"ANALYSIS OF THE CRUISING SPEED OF A MERCHANT SHIP USING SPECIALIZED SOFTWARE"

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SUMMARY

The increasing globalization, characterized by an ever-increasing trade between all nations based on the development of the maritime transport operates in a very competitive market and at the global level, still conditioned by the evolution of the international economy, and the volume of world trade and the cycles of the shipbuilding industry. The indicators of effective demand usually used and of the available statistics, are the tons per mile transported from three types of goods: liquid bulks, among which the most important traffic is the one corresponding to the oil and its derivatives; solid bulk in which we can highlight the iron ore, coal and grain; and other goods which include ocean container, ro-ro, another general cargo, cars, etc. has been past the port to port to door-to-door through the development of logistics and intermodality. With fast, competitive freight rates, frequency, documentation simplified, security by preventing loss and theft, have changed our way of life and the world has grown smaller.

Currently, the computer science has shown that it can give value added to goods and services in an organization, because it enables you to transform or improve the coordination of activities related to the process of generation of these.

This project consists in the need to develop a design of a control system to analyze the cruise speed of a merchant vessel, driven by a conventional propulsion or non-conventional, depending on the automation of a specialized software that meets the technical requirements and operational security policy for these vessels.

To do this, it will be necessary carry out:

- The estimation of the parameters.
- The modeling of the system will be based on these parameters.
- The control system design and its suitability for their subsequent automation with the software.

In this way seeks to improve the efficiency of marine transport of merchant vessels and thereby reduce costs and the fuel oil for the carrier.

Key Words: Automation with software, cruise speed, merchant vessel.

INTRODUCTION

The automatic control systems have played and do play a very important role within and outside the industry. You can find examples of this already in the third century before Christ, in ancient Greece, with the design of the water clock, also known as Clepsydra, by Ktesibios. The first use of the automatic control in the industry seems to have been the centrifugal governor of Watt's steam engine, in 1775, thanks to the mathematical explanation of the centrifugal governor by James Clerk Maxwell. Today, the automation of systems is one of the areas of study more interesting and complete for the student of naval engineering, both by the complexity that in itself represents the automation, such as the wide range of fields of knowledge that have been parallel to dominate in shaping the system (mechanical, theory of fluids, heat transfer… etc. , depending on the type of system), designing the actuator which will act on the floor of the system (power electronics, operation of electrical machines), or to design the conditioning circuit measure of signals (analog electronics, electronic instrumentation). In addition, are very large applications that has the control of systems by using a software (Hullspeed), by which this project takes great educational value in the face of the incorporation of the student into the labor market. It was considered quite interesting from the beginning that the software (Hullspeed) of automation would be applied to a merchant vessel. In this way you can observe the effects of various speeds from simulations of the computer. In addition, the maritime transport sector is a field of work quite attractive, and presumably will win a lot more accepted in the future compared to other means of transport (plane, car).

GENERAL OBJECTIVE

Analysis of the cruise speed of a merchant vessel through a software (Hull Speed).

Additionally, it stands out as it can be used to make database queries, facilitating and saving time in the point of application.

SPECIFIC TARGET

Demonstrate the feasibility of implementing the software.

Improve the efficiency and effectiveness of the speed of the ship.

Allow the participants in the project, that the systems become more flexible, and understandable, to facilitate testing through the detection of errors.

HYPOTHESIS

An analysis of the cruise that is processed using a methodology that handle properly the data, allows you to view most critical failures and allows you to associate causes, effects and failures of the ship to have a more rapid diagnosis and complete.

THEORETICAL ARGUMENT.

MERCHANT SHIP:

A ship is any floating structure designed for the transport of persons and/or loads or for the execution of special tasks. Are synonymous with "ship", the expressions "boat", "craft" and "nave".

The vessel is an integrated system, complex that combines several subsystems, must float, has a commercial purpose, self-reliant energy, move, and govern themselves in the sea. It may be one of the most complex engineering systems that exist.

The vessel from the legal aspect is as a physical person, has a name that distinguishes it, a homeland, is an extension of the national territory, a home, a number of identity and although it is considered a movable thing it may be attached as well mortgage property.

CRUISING SPEED:

The vessels are typically designed to obtain, in conditions of maximum load and in the cruise stage, a speed called "speed of service" using a power between 85 and 90 per cent of the installed propulsion power.

The reason not to use normally maximum propulsion power is because to the reduce in a high percentage maintenance costs of the travel motor and extends the life of this.

When the ship sails in ballast cannot use more than a part of the motive power.

For the same speed, it is estimated that the power in ballast represents a 90 per cent of the power that uses with a 75 per cent of the load.

In conditions of poor sea, or strong wind the resistance to forward motion of the ship increases, and in addition must reduce speed to not suffer damage.

The condition of the hull, in particular the inlay, can increase the resistance up to 15 % in modern ships and up to 50 % in older vessels.
In an empirical manner, you get the following average values for the cruising speed, by type of vessel:

Speeds at cruising speed:
• Tanks: 26, 7 km/h
• Bulkcarriers: 26, 2 km/h
• Container: 36.4 km/h
• General Cargo: 25.6 km/h
• RORO/ferry/Load: 26.2 km/h
• Passengers: 37.8 km/h

The information was obtained from the following documents: "Quantification of emissions from ships associated with ship movements between ports in the European Community" developed by ENTEC UK Limited; and "emission inventory guidebook Shipping activities" developed by National Environmental Protection Agency, Italy (EINNDHOVEN).

RESISTANCE TO FORWARD MOTION OF THE SHIP

Among the many problems that face the naval engineering in the design of a new ship is the need to ensure that within another design requirement of hull shape, the travel arrangements are the most efficient in the sense.

The ultimate test is that the ship will carry out the required speed with the minimum of horsepower, and the problems that to achieve the best combination of low resistance and high-efficiency propulsion.

TYPE OF RESISTANCE

The resistance of a vessel to a particular.

If the helmet does not have appendix this is called (bare hull resistance) the power needed to eliminate this resistance is called horsepower and cash is given:

$$\boldsymbol{EHPO\ (PE) = \frac{RT \cdot V}{323}}$$

RT: total resistance.
EHP: EP: effective power.
V: speed.

RESISTENCE BY FRICTION

It is because to the movement of the helmet through a viscous fluid, one has only to below the deck of a ship at sea and observe the movement that has been swirly in the water close to the hull, which increases in the degree of the wave (of the reverence he said), in order to understand that energy is being absorbed in resistance by friction experiments have shown that in a boat smooth new these represents 80% and 85% of the total resistance in the low speed boat.

$$Rf = KF * Sm * V^{1,825}$$

RF: it is approximately 0.3.
According to Reynolds.
Kf: friction coefficient by Froude.
SM: wet surface.V: speed.

RESISTANCE BY WAVES OR BY FORMATION OF WAVES

It is because to the hydrodynamic effect of the waves when they contact with the hull. The resistance by the formation of waves is a function of the speed, length and shape of the careening that when colliding the vessel with the calm waters form a series of waves to divergent bow and stern.

$$Ro = Ko \frac{(\Delta^{\frac{2}{3}} * V^4)}{L}$$

Ro: resistance of swell.
For coefficient understood ship small coefficients of blocks (Cb9 is 0.05 and to large Cb 0.09 . Ko.
Δ: Displacement.
V: speed.
L: length.

RESISTANCE DIRECTLY OR BY FORMATION OF EDDIES

It is because to the energy thrown by the whirlwinds developed by the hull and the appendices.

$$Rd = 8\% * Rf$$

BY AIR RESISTANCE

Occurs above the waterline the main part of the hull and superstructure because to the movement of the ship through the air.

$$Ra = Ka * Sp\ (V + Va * \cos\infty)$$

Ra: resistance by opposition from the wind.
Ka: coefficient depends on the aerodynamic shape and its value is between 0.025 and 0.05 .
SP: summation of the areas of the dead work projected and superstructure.
V: speed.
Va: wind speed.
COS ∞: Angle formed by the wind direction and the radial plane of the ship, we use the angle of Kelvin are you going to do equal to 0.

RESISTANCE BY THE EFFECT OF THE APPENDICES AND CLEANLINESS OF THE TOWN

The effects of the appendices are of two types.

According to Bonilla 1979 on the one hand increases the wet surface and on the other hand if the forms of the careening are not corectiformes, which increases the resistance by whirlpools. Both effects can reach up to 20% of the frictional resistance.

$$Ral = 20\% * Rf$$

Ra: resistance of the appendices.
RF: resistance by friction.

TRAILER RESISTANCE

Once you have obtained all the resistance is the sum of all the resistors.

$$Rt = Ro + Rd + Rf + Ral$$

RESISTANCE TO THE PROPULSION

It is approximately 20% of trailer resistance.

$$Rp = 20\% * Rt$$

Rp: travel resistance.
Rt: resistance to the trailer.

TOTAL RESISTANCE IN CALM WATERS

$$RT = Rt + Ra + Rp$$

Example: calculating the total resistance to progress.

Data:
E= 25m.
CB= 0,414 .
M= 4.9m.
V= 50 knots.
Cm= 0.9m.

$$50\ nudos * 0.5144 = 25.72\ {}^{m}/_{s}$$

1) It is estimated the Froude number of

$$Fr\ \nabla = \frac{V}{\sqrt{g * L}} = \frac{25.72\ {}^{m}/_{s}}{\sqrt{9}.81\ {}^{m}/_{s^2}} = 1.64$$

2) Calculation of the frictional resistance

$$Rf = Kf * Sm * V^{1.825}$$

$$Sm = L * 1.5 * Cm + (0.09 + Cb) + M$$

$$Sm = 25m * 1.5 * 0.9m + (0.09 + 0.414) + 4.9$$

$$Sm = 39.15\ m^2$$

$$Rf = 0.3 * 39.15 * 25.72^{1.825} = 4401.46\ Kg$$

3) Calculation of the resistance by the formation of waves

$$Ro = Ko\ \frac{\left(\Delta^{\frac{2}{3}} * V^4\right)}{L} = 0.05\ \frac{\left(67000^{2/3} * 25.72^4\right)}{25} = 1443766.812\ kg$$

4) The calculation of direct resistance

$$Rd = 8\% * Rf = 8\% * 4401.46\ Kg = 352.11\ Kg$$

5) Calculation of resistance because to the effects of appendix

$$Ral = 20\% * Rf = 20\% * 4401.46\ Kg = 880.292\ Kg$$

6) Calculation of the resistance to the trailer

$$Rt = Ro + Rd + Rf + Ral = 1443766.812\ kg + 352.11\ Kg + 4401.46\ Kg + 880.292\ Kg = 1449400.674\ Kg$$

7) Calculation of the resistance by air

$$Ra = Ka * Sp\ (V + Va * \cos \infty) = 0.025 * 12.3\ (25.72 + 25.72 * \cos 0\ )^2 = 813.66\ Kg$$

8) Compute travel resistance

$$Rp = 20\% * Rt = 20\% * 1449400.674\ Kg = 289880.13\ Kg$$

9) Calculation of the total resistance

$$RT = Rt + Ra + Rp = 1449400.674\ Kg + 813.66\ Kg + 289880.13\ Kg = 1740094.464\ Kg$$

POWER

A. Sirverleaf Method and J. Dawson

Validity of the method

L/B	Between 6.4 and 7.7
L/T	Between 15 and 19.
CB	Between 0.50 and 0.85 .
L	Between 120 m and 360 m.
V	Less than 30 knots.

Power input. Less than 100000 HP.

Revolutions of the propeller: Between 85 and 185 rpm ships in a line of axles.

Formulas

Speed limit:

$$V_B = (1.7 - 1.4 * C_B)\sqrt{\frac{L}{0.3048}}$$

Performance of the open-water propeller

$\eta_0 = 1.30 - 0.55 \times CB - 0.00267 \times N$

N = revolutions of the propeller, in rpm.

Performance of the careening

For CB < 0.80

$H = 0.385 + 0.7 \times CB + 0.11\frac{B}{T}$

For CB ≥0.80 speed

$n_H = 0.945 + 0.11\frac{B}{T} + 20 * (C_B - 0.80) * (1.54 - (0{,}945 + 0.11))\frac{B}{T}$

Relative Performance rotary

$$n_R = 1.01$$

Performance cuasipropulsivo

$$\eta D = \eta 0 \times \eta H \times \eta R$$

Prediction Factor of evidence

For L/0.3048 , implying > 1000

$$CHI = 0.850$$

For L/0.3048 , implying ≤1000

Type of vessel	Fn ma	CP		L/B		B/T	
		Min	Max	Min	Max	Min	Max
Oil tankers, bulkcarriers	0.24	0.73	0.85	5.1	7.1	2.4	3.2
Trawlers, coastal, tugboats	0.38	0.55	0.65	3.9	6.3	2.1	3.0
Containerships	0.45	0.55	0.67	6.0	9.5	3.0	4.0
Freighters	0.30	0.56	0.75	5.3	8.0	2.4	4.0
Roll-on roll-off ferries	0.35	0.55	0.67	5.3	8.0	3.2	4.0

$$CHI = 0.85 + 0.00185(\frac{1000 - l * 3.28}{100})^{2.5}$$

Power input to the speed limit. Test Conditions

$$DHP_B = \left(\frac{75}{76}\right) * \left(\frac{1}{427.1}\right) * CHI * 0.71 * (L * B * T * C_B * 1.0137)^{\frac{2}{3}} * \frac{V^3{}_B}{n_D}$$

Power input at the speed V. testing conditions

$$DHP = DHP_B * PPB$$

Being:

$$PPB = (\frac{V}{V_B})^{4.167*(V/V_B)}$$

Brake Horsepower at the speed V. conditions of service

$$BHP = DHP * \frac{S}{n_M}$$

Being:
S = service factor.
$n_M = \text{Rendimiento mecánico}$

Method and Harvald Guldhamer

Range of application:

0.15 < Fn < 0.45
0.50 < Cp < 0.80
4.0 < Lpp/∇1/3 < 8.0
- 3.0 < XB < 3.0

Holtrop Method and Mennen

Range of application:

Includes formulas for the determination of the propulsive coefficients.

Method of Van Oortmersen

Method of the channel of Wageningen for small ships. Range of application:

Fn < 0.50
0.50 < CP < 0.73

0.70 < 0.97 < CM
3.0 < Lpp/B < 6.2
1.9 < B/T < 4.0
8.0 < Lpp < 80.0
5.0 <∇< 3000.0
- 7.0 < XB < 2.8

Includes formulas for the determination of the propulsive coefficients.

Method of Amadeo Garcia

This method can be used for the prediction of the resistance to the advance of fishing with conventional forms of bow or endowed with bulb. The application range is determined by the following limits.

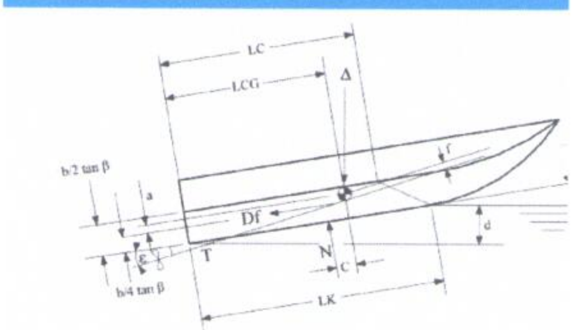
25 ≤LPP ≤60
0.25 ≤Fn ≤ 0.40
0,095 ≤CB≤B/LPP≤60

Method of Daoust

For fishing method, is based on the studies of the FAO.

Method of Mercier-Savitsky

Figura 1.Variables de tipo geométrico en el método de Savits



This method is valid for estimating the resistance to the forward movement of vessels, even when they are in the area of contact. The forms of round bilge are more in line with a method that the toggle pronounced.
The application range is
determined by the following limits.

1.0 ≤ Fn ≤2.0

Method of Ping-Zhong

This treatment method to improve the results of the work of Mercier - Savitsky, making it more applicable to forms of rounded bilge.
The limits of variation of these variables are the following:

1.5 < CV < 11.0
0,573 < CP < 0,764
0.00 < 0.74 < FT
0.00 < F < 6.40
7.60 < IE < 26.6

Estimate of the power to install

Estimate is the power to install so that the ship of a certain speed (speed of contract).
If at that speed the effective power is EHP, the power to install will be given by the following expression:

$$BHP = \frac{EHP}{n_M * n_D}$$

Normally the diesel engines operating point of the propellant is a fixed percentage of the installed power (between 85 and 90 per cent) to 100 % of the rated speed. If we call KP in this ratio we will need a power:

$$BHP = \frac{EHP}{n_M * n_D * K_P}$$

Displacement (Tm.)	Revolutions (rpm)
Less than 1000	500
From 1000 to 2000	400
From 2000 to 3000	300
From 3000 to 5000	200
From 5000 to 7500	150
From 7500 to 12000	125
Of 12500 to 25000	115
Of 25000 to 50000	110
More than 50000	100

In the above point, we have seen how to estimate □M. The value of KP we can consider that varies between 0.85 to ships slow and filled with a large percentage of viscous resistance of type and 0.9 for fine and fast vessels in which predominates the resistance by the formation of waves.

For the estimation of the performance quasi-propulsive there are many expressions, some of which, for vessels of a propeller, outlined below.

Lap Formula

Formula of Parga

$$n_D = 0.84 - \frac{N\sqrt{L_{pp}}}{18000} + \frac{(\frac{V}{C_B})^2}{24000}$$

N=revolutions per minute the propellant.

Lpp=length between perpendiculars, in feet.

V=speed in knots.

Formula of the channel of the Pardo

$$n_D = 0.973 - 0.000187N\sqrt{L_{pp}} + 0.023\frac{B}{T} - 0.2C_B + 0.00013 * N * C_B$$

N = revolutions per minute of the propeller.

Dimensions, in m.

When we don't know the revolutions of the propeller, in a first approximation, we estimated in accordance with the following table:

In estimating the performance quasi-propulsive we are estimating:

$$\eta D = \eta 0 \times \eta H \times \eta R$$

ηH, Performance of the careening and ηR, performance rotary-relative, can be estimated with sufficient approximation with statistical formulas, while $\eta = 0$, Performance of the propellant isolated, depends on the characteristics of the propellant (diameter, H/D, AE/A0, Z) and the operating point of the same and do not know with accuracy until we have selected the propellant.

At this point, the known performance of the propellant isolated, we will calculate the performance again propulsive:

$$\eta P = \eta M \times \eta 0 \times \eta H \times \eta R$$

It may be necessary a review of power needs to be installed.

Correction by conditions of service

To take into account the conditions of service, increases the total resistance in a percentage, depending on the route followed by the ship:

North Atlantic route, toward the East, 15-20 per cent in summer and winter, respectively.

North Atlantic route, toward the West, 20-30 per cent in summer and winter, respectively.

The Pacific route, 15-30 %.

Path of the South Atlantic and Australia, 12-18 %.

Path in East Asia, 15-20 %.

Estimate of the performance of the propellant

At this stage, in which we are interested in mainly estimate the performance of the propellant isolated, are used to some of the ongoing series of existing thrusters, choosing the most appropriate for the particular case. The most frequently used are:

Series B of Wageningen.
Series of Kaplan.
Series of Gawn.

In the reference1 indicates how you can estimate the performance of the propellant isolated using the theory of the pulse.
The variables that are used for the project are two, chosen from among the four following alternatives:

Revolutions of the propeller, n, and speed, V. revolutions of the propeller, n, and diameter of the propeller. Installed Power, BHP, and speed, V.
Installed Power, BHP, and diameter of the propeller.

Selection of the number of lines of axs

The most economical solution coincides with the number, at least lines of axs. This is the solution most frequent and is not commonly used with another solution when they are not you can meet the project goals.
The number of lines of axs is determined by two basic constraints (in addition to improving the maneuverability or the maintenance of the operability in case of failure of one of the propulsion units):

The minimum depth of operation of the ship.
The needs of power and motors available.

The minimum depth determines the maximum diameter of the propeller. The diameter affects the absorption capacity of power, so that should be installed two lines of spindles work with drafts low.

The other condition is closely related to the previous and deducted from the power to install and marine engines available.

Estimate of the diameter of the propeller

It is a good idea to make a preliminary estimate of the diameter of the propeller, to analyze the immersion in the situations of ballast, and check the gaps Between the same and the hull of a ship, that have a large impact on very important issues, such as cavitation and vibration excited in the hull. In a principle we can use the following formula:

$$D = \frac{15.75 * MCO^{0.2}}{N^{0.6}}$$

D = diameter of the propeller, in meters
MCO = Maximum continuous power, (HP)
N = revolutions per minute of the propeller

FROUDE NUMBER OF

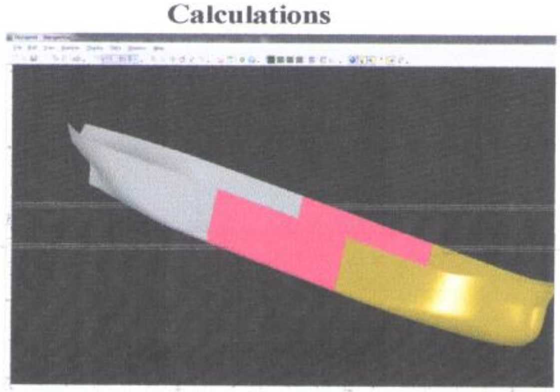
It is considered a boat as planner when the hydrodynamic thrust is much greater compared to the hydro. As you increase the speed also are increasing the hydrodynamic forces. This phenomenon can be expressed in terms of the Froude number of as follows:

- If $Fn < 0.25$ the hydrodynamic forces are completely worthless compared to the displacement of the boat, so that the formascon round up and downwind, or up and downwind of mirror submerged are not the most appropriate.
- If $0.25 < Fn < 0.6$ the hydrodynamic forces acting down, causing a collapse in the boat and a certain angle of trim.
- If $Fn \approx 0.5$ is obtained with a lower resistance up and downwind of mirror submerged (with the boat static) already in

progress that are beeginning to be clean and with a free flow, although still better rounded hull forms.

- If Fn ≈ 0.6, the center of gravity is at its lowest position and the coefficient of resistance is at its maximum.
- If Fn ≈ 0.8 the center of gravity returns to its static level. The trim of the boat is at its maximum. The hydrodynamic forces begin to be positive.
- If Fn ≈ 1 for lower resistance already beginning to be used flat shapes with sharp edges. Hydrodynamic forces are already major (about 50 % of the displacement of the boat).
- If Fn ≈ 3 the hydrodynamic forces are in the order of 90 % of the displacement. There is a optimal seat angle that minimizes the resistance to forward motion. This angle is decreasing as we increase the speed. Sometimes use different solutions (such as spray rails, flaps or staggered helmets) to achieve this optimal seat angle.

Calculations



CONCLUSIONS

- The method used, it has been valid getting a percentage of overall difference not greater than 9% compared with the channel of tests, which for this stage of preliminary study is a good approximation to decide between the options calculated, although for a trade study differences should not be greater than 5 %, and you should choose depending on the computing resources that are counted and time to be used in these tests.
- With a better definition of the hull and largest concentration of volumetric elements around the helmet throwing results with the least difference local and global, which have been improved.
- The comparison between turbulence models that took place in the first case tested revealed that the best option for the quality of results and the less time spent in the calculation because it required a minor number of iterations in the convergence.

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