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ESTIMATION OF BARE HULL RESISTANCE OF A ROPAX VESSEL USING THE ITTC-57 METHOD AND GERTLER SERIES DATA CHART

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ABSTRACT

Bare hull resistance estimation is critical in the initial design and subsequent analysis of a vessel's total resistance. Using the ITTC-57 method and Gertler Series Data Chart, this study therefore, predicts the bare hull resistance of *BRODOSPLIT* ROPAX Vessel with a dead-weight of 9,000 tonnes, 3560 lanes in meters (LIMs) and 400-passengers carrying capacity. The research considers a case study of the Gulf of Guinea which is the intended region of vessel's operational route. The region under review has dry season (November-April) and wet season (May-October) with sea surface temperature of 31.5^{0}C and 26^{0}C respectively. Analysis was done in the Matlab R2015A environment to simulate the bare hull resistance at varying speed in relation to the wetted surface area. Results show that for vessels of similar hydrodynamic particulars, and at average and economic speed range of 24 Knots, the bare hull resistance was estimated to be 2495.6 KN and 2518.3KN for Dry and Wet season respectively. Further analysis for the effective power required shows that an estimated 30,820kW is required by the vessel when running at the design economic speed of 24 knots in dry season and with an effective power increment of about 0.99% in wet season.

KEYWORDS: Bare Hull, Resistance, ROPAX, and Gulf of Guinea.

1. INTRODUCTION

The ability of a vessel to maintain its smooth operations through-life depends largely on accurate analysis of its hydrodynamic characteristics especially its resisting factors. Hull based resistance is an important parameter that influences ship performance and economic effect on ship operation. The predictive estimation of the various resisting factors on the hull form is paramount to optimize ship performance and operation (Journee, 1976).

The ROPAX which means Roll-on/roll-off passenger vessel is generally used for freight vehicle transport along with passenger accommodations. ROPAX vessel uses lanes in meters (LIMs) as the unit for measurement of her cargo. LIM is calculated by multiplying cargo length in meters by the number of decks and by its width in lanes. The lane width will differ from vessel to vessel and there are a number of industry standards. It is a commercial ship usually of displacement hull form and block coefficient range of 0.50-0.70 to compensate for its high speed (Marine-Insight, 2017).

1.1 General Concept of Bare Hull Resistance

Bare hull resistance is the resistance of a hull without appendages or penetrations under tow. This resistance comes from a number of components such as energy expended forming waves and friction between the hull and water. It is the summation of both the frictional resistance of the hull which is influenced by the size of the hull's wetted area below the waterline as the ship moves through water and the residuary resistance of the ship which comprises wave resistance caused by waves created by the vessel during its propulsion through water and eddy resistance caused by flow separation which creates eddies particularly at the aft end of the ship. Bare hull resistance is often regarded as the total resistance of a ship when the air resistance and appendage resistance of the ship is not considered. The amount of power required to overcome this resistance can be determined by multiplying the total bare hull resistance by the velocity of the ship. This is referred to as the effective power, PE (Narciki, 2010).

1.2 Statement of Problem

During the initial design and construction of a ROPAX Ship, the vessel is designed for specific operational route taking into account peculiar environmental conditions, and special consideration is given to the sea surface temperature, kinematic viscosity and mass density of the sea route in other to estimate the design bare hull resistance. Previous research efforts on bare hull resistance estimation were on general basis. They failed consider in particular consider the Gulf of Guinea region.

In addition, previous research work did not also employ the use of simulation tool to analyze and validate Bare-hull resistance and effective power at different speed range.

2. METHODOLOGY

2.1. Theoretical Framework

According to the Bernoulli's Law; water with a speed of V and a density of ρ has a dynamic pressure of P= $\frac{1}{2} \times \rho w \times V^2$, **Eqn 2.1**

Thus, if water is completely stopped by a body, the water will react on the surface of the body with a dynamic pressure, resulting in a dynamic force on the body.

This relationship is used as the basis when estimating or measuring the source resistance (R) of a ship hull by means of dimensionless resistance coefficient (c). Thus, C is related to the reference force K, defined as the force which the dynamics of water with the ship's speed V exerts on a surface which is equal to the hull's wetted surface area (Ss) (Charles, 1999).

The general data for resistance calculations is thus;

$$K = \frac{1}{2} \times \rho w \times Ss \times Vs^2$$ **Eqn 2.2**

And,

$$R = C \times K$$ **Eqn 2.3**

Where; ρ_w = mass density of water at a given water temperature (kg/m^3)

Vs = ship speed (m/s)

Ss = ship surface wetted (m^2)

C = resistance coefficient

K = reference force in Kilo Newton (KN)

R = source resistance in Kilonewton (KN)

The wetted surface area is calculated as by Debby's Formula

$$Ss = 1.7Lwl \times B + \frac{\nabla s}{D} \quad (m^2)$$ **Eqn 2.4**

Where; B= breadth or beam in meters

∇s =Volume displacement of ship in m^3

L_{wl} = ship waterline length in meters

D = draught in meters

The vessel waterline length is calculated as;

$Lwl = \frac{Lpp}{0.97}$ (m) **Eqn 2.5**

Where; L_{pp} = length between perpendicular of the vessel.

The vessel volume displacement is calculated as;

$\nabla s = Cb \times B \times Lwl \times D$ (m^3) **Eqn 2.6**

Where; C_B = block coefficient of the ship

2.1.1 Total Bare Hull Resistance (R_{TBHS})

Energy expended forming waves as a result of ship speed and friction between the hull and water are the major source components of ship bare hull resistance. Bare hull resistance is the summation of the frictional resistance and the residuary resistance of a ship. It represents a considerable part of the total ship resistance when air and appendages resistance are not considered (Harvald, 1983)

For a ship moving in still water, the total bare hull resistance can therefore be calculated as

$R_{TBHS} = C_{TBHS} \times \frac{1}{2} \times \rho_w \times S_s \times V_s^2$(KN) **Eqn 2.7**

Where; $R_{TBHS} = total\ bare\ hull\ resistance\ of\ ship$

$C_{TBHS} = total\ bare\ hull\ resistance\ coefficient$

Using International Towing Tank Conference – 57 Method (ITTC -57 Method) the total bare hull resistance coefficient is computed as;

$C_{TBHS} = C_{Fs} + C_{Rs} + C_A$ **Eqn 2.8**

Where;$C_{Fs} = frictional\ resistance\ coefficient$

$C_{Rs} = residuary\ resistance\ coefficient$

$C_A = incremental\ resistance\ coefficient, accounts\ for\ surface\ roughness\ of\ ship$

Note; C_A = 0.0004 (i.e. a reasonable default value)

2.1.2 Frictional Resistance of Ship (R_{FS})

The frictional resistance of a ship depends on the size of the hull's wetted surface area and on the specific frictional resistance coefficient. The friction increases with fouling of the hull and also when the ship is propelled through water, the frictional resistance increases at a rate that is virtually equal to the square of the ship speed. Frictional resistance represents a considerable part of the ship resistance, practically 70 – 90% of the ship total resistance for low-speed ships and less than 40% for high-speed ships (Harvald, 1983).

Using International Towing Tank Conference – 57 Method (ITTC -57 Method) the frictional resistance is computed as;

$R_{Fs} = C_{Fs} \times \frac{1}{2} \times \rho_w \times S_s \times V_s^2$ (KN) **Eqn 2.9**

Where; $C_{Fs} = frictional\ resistance\ coefficient$

Using ITTC-57 method the frictional resistance coefficient is calculated as thus

$C_{Fs} = \frac{0.075}{(\log_{10} R_{ns} - 2)^2}$ **Eqn 2.10**

Where; $R_{ns} = Reynolds\ Number\ of\ a\ ship$ is calculated thus;

$R_{ns} = \frac{V_s \times L_{wl}}{\gamma_w}$ **Eqn 2.11**

Where; $\gamma_w = Kinematic\ viscosity\ of\ water\ (sea\ or\ fresh)\ at\ a\ given\ temperature.$

2.1.3 Residuary Resistance of Ship (R_{RS})

Residuary resistance comprises wave resistance and eddy resistance. Wave resistance refers to energy loss caused by waves created by the ship during her propulsion through water, while eddy resistance refers to the loss caused by flow separation which creates eddies particularly at the aft end of the ship. The residuary resistance practically represents 8—25% of the total ship resistance for low-speed ships and up to 40—60% for high-speed ships (Harvald, 1983).

The residuary resistance is calculated thus;

$R_{Rs} = C_{Rs} \times \frac{1}{2} \times \rho_w \times S_s \times V_s^2$(KN) **Eqn 2.12**

Where; $C_{Rs} = Residuary\ resistance\ coefficient$

Note: The procedure used in calculating the residuary resistance coefficient includes but not limited to the one stated below.

Using Gertler series data (C_R contour) Charts

- Calculate for the Froude number of the ship using the formula below

$F_{ns} = \frac{V_s}{\sqrt{g \times L_{wl}}}$ **Eqn 2.13**

Where; $F_{ns} = Froude\ Number\ of\ the\ ship$

g = 9.87m/s^2 i.e. acceleration due to gravity

- Calculate for the volume displacement : length ratio

  i.e. $\frac{\nabla_s}{L_{wl}^3}$ **Eqn 2.14**

- Calculate for the Beam : Draught ratio

  i.e. $\frac{B}{D}$ (Molland and e t'al.2011) **Eqn 2.15**

- Calculate for the longitudinal prismatic coefficient (Cp)

  i.e. $C_p = \frac{\nabla_s}{A_m \times L_{wl}}$ **Eqn 2.16**

  But; $A_m = B_m \times D$ (m^2) **Eqn 2.17**

  Where; $A_m = midship\ section\ area$

  $B_m = breadth\ moulded$ **(Harvald, 1983)**

- Choose a Gertler series data chart that corresponds in value with the calculated B/D and Cp.
- Enter into the Gertler Series Data chart using the calculated values of F_{ns} *and* $\frac{\nabla_s}{L_{wl}^3}$, at the point of interception between these value lines, trace out a horizontal line to the right hand side of the chart to get the value for C_{RS} ,(i.e. the residuary resistance coefficient).

2.1.4 Effective Power (P_E)

Effective power is the power required to tow the ship at a required speed. It is the total bare hull resistance multiplied by the ship speed when appendages and air resistance is not considered.

The effective power is calculated thus;

$P_E = R_{TBHs} \times V_s$ (kW) **Eqn 2.18**

2.1.5 Bare-Hull Resistance Estimation Method Adopted

The ITTC and Taylor Gertler series chart method for estimation of Bare-Hull resistance is adopted for this analysis because it is observed that the ITTC lines method has proven to be more accurate and precisely used for the estimation of the total resistance of a ship as it considers the incremental resistance coefficient which accounts for surface roughness of the ship.

2.2 Materials

Therefore, using the Gulf of the Guinea and the BRODOSPLIT ROPAX as a case study, this study will estimate the total bare hull resistance and prescribe the most economically viable operational speed and amount of power that will increase the power delivered to the propulsion systems in other to achieve an economical running cost and voyage time

2.2.1 Particulars of Basis Ship;

Dead weight at design draught	9000 Tonnes
Delivered power	38000Kw
Lane length/ lanes meter	3500
Passengers	400
Length between perpendiculars (Lpp)	184.60m
Breadth (B)	29.80m
Draught (D)	7.40m

Source: (Shipyard BRODOSPLIT Project No.: 987D)

2.2.2 Software Program

Matlab (Matrix Laboratory) software program will be used to write the algorithm for the above mathematical models because of its integration of computation, visualization and programming in an easy to use environment where problems and solutions are expressed in a familiar mathematical notation (Mathsworks, 2005). This will be in conducting several iterations to enhance optimum result.

2.2.3 Nigerian Institute of Oceanography and Marine Research Lagos. Technical Paper No.59

This paper provides the experimental values of the sea surface temperature of the Gulf of Guinea.

2.2.4 Table of Values for Kinematics Viscosity and Mass Density for Sea Water As Adopted By ITTC In 1963

This table will provide the values of kinematic viscosity and mass density at specific temperatures.

2.2.5 Hydrodynamics in Ship Design Data (The Typical Set of Cr Contour from Gertler Reworking of The Taylor Standard Series) Chart.

This chart will provide the contours of volumetric coefficients used to trace the value of Residuary Resistance coefficient (Cr).

3. RESULTS AND DISCUSSIONS

3.1 Theoretical Analysis of Basic Parameters

The ship length on waterline,

$$Lwl = \frac{Lpp}{0.97} = \frac{184.60}{0.97} = 190m$$

3.2 Sea State of the Gulf of Guinea in Dry Season (Environmental Conditions of the intended Service Route)

Sea Surface Temperature (T^oC) 31.5°C

Mass Density (ρ_{sw}) in Kg/m^3 and Kinematic viscosity (υ_{sw}) in ($m^2/sec \times 10^{-6}$) of Sea Water at 31.5°C is thus below

By interpolating respectively from table of Values for mass density and kinematic viscosity for Sea Water as adopted by ITTC.

Table 3.1: Showing Temperature, Density and Viscosity adopted by ITTC

Temp (T^oC)	Density (ρ_{sw})	Viscosity (υ_{sw})
29	1022.0	0.86671
30	1021.7	0.84931
31.5	Y	x

$\therefore$ $y = 1022.0 + (\frac{31.5-29}{30-29}) \times (1021.7 - 1022.0) = 1021.3\ Kg/m^3$ i.e the mass density for sea water at 31.5°C.

$\therefore$ $x = 0.86671 + (\frac{31.5-29}{30-29}) \times (0.84931 - 0.86671) = 0.82321 \times 10^{-6} m^3/sec$ i.e the kinematic viscosity for sea water at 31.5°C.

The block coefficient (C_B) of the ROPAX vessel with speed of 24Knots is calculated by interpolating from Table 3.1 ferry boat.

Table 3.2: Showing Block Coefficient and Speed.

C_B	Speed (Knots)
0.50	15
Y	24
0.70	26

∴ $Y = 0.50 + (\frac{24-15}{26-15}) \times (0.70 - 0.50)$ = 0.66 of the Ropax Vessel with 24Knots.

Thus, Ship's volume displacement $\nabla s = 0.66 \times 29.80 \times 190.3 \times 7.40 = 27696.87 m^3$

The ship's wetted surface area $Ss = 1.7 \times 190.3 \times 29.80 + \frac{27696.87}{7.40} = 13383.42\ m^2$

The Reynolds number of the ship at 31.5^{0}C is thus

$$R_{ns} = \frac{12.34 \times 190.3}{0.82321 \times 10^{-6}}$$

$$R_{ns} = 2.85 \times 10^9$$

3.2.1 Calculating the Ship's Frictional Resistance Coefficient (C_{Fs}) by ITTC-59 Method

$$C_{Fs} = \frac{0.075}{(\log_{10} 2.85\times10^9 - 2)^2} = 1.35 \times 10^{-3}$$

3.2.2 Calculating the Ship's Residuary Resistance Coefficient by Gertler's Series Data Line Method

The Froude number of the ship is thus

$$F_{ns} = \frac{12}{\sqrt{9.87\times190.3}} \cong 0.3$$

The Volume Displacement to Length ratio $(\frac{\nabla_s}{L_{wl}^3})$ of the Ropax Vessel is thus

$$\frac{\nabla_s}{L_{wl}^3} = \frac{27696.87}{190.3^3} \cong 4.0 \times 10^{-3}$$

The Breath to Draught ratio ($\frac{B}{D}$) of the ship is thus

$$\frac{B}{D} = \frac{29.80}{7.40} \cong 3.75 \quad (i.e\ 4.02)$$

And assuming that Cp = 0.64, entering Gertler (Contours of Volumetric Coefficient) Series Chart of $\frac{B}{D} = 3.75$ and Cp = 0.64 with the following variables; $F_{ns} \cong 0.3$ along $\frac{\nabla_s}{L_{wl}^3} \cong 4.0 \times 10^{-3}$.

Thus the residuary resistance coefficient $(C_R) = 0.65 \times 10^{-3}$ as traced from the chart.

3.2.3 The Total bare hull resistance coefficient by ITTC-57 method

$$C_{TBHS} = 1.35 \times 10^{-3} + 0.65 \times 10^{-3} + 0.4 \times 10^{-3} = 2.4 \times 10^{-3}$$

3.2.4 The Total bare hull Resistance of the Ropax Vessel plying the Gulf of Guinea during dry season with temperature 31.5^{0}C and mass density of 1021.3 kg/m^3 using ITTC-57 method

$$R_{TBHS} = 2.4 \times 10^{-3} \times \frac{1}{2} \times 1021.3 \times 13383.42 \times 12.34^2$$

$$R_{TBHS} = 2497652.443\ N$$

$$R_{TBHS} = 2497.65\ KN$$

3.2.5 The Effective Power (P_E) required by the Ropax Vessel to overcome the Total Bare Hull Resistance above thus

$$P_E = 2497.65 \times 12.34$$

$$P_E = 30{,}821\ KW$$

3.2.6 Results of Matlab Simulation at Varying Speed of the Ropax Vessel during Dry Season

Matlab software was used to simulate the behavioral resistance characteristics of the ROPAX in dry season in the gulf of guinea as shown in table 3.3 below.

Table 3.3: Table of Total Resistance, Speed and Effective Power during Dry.

Speed (Knots)	Speed (m/sec)	CTBHs	RTBHs (KN)	P_E (KW)
15	7.71	0.0025	1006.1	7757
18	9.252	0.0024	1430.9	13239
20	10.28	0.0024	1754.1	18032
22	11.308	0.0024	2109	23849
24	12.336	0.0024	2495.6	30820.7
26	13.364	0.0024	2913.6	38937

Season

The table above represents the values of total bare hull resistance coefficient ($CTBH_S$), Total Bare hull resistance ($RTBH_S$) and the effective power (P_E) of the Ropax Vessel at varying speed in knots and meters per seconds during Dry Season for the Gulf of Guinea.

Bare-hull Resistance Coefficient against Ship Speed (Dry Season)

This graph in figure (3.1) represents the total bare hull resistance coefficient against the speed of the Ropax vessel during Dry Season with sea surface temperature of 31.5^0C, sea water density of 1021.3 kg/m^3 and sea water kinematic viscosity of $0.82321*10^{-6}m^2$/sec at the Gulf of Guinea.

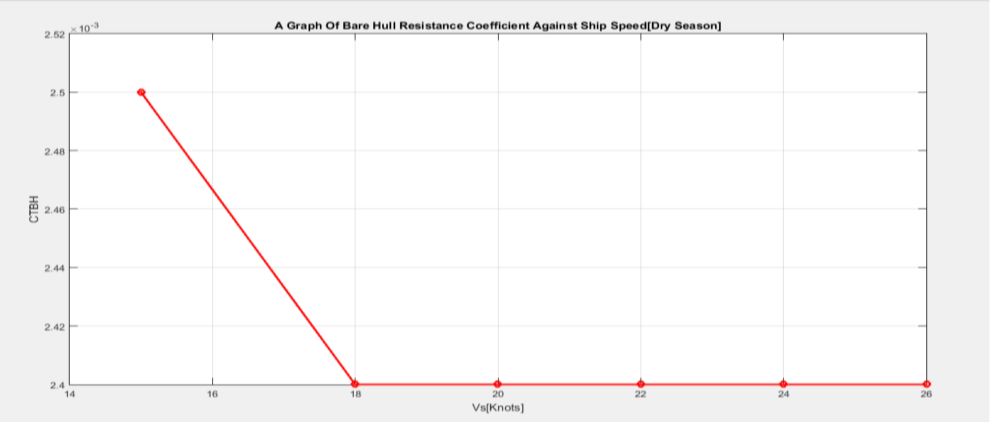

Figure 3.1: Graph of Total Bare Hull Resistance Coefficient of the Ropax Vessel in dry season.

From the graph, it is observed that the total bare hull resistance coefficient of the vessel is at a high of 0.0025 at a speed of 15knots but reduces to a constant of 0.0024 as the speed increases from 18 to 26knots.

Bare Hull Resistance of the Vessel against Vessel Speed (Dry Season)

This graph in figure (3.2) represents the total bare hull resistance against the speed of the Ropax vessel during Dry Season with sea surface temperature of 31.5^0C, sea water density of 1021.3 kg/m^3 and sea water kinematic viscosity of $0.82321*10^{-6}m^2$/sec at the Gulf of Guinea.

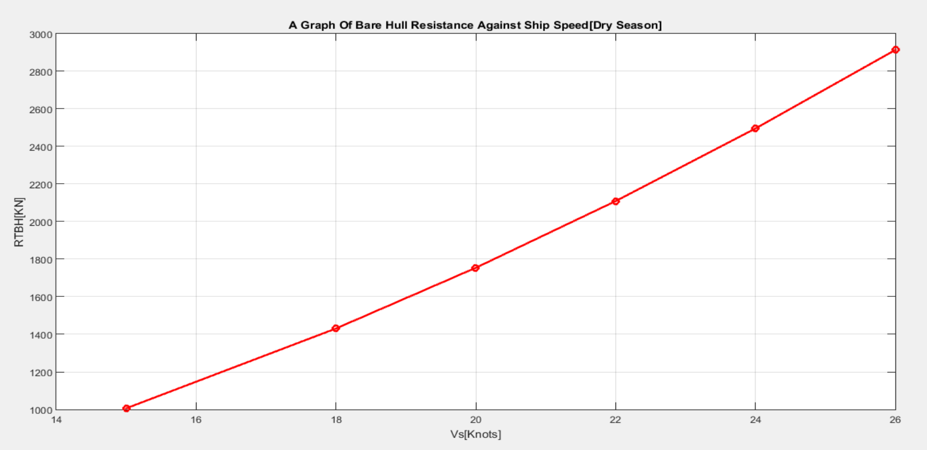

Figure 3.2: Bare Hull Resistance against Vessel Speed in Dry Season.

From the graph, it is noticed that the bare hull resistance of the Ropax vessel increases linearly as the speed of the vessel increases. The bare hull resistance encountered by the vessel running at its design speed of 24knot is 2495.6KN as shown above.

Effective Power against Bare Hull Resistance by the Ropax Vessel (Dry Season)

This graph in figure (3.3) represents the effective power against the bare hull resistance of the Ropax vessel during Dry Season with sea surface temperature of 31.5^{0}C, sea water density of 1021.3 kg/m^3 and sea water kinematic viscosity of 0.82321*10^{-6}m^2/sec at the Gulf of Guinea.

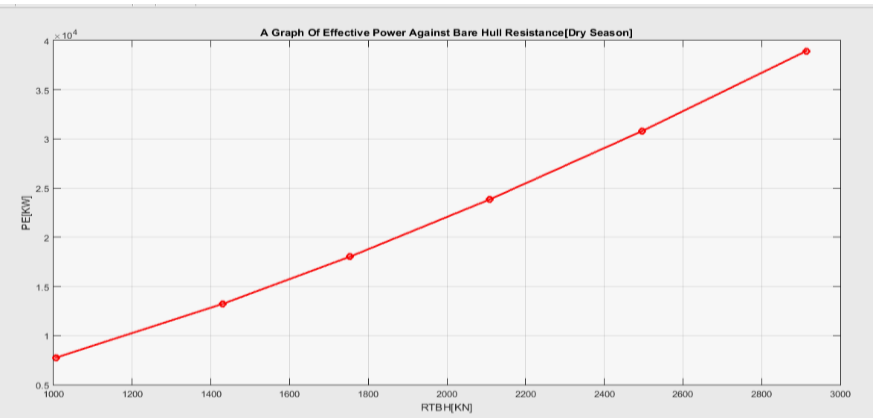

Figure 3.3: Effective Power against Bare Hull Resistance during Dry Season.

From the graph, it is observed that the effective power required by the vessel increases continuously as the bare hull resistance of the vessel increases.

The Effective Power required by the ROPAX Vessel against Vessel Speed (Dry Season)

This graph in figure (3.4) represents the effective power against the speed of the Ropax vessel during Dry Season with sea surface temperature of 31.5^{0}C, sea water density of 1021.3 kg/m^3 and sea water kinematic viscosity of 0.82321*10^{-6}m^2/sec at the Gulf of Guinea.

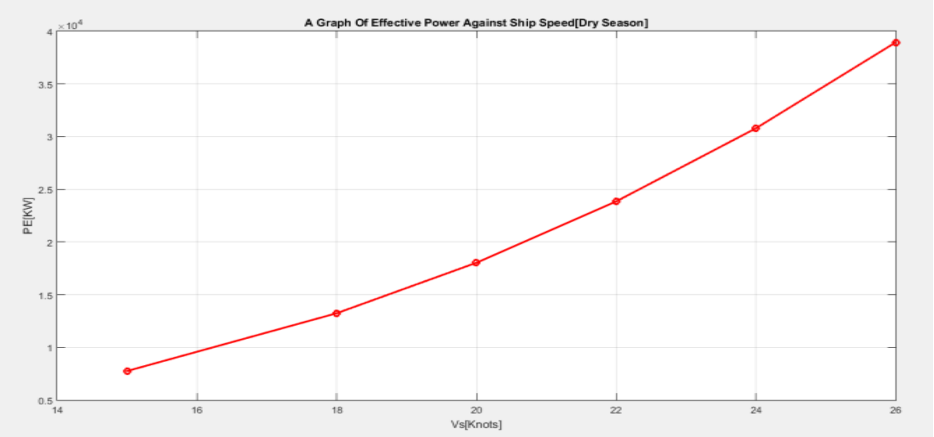

Figure 3.4: The Effective Power required by the ROPAX Vessel during Dry Season.

From the graph, it is observed that the effective power required by the vessel increases continuously as the speed of the vessel increases. The effective power required by the vessel running at its design speed of 24knot is 30786KW as shown above.

3.3 Sea State of the Gulf of Guinea in Wet Season (Environmental Conditions of the intended Service Route)

Sea Surface Temperature (T^oC)	26^oC
Mass Density of Sea Water (ρ_{sw}) in Kg/m^3 at 26^oC	1022.9
Kinematic viscosity of sea water (υ_{sw}) in ($m^2/sec \times 10^{-6}$) at 26^oC	0.92255

3.3.1 Results of Matlab Simulation at Varying Speed of the Ropax Vessel during Wet Season

Matlab software was used to simulate the behavioral resistance characteristics of the ROPAX in wet season in the gulf of guinea.

Table 3.4: Table of Total Resistance, speed and Effective Power (Wet Season).

Speed (knots)	Speed (m/sec)	CTBHs	RTBHs (KN)	P_E (KW)
15	7.71	0.0025	1015.7	7831.1
18	9.252	0.0025	1444.3	13363
20	10.28	0.0024	1770.3	18199
22	11.308	0.0024	2128.4	24068
24	12.336	0.0024	2518.3	31066
26	13.364	0.0024	2939.9	39289

The table (3.4) above represents the values of total bare hull resistance coefficient ($CTBH_S$),Total Bare hull resistance ($RTBH_S$) and the effective power (P_E) of the Ropax Vessel at Varying speed in knots and meters per seconds during wet Season for the Gulf of Guinea.

Total Bare Hull Resistance Coefficient of the Ropax against Ship Speed (Wet Season)

This graph in figure (3.5) represents the total bare hull resistance coefficient against the speed of the Ropax vessel during Wet Season with sea surface temperature of 26^0C, sea water density of 1022.9 kg/m^3 and sea water kinematic viscosity of $0.92255*10^{-6}m^2/sec$ at the Gulf of Guinea.

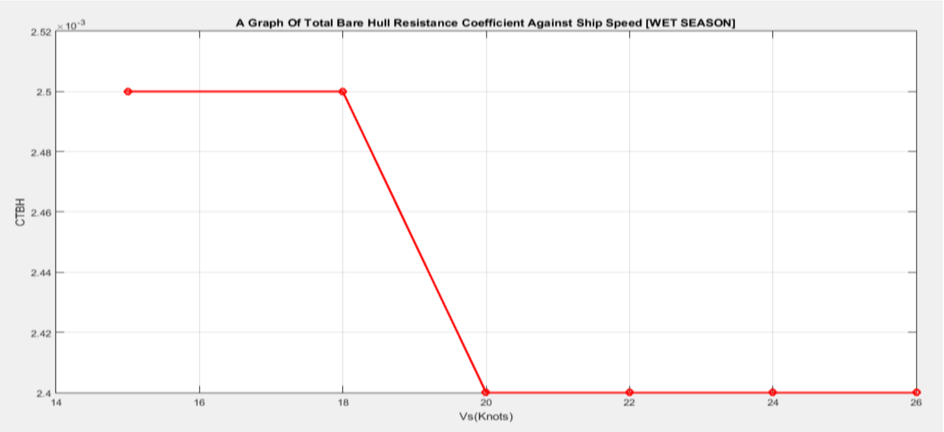

Fig 3.5: Total Bare-hull Resistance Coefficient against Ship Speed.

From the graph, it is observed that the total bare hull resistance coefficient of the vessel is at a high of 0.0025 at a speed of 15-18knots but reduces to a constant of 0.0024 as the speed increases from 20 to 26knots.

Total Bare Hull Resistance of the Ropax Vessel against Ship Speed (Wet Season)

This graph in figure (3.6) represents the total bare hull resistance against the speed of the Ropax vessel during Wet Season with sea surface temperature of 26^0C, sea water density of 1022.9 kg/m^3 and sea water kinematic viscosity of $0.92255*10^{-6}m^2$/sec at the Gulf of Guinea.

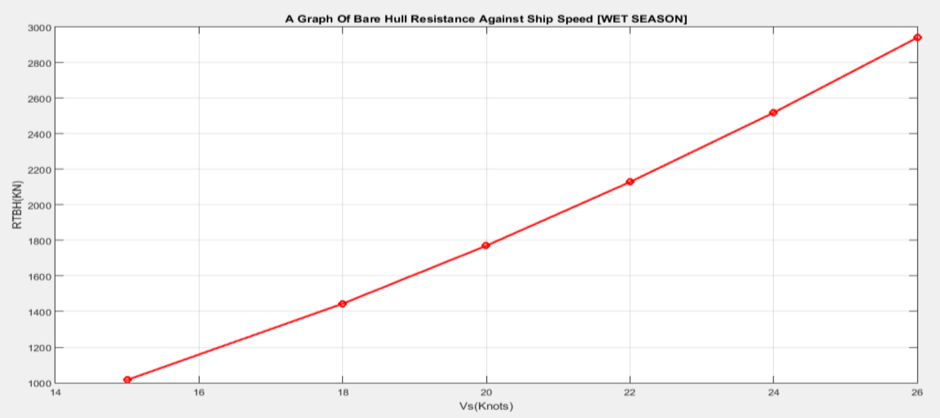

Fig 3.6: Total Bare Hull Resistance against Ship Speed.

From the graph, it is noticed that the bare hull resistance of the Ropax vessel increases linearly as the speed of the vessel increases. The bare hull resistance encountered by the vessel running at its design speed of 24knot is 2518.3KN as shown above.

The Effective Power required by the Ropax Vessel against Ship Total Resistance (Wet Season)

This graph in figure (3.7) represents the effective power required against the bare hull resistance of the Ropax vessel during Wet Season with sea surface temperature of 26^0C, sea water density of 1022.9 kg/m^3 and sea water kinematic viscosity of $0.92255*10^{-6}m^2$/sec at the Gulf of Guinea.

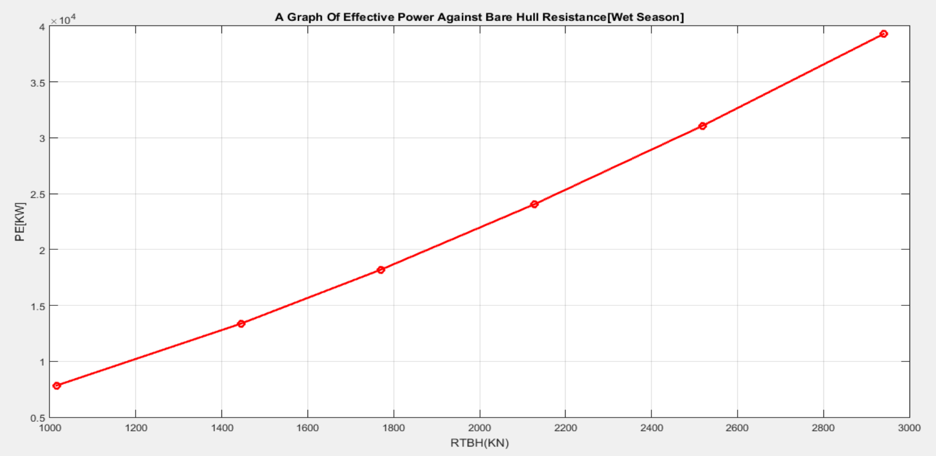

Fig 3.7: The Effective Power required against Ship Total Resistance in Wet Season.

From the graph, it is observed that the effective power required by the vessel increases continuously as the bare hull resistance of the vessel increases.

The Effective Power required by the Ropax Vessel against Bare-hull Resistance (Wet Season)

This graph in figure (3.8) represents the effective power required against the bare hull resistance of the Ropax vessel during wet season with sea surface temperature of 26^0C, sea water density of 1022.9 kg/m^3 and sea water kinematic viscosity of $0.92255*10^{-6}m^2$/sec at the Gulf of Guinea.

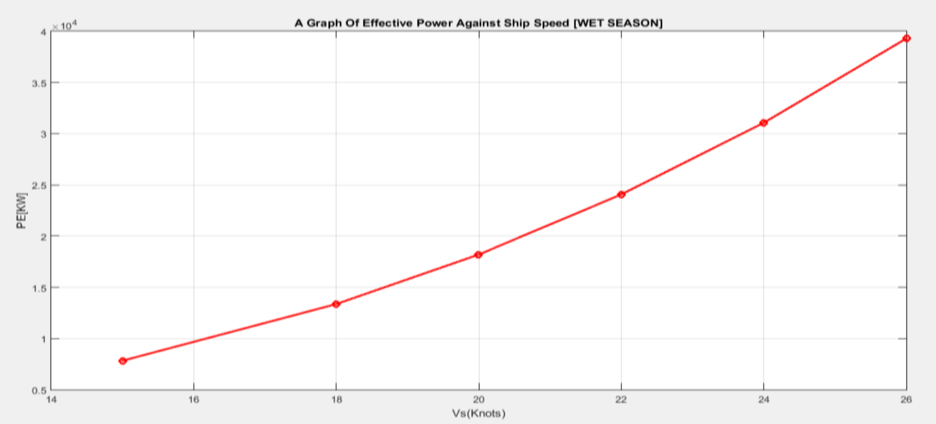

Figure 3.8: The Effective Power required against Ship Speed in Wet Season.

From the graph, it is observed that the effective power required by the vessel increases continuously as the speed of the vessel increases. The effective power required by the vessel running at its design speed of 24knot is 31066KW as shown above.

3.4 DISCUSSION

This research analysis was made from data and particulars of shipyard BRODOSPLIT Ropax Vessel with project No. 987D. The principal ship particulars collected were used to estimate the bare hull resistance of the vessel relative to the sea states of the Gulf of Guinea.

At 24 Knots, the bare hull resistance of the vessel was estimated to be 2495.6 KN and 2518.3KN for Dry and Wet season respectively. Further analysis made for the effective power required by the vessel, shows that an estimated 31,066KW required by the vessel when running at the design economic speed of 24 knots in dry season with an increment of about 0.99% in wet season.

The results and graphs generated from the MATLAB simulations, further shows that the bare hull resistance and effective power of the Ropax Vessel increases and decreases with respect to an increase or decrease in the vessel speed during operations in wet or dry seasons. Except for the Bare hull resistance coefficient which decreases from 0.0025 to a constant of 0.0024 as the speed of the vessel increases as shown in figures 4.1 and 4.5 for dry and wet season respectively.

4. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The Bare hull resistance of the Ropax vessel running with a design speed of 24knots in the Gulf of Guinea during dry (November-April) and wet (May-October) season is 2495.6KN and 2518.3KN respectively and these values will reduce to 1006.1KN and 1015.7KN respectively when running at a speed of 15Knot or increase to a high of 2913.6KN and 2939.9KN respectively when running at a speed of 26 Knots in the Gulf of Guinea.

The ROPAX vessel encounters an increase of 22.7KN in her bare hull resistance and also an increase of 280KW in her required effective power during wet season relative to dry season when running at the same speed of 24 Knots.

The MATLAB program developed in this research could be readily used to conduct preliminary bare hull resistance evaluation of similar vessels.

4.2 Recommendations

The following recommendations are made for optimal performance and operation of the BRODOSPLIT ROPAX Vessel with delivered power of 38000KW in the Gulf of Guinea at any season of the year and also for anyone willing to further on this research.

1. For economic and optimal performance implications, the maximum speed of operation of the ROPAX should be in the range of 20Knots for both dry season (November-April) and wet season (May-October) in the Gulf of Guinea.
2. To operate at a speed greater than 20 Knots in the Gulf of Guinea, the delivered power of the vessel should be increased.
3. For further research, the resistance of the ROPAX vessel due to air, appendages, fouling and other hydrodynamic factors (waves) should be considered.
4. The algorithm and codes should also be made more flexible with the use of other programming languages.

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