general speed of the strip to the water and the geometry of the section shape. The simple powers are then sunk into the parts of push dT the forward way, and of torque dQ in the plane of propeller turn. By plotting bends of dT and dQ along the edge from supervisor to tip, bends of push and torque stacking are acquired which when incorporated will give the all-out push T and torque Q all in all propeller. The propeller efficiency is then characterized by

$$\eta_0 = \frac{TV_A}{2\pi n Q}$$

The states of cutting-edge frameworks and areas differ fundamentally as indicated by the sort of ship for which the propeller is expected. On the off chance that we consider a segment of the propeller cutting edge at a range r with a pitch edge φ and pitch P, and envisioning the sharp edge to work in a relentless medium, at that point in one upset of the propeller it will progress from A to A , a separation called the pitch, P. On the off chance that we unroll the chamber of span r into a level surface, the helix followed out by A will form into a straight-line AM, and the edge

$$\tan \phi = \frac{P}{2\pi r}$$

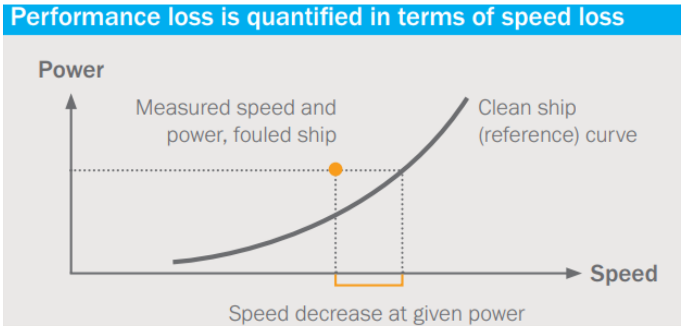
is the pitch point. In the event that the screw is turning at n cycles per unit time, at that point in that time it will propel a separation P n and we can get a velocity outline for the area [5].

As on account of resistance, a lot of learning concerning the presentation of propellers can be picked up from examinations on models and it is significant in this way to analyze the connection among model and full-scale results. Dimensional examination can be utilized to set up this connection and in what pursues an articulation will be gotten for the push delivered by a propeller. The push of the propeller, T, could rely on: Mass density of water, ρ.Propeller size, represented by the diameter, D. Speed of advance, VA. Acceleration due to gravity, g. Speed of rotation, n. Pressure in the field, p. Viscosity of the water, μ.

4. *ISO 19030*

Today hull and propeller performance is a ship efficiency killer. According to the Clean Shipping Coalition in MEPC 63-4-8, poor hull and propeller performance accounts for around 1/10 of world fleet energy cost and GHG emissions. This points to a considerable improvement potential; 1/10 of world fleet energy costs and GHG emissions translates into billions of dollars in extra cost per year and around a 0.3% increase in man-made GHG emissions. The culprits are a combination biofouling and mechanical damages. Most vessels leave the new build yard or subsequent dry-docking with their hull and propeller in a good condition. Then on account of a combination of biofouling and mechanical damage, hull and propeller performance begin to deteriorate.

ISO 19030 has been created to be generally satisfactory by Shipbuilders, ship proprietors, motor producers, covering organizations, grouping social orders, the IMO and so forth. It empowers ship proprietors and operators to contrast hull and propeller arrangements and straightforward and straightforward information, that they can choose the most effective alternatives for their vessels. Estimating the amount pretty much power is required to move the ship through water at a given speed [7].



The standard is sorted out into three sections:

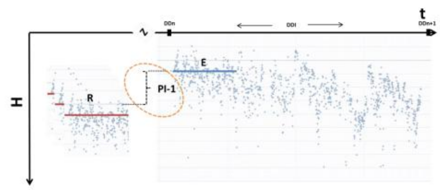
ISO 19030-1 frameworks general standards for how to gauge changes in hull and propeller performance and characterizes the 4 performance pointers for hull and propeller maintenance, fix and retrofit exercises.

ISO 19030-2 characterizes the default technique for estimating changes in hull and propeller performance. It likewise gives direction on the normal precision of every performance pointer.

ISO 19030-3 plots options in contrast to the default strategy. Some will result in lower generally precision however increment appropriateness of the standard. Others may result in same or higher in general precision however incorporate components which are not completely approved in business shipping.

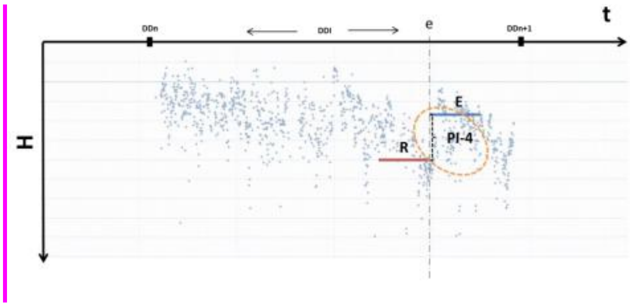
4.1 Performance indicators

Change in hull and propeller execution following present out-docking as contrasted and the normal from past out-dockings The adjustment in hull and propeller execution following present out-docking as contrasted and the normal from past out-dockings (where information/estimations are accessible) is valuable for deciding the viability of the dry-docking.



where:

H	Hull and propeller performance
t	Time
DDn	Present dry-docking
DDn+1	Next dry-docking
DDI	Dry-docking interval
R	Reference period: average hull and propeller performance following previous out-dockings
E	Evaluation period: hull and propeller performance following present out-docking
PI-1	Performance Indicator 1: Dry-docking performance



The normal change in hull and propeller performance over the period following out-docking as far as possible of the dry-docking interim The normal change in estimated hull and propeller performance over the period from the out-docking as far as possible of the dry docking interim can be utilized to decide the adequacy of the underwater hull and propeller arrangements including hull coatings utilized and any upkeep exercises that have happened through the span of the dry-docking interim [8].

Change in hull and propeller performance from the beginning of the drydocking interim to a moving normal at any picked time The deliberate change in hull and propeller performance from the beginning of the dry-docking interim to a moving normal at a picked time during a similar interim can be utilized as a trigger for underwater hull and propeller upkeep, including propeller or potentially hull cleaning [8]. The change in hull and propeller performance estimated when a support occasion can be utilized to decide the viability of a particular upkeep movement that has occurred in the interim between the estimations, including any propeller and additionally hull cleaning.

5. Environmental footprint

Today hull and propeller performance is a ship efficiency killer. As per the Clean Shipping Coalition in MEPC 63-4-8, poor hull and propeller performance represents around 1/10 of world armada vitality cost and GHG discharges. This focuses to an impressive improvement potential; 1/10 of world armada vitality expenses and GHG emanations converts into billions of dollars in additional expense every year and around a 0.3% expansion in man-made GHG discharges. The guilty parties are a mix of biofouling and mechanical harms. Most vessels leave the new form yard or consequent dry-docking with their hull and propeller in a decent condition. At that point by virtue of a blend of biofouling and mechanical harm, hull and propeller performance start to decay.

The contrast between market normal and best performance is around 18% in the power required to keep up a similar speed in the course of recent long periods of the dry-docking interim. On a 54k dwt mass transporter as an example, at a dugout cost of $350 per ton, this distinction would convert into a $1.8 million contrast in fuel cost and a 16,000-ton distinction in CO2 outflows.

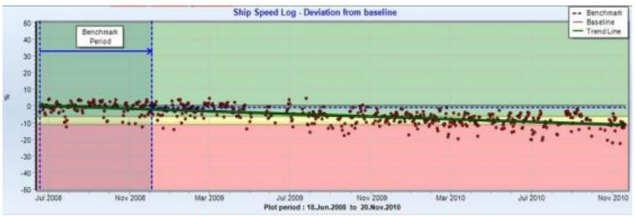


Fig. 10: Speed loss due to deteriorated hull condition

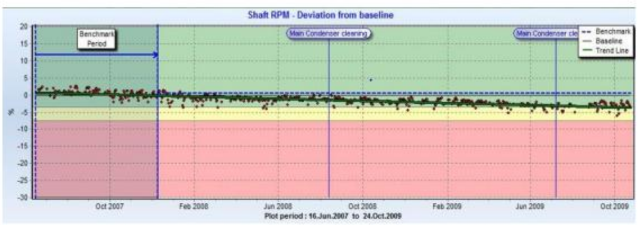


Fig. 12: The propeller is getting 'heavy', indicating a need for a propeller cleaning

6. Conclusions

In the current market where low freight prices are squeezing the margins to its minimum, it is safe assuming that all ship-owners would aim to run their fleet as optimum as possible in terms of fuel efficiency. While operating a ship, the hull's anti-fouling system is less efficient. Marine fouling on the hull increases the frictional resistance and the surface of the propeller can be rough and fouled, making the propeller less efficient. The resistance, caused by fouling, can increase significantly throughout a docking interval, with a typical loss in speed of 2-4 % per year. Increased focus on environmental regulations and smaller profit margins at the shipping industry make fleet performance and efficiency key topics within the maritime world. For this, a Ship Performance Monitoring (SPM) software with continuous monitoring can be of valuable assistance to the ship crew and the owner.

The concept and requirement for this system is to measure key parameters onboard, perform processing on these data, and present the results in an easy and intuitive way for the onboard crew and onshore personnel. Based on this continuous monitoring, corrective actions can be planned and performed accordingly, one challenge in this respect is to present a vessels performance status or rather degraded performance correct and adequate, in order to decide when maintenance/repairs are appropriate. An example could be indication of high fuel oil consumption on the main engine. The C/E have to interpret and evaluate this fuel flow and find out if this measurement is correct. The root cause for an overconsumption could of course be a reduced performance of the vessel. However, a sensor malfunction, wrong or missing manual recordings, adverse weather, or other external factors can also cause it. Therefore, automatic data collection, filtering, repeatability and transparency in a performance monitoring system are critical elements for the credibility of the SPM system. The combination of displaying instant performance values together with investigating the long trend of important key performance values are keeping the crew and the management continuously updated on a vessel's performance.

7. References

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