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The Initial Design Analysis Of 80 Meters Corvette Ship Propulsion System

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Abstract

The Indonesian Navy currently has several types of warships. One of which is a type of corvette ship, which is a fully armored ship with a CODOG (Combined Diesel Or Gas Turbine) propulsion system; the current condition is that the age of the ship has already been 20 years; thus, it can not reach maximum speed. In the design of this corvette ship, the stimulation system used the CODAD system (Combine Diesel and Diesel). Diesel is suitable for the development of Indonesian technology today because diesel engine drives have a high efficiency than others. Based on the results of the matching research between engines, propellers, and hull, the speed of the ship was obtained, which was 31.346 knots on 95% BMEP, so the condition was still safe for engines while propellers with 5% BMEP power reserves for terrible weather conditions.

Keywords - *Ship Resistance, Power Boats, Propeller, Ship Propulsion, Engine Propeller Matching.*

I.INTRODUCTION

Corvette ship is a warship owned by the Indonesian state that has an essential role in sea operation. Indonesia has 4 Dutch-made corvette type vessels, and its propulsion system uses CODOG (Combined Diesel Or Gas Turbine). These, with a full weight of 1500 tons, has a maximum speed of 30 knots using gas turbine and 18 knots using diesel engine propulsion. However, the current condition is the vessel can not reach top speed (Arica Dwi Susanto 2017).

This paper has any literature to support the research about it, for example, article with title An Approximate Method For Calculation of Mean Statistical Value of Ship Service Speed on a Given Shipping Line, Useful in Preliminary Design Stage (Żelazny 2015). Experimental Investigation on Stern-Boat Deployment System and Operability For Korean Coast Guard Ship (Chun.et.al. 2013). Performance of VLCC Ship with Podded Propulsion System and Rudder (Amin 2014). Introduction to Naval Architecture (Tupper 1975). Basic Ship Theory (Tupper 2001). Practical Ship Design (Watson 1998). Ship Resistance and Propulsion: Practical Estimation of Ship Propulsive Power (Anthony F. Molland 2011). Practical Ship Hydrodynamics (Bertram 2000). Effect of Fluid Density on Ship Hull Resistance and Powering (Samson 2015). Ship Design and construction (D'arcalengelo 1969). Resistance Propulsion and Steering of Ship (WPA Van Lamerren 1984). Predictive Analysis of Bare-Hull Resistance of a 25,000 Dwt Tanker Vessel (Adumene 2015). Resistance and Propulsion of Ships (Harvald 1992). Hydrodynamic of Ship Propellers (Andersen 1994). Ship Design for Efficiency and Economy (Bertram 1998). Design of Propulsion Systems for High-Speed Craft (Bartee 1975). A method of Calculation of Ship Resistance on Calm Water Useful at Preliminary Stages of Ship Design (Zelazny 2014). Increase of Ship Fuel Consumption Due to the Added Resistance in Waves (Degiuli.et.al. 2017). An Investigation Into The Resistance Components of Converting a Traditional Monohull Fishing Vessel Into Catamaran Form (Samuel 2015). Simulation of a Free Surface Flow over a Container Vessel Using CFD (Atreyapurapu.et.al 2014). Empirical Prediction of Resistance of Fishing Vessels (Kleppesto 2015). Designing Constraints in Evaluation of Ship Propulsion Power (Charchalis 2013). Coefficients of Propeller-hull Interaction in Propulsion System of Inland Waterway Vessels with Stern Tunnels (Tabaczek 2014). Cost optimization of marine fuel consumption is a vital factor in the control ship's sulfur and nitrogen oxides emissions (Kowalski 2013). Numerical Investigation of the Influence of Water Depth on Ship Resistance (Premchand 2015). The Wageningen Propeller Series (Kuiper 1992). Principles of Naval Architecture Second Revision (Lewis 1988). Marine Propulsion (Sladky 1976).

Based on the above problems, it is necessary to analyze the design of the corvette ship propulsion system so that the corvette ship could be more effective, efficient, and able to move quickly. The author determined this initial design with a length of 80 meters and a weight of 1500 tons (Gerr 2001).

This paper is organized as follows—section 2 reviews the basic ship theory. Section 3 gives results and discussion of research; finally, section 4 presents the conclusion of this paper.

II. RESEARCH METHODOLOGY

A. Technical Concept

In designing the corvette ships that will use as a battleship vessel, it is expected to have the following conditions:

a. The speed and accuracy of the work system (high accuracy)
b. Speed and accuracy in control (high acquisition)

c. Great destructive nature
d. High speed

B. Ship Resistance

The systems consist of ships, main propulsion motors, and propellers. If the vessel enlarged, then the required driving motors are more energized if the speed to be achieved is the same. Also, the propeller must change the power transferred by the motor to the water around the vessel is sufficient

C. Hull

The total resistance of the ship is made up of several different components that interact with each other. The total resistance value is the sum of all forces opposed to the force of the ship's movement. Therefore, the total resistance of the R_T contains the influence of friction, wave influence, wind influence, etc.

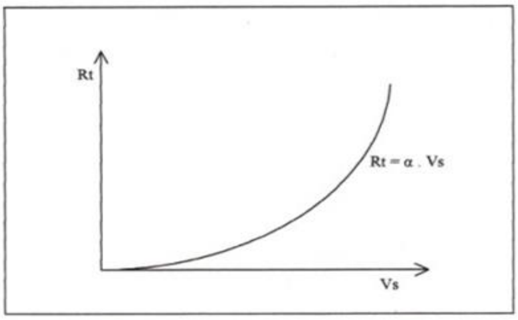

Fig. 1, The relationship between total resistance and speed of the ship

D. Selection of The Main Engine

In selecting the main engine, it is necessary to calculate the need for a powerful engine. Several indicators need to be sought to obtain the desired results; those are sufficient horsepower (EHP), thrust horsepower (THP), delivery horsepower (DHP), shaft horsepower (SHP) dan brake horsepower (BHP) (Anthony F. Molland 2011):

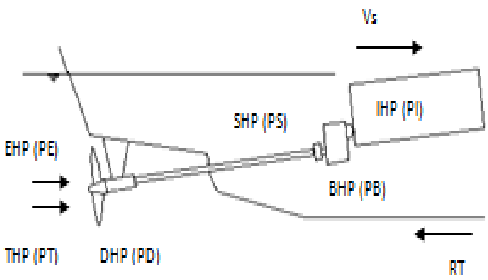

Fig. 2, Ship propulsion system

E. Propeller

The selection of the number of propellers on a ship depends on operational factors and limits. These factors include the amount of transmitted power, laden vessel, diameter, position, height, machine type restrictions, and the desired security limits.

The vessel resistance that has been converted into the quadratic function between KT and J will be plotted into the open water diagram to determine the operating point of the propeller. The intersection point is the operating point of K_T of the propeller; when the vertical line is drawn upwards. The operating point K_Q and η_o from the propeller will be obtained, and when the vertical line is drawn down, a J operating point of the propeller will be obtained.

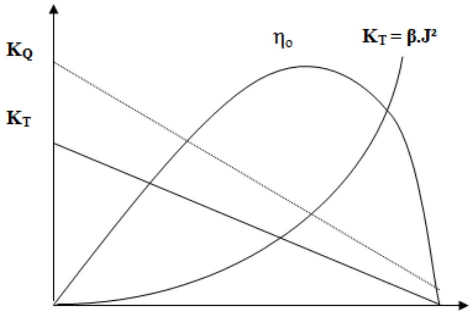

Fig. 3, Open water diagram for fixed propeller with curve

Characteristics of Torque and Power Propeller, A motor drive will provide torque to the propeller at a particular turn. To adjust the combination between the motor and the propeller, it will require the characteristics of the propeller shown in the relationship between speed torque or the power-speed relation.

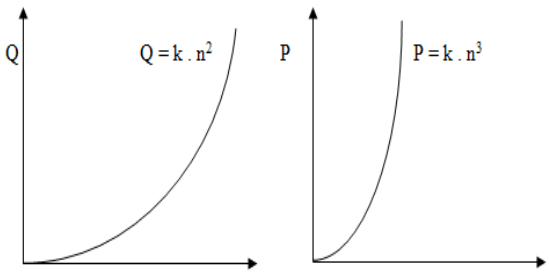

Fig. 4, The curves of torque vs. rpm and power vs. propeller rpm

F. Method of Research

The research conducted is basic research (basic research) based on how the implementation using the method of comparative research was performed (research a comparison). The steps in the initial design of the corvette ship propulsion system will be described as follows:

1. Determining the vision and mission of the ship to be designed.
2. Determining the technical concepts and engineering design.
3. Determining the principal dimensions and size of ships designed using computer software.
4. Determining the desired operating speed and driving power of the design can be designed as the required driving engine.
5. Determining the vessel operating points, whether the designed propulsion system between

the propeller characteristics and the design of the drive system is aligned or as expected.

III. RESULT AND DISCUSSION

In the design of this corvette ship, the primary size was inseparable from the size of the comparative ships, where the size of the comparative ships was drawn from the literature data, then from those data, we got the price of the primary size of the vessel

Based on these results, we could make the input for the Maxsurf program, which is computer software used for 3-dimensional modeling and is very appropriate to design a ship.

Table 1, Designed ship data

No		Value	Unit
1	LWL	77.397	m
2	Beam	9.171	m
3	Draft	3.85	m
4	Displaced volume	1498.778	m^3
5	Wetted area	892.52	m^2
6	Prismatic coeff.	0.621	
7	Waterplane area coeff.	0.776	
8	1/2 angle of entrance	8	deg.
9	LCG from midships	-3.313	m
10	Transom area	9.303	m^2
11	Max sectional area	31.187	m^2
12	Bulb transverse area	0.153	m^2
13	Bulb height from keel	1.804	m
14	Draft at FP	3.85	m
15	Deadrise at 50% LWL	51.84	deg.
16	Hard chine		
17	Frontal Area	0	m^2
18	Headwind	0	kts
19	Drag Coefficient	0	
20	Air density	1.293	kg/m^3
21	Appendage Area	0	m^2
22	Nominal App. length	0	m
23	Appendage Factor	1	
24	Correlation allows.	0.0004	
25	Kinematic viscosity	1.188E-06	m^2/s
26	Water Density	1025.9	$kg/\ m^3$

Based on the data above, it was known that it could be used as the basis for the calculation of ship resistance. The Maxsurf program using the HOLTROP method obtained a value of 560,41 kN, while with the manual method HARVALD GULDAMER the value of 547.92 kN was obtained. From these results, it could be concluded that the results of computer software were not much different from the manual. After the ship resistance was known, the power required to move the ship could be calculated, namely:

EHP (PE) = 8648.25 kW,
DHP = 13305 kW (17828,7Hp),
SHP = 13716,49kW (18380,7Hp)

The effect of position behind engine room midship :

BHP = (1 + 2%)
SHP = 13990,82 kW (18380,09 Hp),
Kondisi 85 %
MCR (BHP) = 16459,79 kW (21397,73 Hp)

The effect of sailing condition 15 %:
BHP* = 18928,76 kW (25364,53Hp),
$BHP_{\text{(each machine)}}$ = 4732,91 kW (6341,14 Hp).

A. Selection of Motor Drive

Based on the calculation of power required in this design, obtained diesel engine

Table 2, Data Main engine

Engine Model	16 V 1163 TB 73L
Rated Power (kW) (Bhp)	5200 (6975)
Speed Rpm	1230
Fuel Consumption	
at rated power g/kWh	220
l/h(gal/h)	1378.3 (364.2)
at optimum g/kWH	208
Dimension & Masses (Inc Coupling)	
Length(L) mm(in)	4660 (183.5)
Width(W) mm(in)	1895 (74.6)
Height(H) mm(in)	3520 (138.6)
Mass(Dry) kg(lbs)	19700 (43431)
Mass(Wet) kg(lbs)	21130 (46583)
Engine Main data	
Number of cylinders	16
Bore/stroke mm	230/280
in	9.1/11.0

The engine performance diagram was the main diagram in matching where the diagram illustrates the capability of the machine in speed (Rpm) and power (Bhp), which is described as follows:

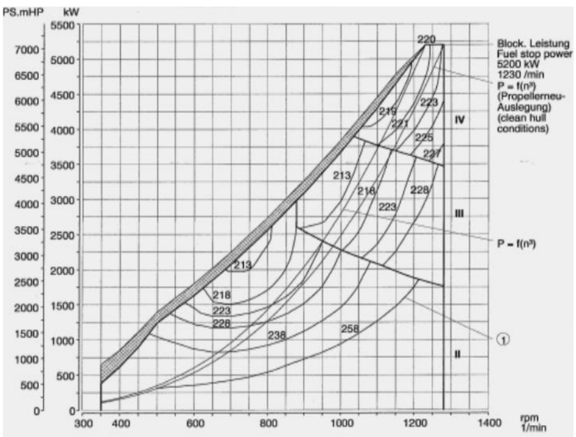

Fig. 5, diagram of engine performance

B. Selection of Propeller

The propeller design propulsion system, propeller CP (Controllable Pitch) type B series 3.50 was used with these aspects to be considered: the open water test chart for propeller B 3.50, η_o = 0.68 and value of $\left[\delta\right]_o$ = 158 were obtained

$$Do = \frac{\delta_o x Va}{N}$$

$$= \frac{158x27{,}125}{615} = 6{,}59$$

D_B (behind the ship) = 0,97 x D_O
= 0,97 x 6,59
= 6,39 ft (twins screw).

The propeller used in this design has 3 propeller blade, Disc area ratio (Fa / Fo) = 0.50, propeller efficiency = 0.68 (Given that the efficiency is rr =1 so $\eta_o = \eta_B$), Diameter = (6.39 ft) 1.95 m

C. Characteristic of Ship Resistance

In conjunction with engine propeller matching, the ship resistance data was beneficial for obtaining specific constant values, given the value was α. In contrast, the α constant was multiplied by the square of the velocity of the vessel; it would be directly proportional to the total of resistance. The calculation or analysis of regression graph vs. velocity was performed to get the constant value of α.

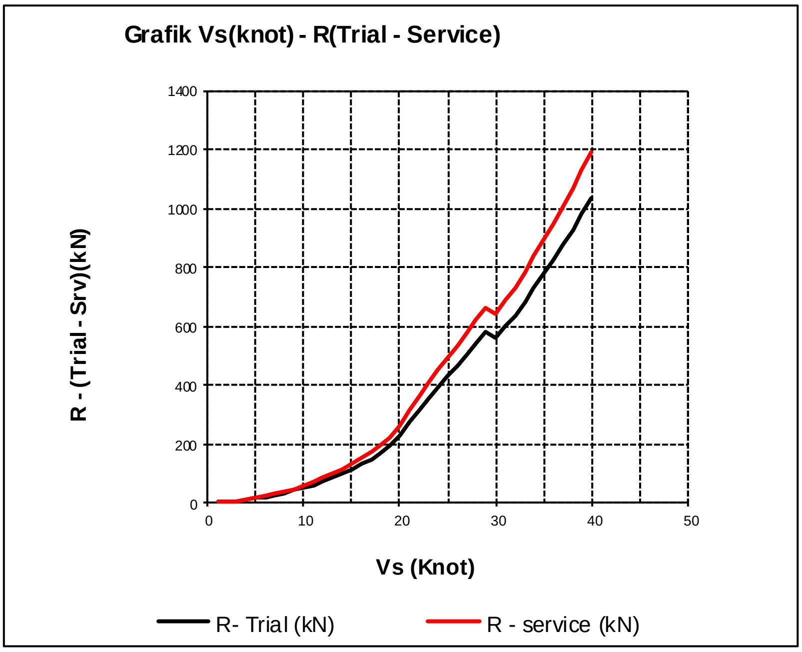

Fig. 6, Correlation between velocity and resistance

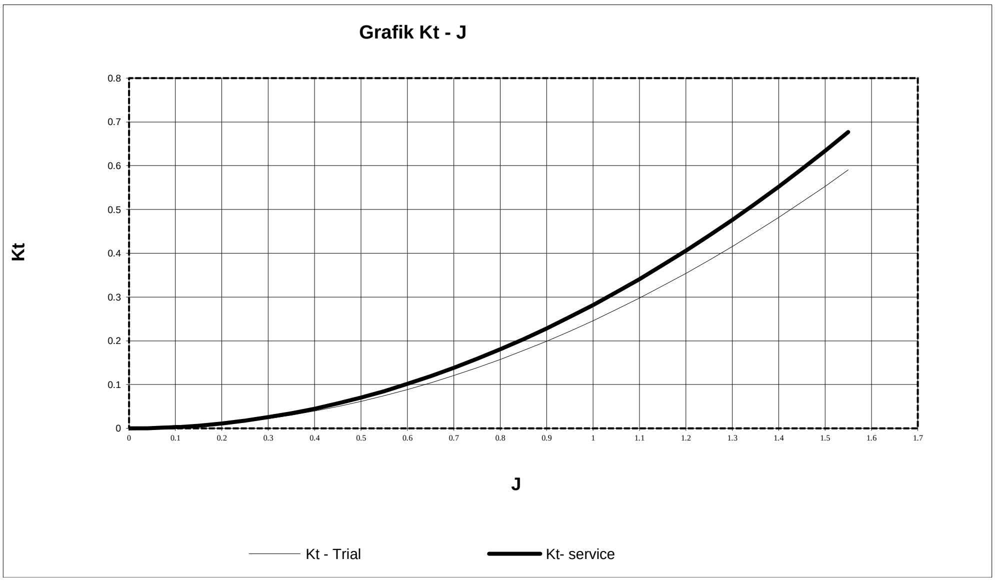

Fig. 7, Diagram of Kt - J

D. Characteristic of Propeller

The propeller characteristics for controllable pitch propellers were given in constants as follows: Coefficient of Push Style (K_T), Coefficient of Torque (KQ), Advance Coefficient (J), Open Water Efficiency (η_O)

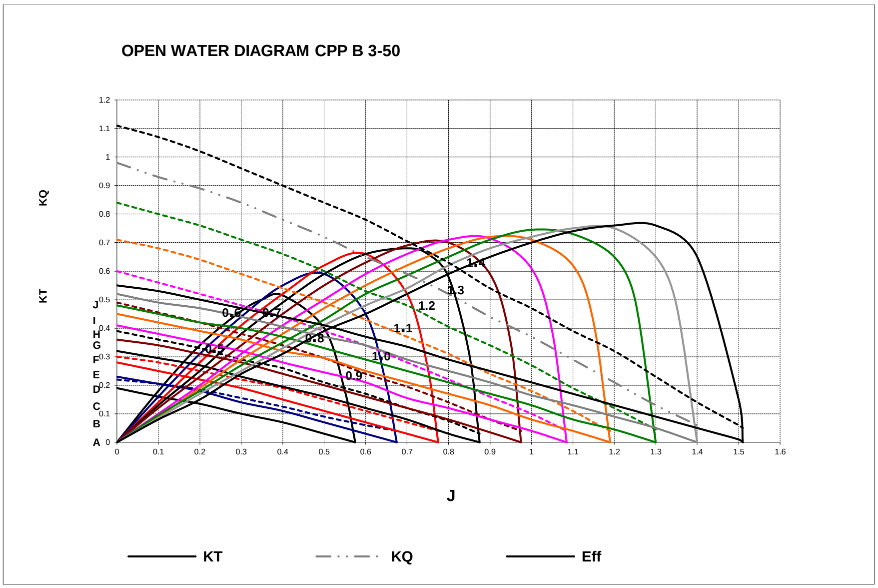

Fig. 8, diagram of open water

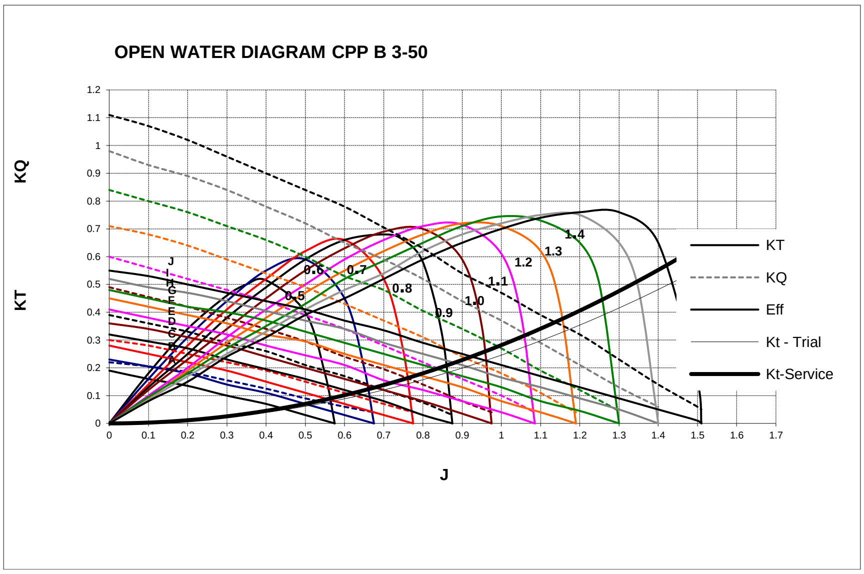

Fig. 9, Plotting diagram of Kt – J in open water

Table 3, Results of trial & service condition graph reading

No	Pitch	J		K_T		K_Q		η_O	
	P/D	Trial	Service	Trial	Service	Trial	Service	Trial	Service
1	0.5	0.45	0.44	0.042	0.048	0.0055	0.006	0.47	0.49
2	0.6	0.51	0.5	0.062	0.065	0.007	0.008	0.58	0.59
3	0.7	0.57	0.56	0.08	0.084	0.012	0.011	0.67	0.65
4	0.8	0.65	0.63	0.1	0.105	0.01	0.0125	0.68	0.67
5	0.9	0.7	0.68	0.12	0.125	0.15	0.016	0.69	0.68
6	1	0.75	0.72	0.14	0.145	0.018	0.02	0.67	0.67
7	1.1	0.82	0.79	0.16	0.175	0.022	0.023	0.68	0.68
8	1.2	0.86	0.83	0.18	0.2	0.025	0.028	0.67	0.69
9	1.3	0.91	0.88	0.2	0.22	0.029	0.032	0.67	0.69
10	1.4	0.96	0.93	0.22	0.24	0.034	0.036	0.68	0.68

Table 4, condition of trial (ideal)

No	P/D	K_Q	Q_D	P_D
1	0.5	0.0055	$158.9497n^2$	$998.2039\ n^3$
2	0.6	0.007	$202.2996n^2$	$1270.441\ n^3$
3	0.7	0.01	$288.9994n^2$	$1814.916\ n^3$
4	0.8	0.012	$346.7993\ n^2$	$2177.899\ n^3$
5	0.9	0.015	$433.4991\ n^2$	$2722.374\ n^3$
6	1.0	0.018	$520.1989\ n^2$	$3266.849\ n^3$
7	1.1	0.022	$635.7987\ n^2$	$3992.816\ n^3$
8	1.2	0.025	$722.4985\ n^2$	$4537.29\ n^3$
9	1.3	0.029	$838.0982\ n^2$	$5263.257\ n^3$
10	1.4	0.034	$982.5979\ n^2$	$6170.715\ n^3$

Table 5, condition of service

No	P/D	K_Q	Q_D	P_D
1	0.5	0.006	$173.3996\ n^2$	$1088.95\ n^3$
2	0.6	0.008	$231.1995\ n^2$	$1451.933\ n^3$
3	0.7	0.011	$317.8993\ n^2$	$1996.408\ n^3$
4	0.8	0.0125	$361.2492\ n^2$	$2268.645\ n^3$
5	0.9	0.016	$462.399\ n^2$	$2903.866\ n^3$
6	1.0	0.02	$577.9988\ n^2$	$3629.832\ n^3$
7	1.1	0.023	$664.6986\ n^2$	$4174.307\ n^3$
8	1.2	0.028	$809.1983\ n^2$	$5081.765\ n^3$
9	1.3	0.032	$924.798\ n^2$	$5807.732\ n^3$
10	1.4	0.036	$1040.398\ n^2$	$6533.698\ n^3$

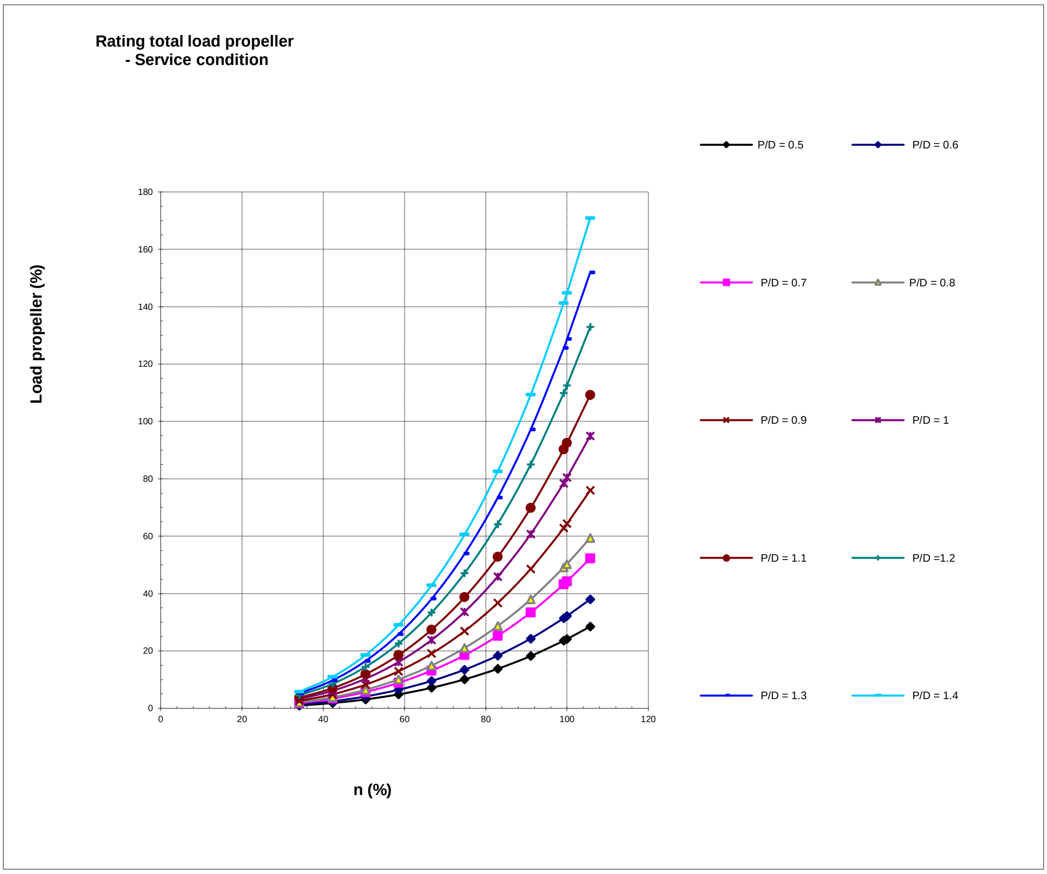

Fig. 10, diagram of rating total load propeller service condition

E. Characteristic of Main Engine

The engine performance diagram 1 was illustrated in the selection of the driving motor, while the engine performance diagram 4 was illustrated as follows:

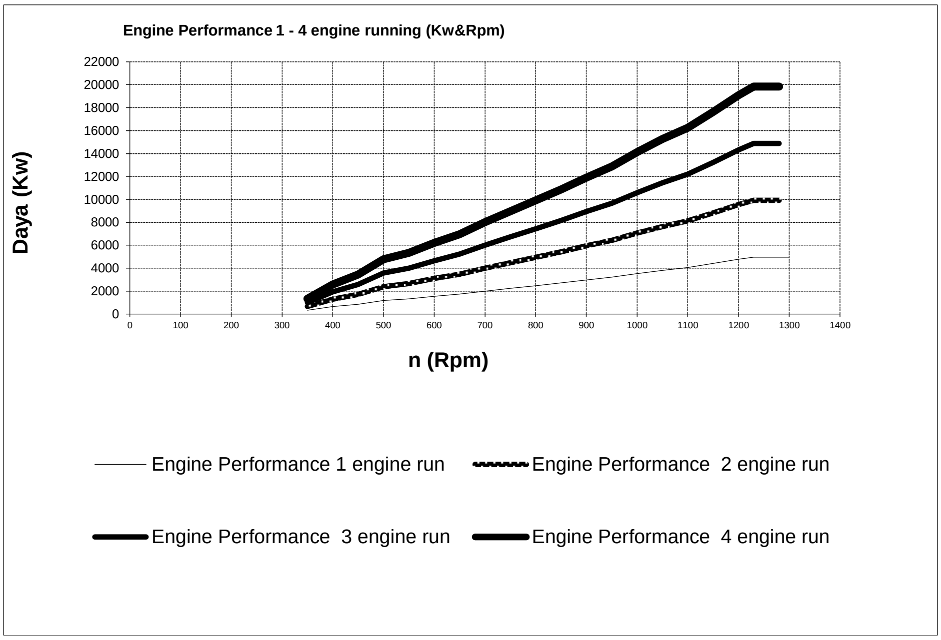

Fig. 11, diagram of engine performance 4

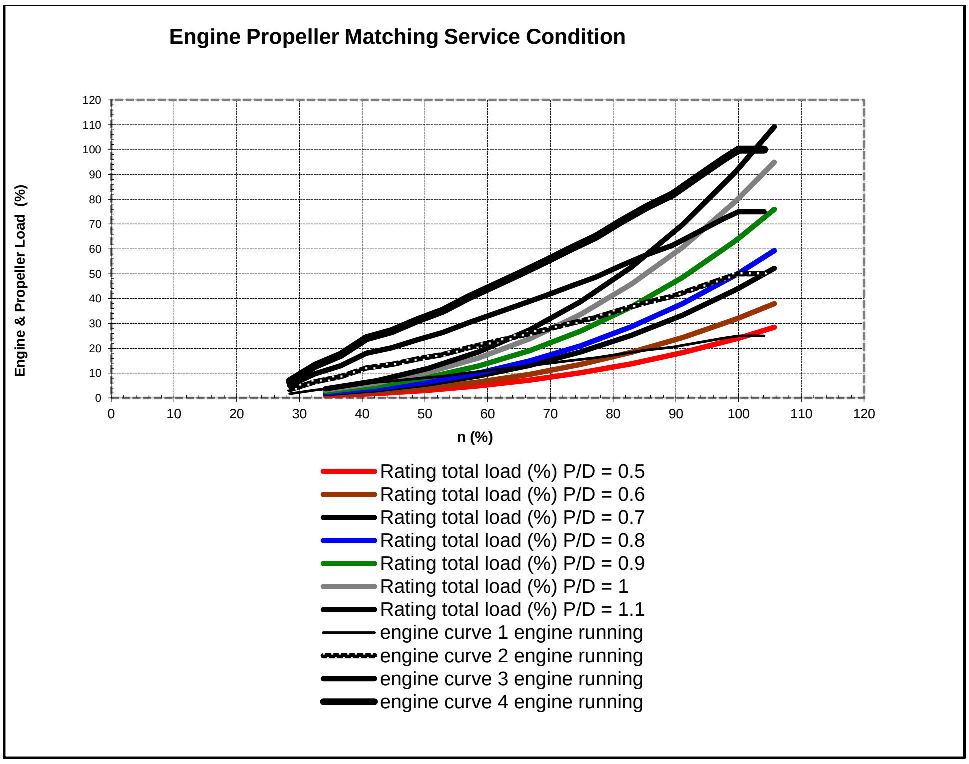

Fig. 12, Engine Propeller Matching 4

Table 6, The results of the graph reading on the condition of Service On P/D 1

P/D	BMEP %	Engine Power (kW)	n-Engine (RPM)	Load Prop (kW)	n-Prop (Rpm)	SFOC (g/Kwh)	Speed (Knots)
1	80	15874.56	1217.7	3968,84	608.85	221	26.397
	85	16866.72	1254.6	1537.848	627.3	223	28.047

Table 7, The result of reading the graph on the condition of Service At P/D 1.1

P/D	BMEP %	Engine Power (kW)	n-Engine (RPM)	Load Prop (kW)	n-Prop (Rpm)	SFOC (g/Kwh)	Speed (Knots)
1.1	80	13493.376	861	3373.344	430.5	218	22.437
	85	14882.4	1131.6	3720.6	565.8	218	24.747
	90	16866.72	1180.8	4216.68	590.4	221	28.047
	95	18851.04	1230	4712.76	615	220	31.346
	100	19843.2	1254.6	4960.8	627.3	220	32.996

IV.CONCLUSION

The stimulation of Combined Diesel and Diesel (CODAD) is an alternative to developing the corvette ship propulsion system in the Indonesian Navy, which is adapted to the technological developments in Indonesia. The speed of the ship reached 31,346 knots on 95% BMEP, so the condition is still safe for engines and propellers with 5% BMEP power reserves for horrible weather conditions.

ACKNOWLEDGEMENTS

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