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The Analysis of Thrust and Efficiency of B – Series Propeller : Influence of Speed Variation

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Abstract **- For variations in ship speed given data such as length perpendicular (LPP) 28 meters, propeller rotation (N) 290 rpm and shaft horse power (SHP) of 452.5 Hp by setting speed values varying from 4 knots to 9 knots, the average propeller efficiency for the B4-40 type is 60% while the average trust or thrust of the ship is 5873.5 kg and the average trust coefficient is 0.28. Likewise for the B4-55 type, the average propeller efficiency is around 58.6%, then the average thrust for the ship is 5736.3 kg and the thrust coefficient for the ship is 6.6.**

Keywords- ***Propeller, B4-40, B4-55, coeffisient of Trust, Effisiensiof Propeller***

I. INTRODUCTION

The ship propulsion system is a system found on ships that is useful for propelling ships. Ships are basically required to be able to maintain service speed as planned. Therefore, the design of the propulsion system on a ship must be able to overcome all the drag received by the ship so that it can meet the service speed. The ship's propulsion system is divided into three components, namely the main engine, transmission system and propulsion (propulsion device). These three components will then be related to one another to move the ship. One of the most important of the three components is the ship's propulsion device (propulsor) [2]. In designing the selection of a driving force must be said to be effective. Effective in this case is the compatibility between the planned power and the power that has been generated by the propulsion device. Currently, the development of the design concept of a ship propulsion device that has the ability to generate large thrust to suit the needs of the ship. Thrust is the amount of power generated by the work of the propulsor to push the hull of the ship. The ship's propeller is one example of the ship's propulsion device. At the beginning of the undeveloped propeller theory as it is now embraced by people, the operation of propellers was explained in a very simple way, namely based on the working principle of nuts and bolts (screws & nuts), propeller efficiency was formulated as follows [5]]:

$$\eta p = \frac{T.Va}{T.nH} = 1 - Sw \quad (1)$$

Where,

$$Sw = 1 - \frac{Va}{nH} \quad (2)$$

From the propeller design formula above, it shows that if slip does not occur, then Sw = 0, and if the propeller efficiency (ηp) = 1 indicates 100% efficiency. However, this is clearly impossible for a working propeller to experience, because with a slip price Sw = 0, it means that there will be no acceleration of the water caused by the working of the propeller. In that case, it means that there is no propulsion against the ship, thus it is very odd because there is no propulsion, meaning the ship will not run if the propeller efficiency = 100%. The analogy of the propeller to the nut and bolt theory cannot solve problems related to the efficiency of the propeller. Meanwhile, with the occurrence of these irregularities, the propeller theory must be developed by people who are competent and experts in the field of ship propellers which then emerge two theories related to the science of designing ship propellers, namely:

I.1. Momentum Theory of Propeller

According to this theory, the propulsion is generated by the work of the propeller in water caused by the difference in momentum so that the efficiency of the propeller depends on the loading blade.

Figure 1 shows that the reaction pressure generated by the propeller to the liquid or thrust (T) is the proportion with increasing pressure (P) multiplied by the surface area of the propeller (Ao) as shown in the equation below:

$$T = P. Ao \quad (3)$$

$$P = P1 - P2 \quad (4)$$

where :

T = *Thrust propeller*
P1 = Pressure by Face Side P2
= Pressure by Back Side
Ao = Surface Area for Propeller

I.2. Theory of Blade Propeller

The theory of the propeller blade element determines the forces generated by each piece of blade or leaf element from the propeller, and then by integrating, the thrust forces from each leaf element will produce the total thrust. Although according to this theory the shape of the propeller blade is taken into

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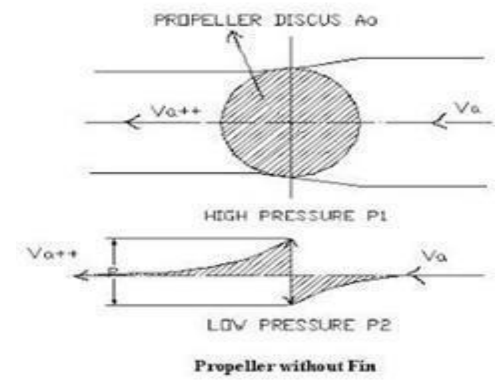

Fig 1. Diagram of Water Load

account, the propeller efficiency obtained is not perfect [2][9][11]. Figure 1 shows that under the propeller moving forward in the water, where the water is not moving

In this theory the propeller leaf is divided into several leaf elements. For each leaf element, the forces

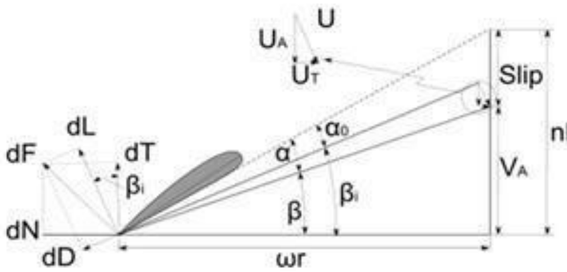

Fig 2. Diagram of Velocity

arising from the operation of the propeller are calculated. The magnitude of these forces depends on the magnitude of the relative velocity (v), namely the speed of the water particles from the water current moving past the leaf element with an angle (angle of attack to the leaf element) and also depends on the area of the leaf element concerned. If we look at a leaf element at radius r, the velocity diagram will be like figure 2.

Where :

V = Relatif Velocity of Water Va

= Speed of advance

Ꞷ.r = Rotation Velocity of Water Ꞷ

= Angular Velocity

L = Angle of Water Flow to Blade Elements

dL = Lift in a direction perpendicular to the relative velocity of the water

dD = Resistance force whose direction is in the same direction as relative velocity of water V

dr = Width of Propeller Blade l

= Length of Propeller Blade

dP is the resultant force and from dL and dD which can then be broken down again in the direction of translation and the direction perpendicular to the first component, namely:

dT =Thrust of Propeller

dQ =Torque of Propeller

I.3. Geometry of Propeller

The surface of the propeller leaf (face) is the surface of the propeller leaf when we see the ship (where the propeller is installed) from behind the ship towards the bow of the ship. This surface when the propeller is working, high pressure. The back of the propeller leaf is the surface of the propeller leaf reversed from the face of the leaf above and when working it will be under low pressure. The tip of the blade (leading edge) is the edge of the propeller blade in advance, so when the propeller rotates it will move forward.

The trailing edge is the edge of the propeller blade behind and is the tail of the blade when rotating. It is explained here that on a moving ship when the propeller rotates/works, the high pressure propeller leaf surface or leaf face/face will form a surface called the helocoidal surface as shown in Figure 3 below. A helocoidal surface is a surface formed by a straight line, where the straight line moves as a result of being rotated at a constant speed about an axis passing through one end of the line, and at the same time the line is moved along that axis at a constant speed and regularly (uniform speed) [2][8].

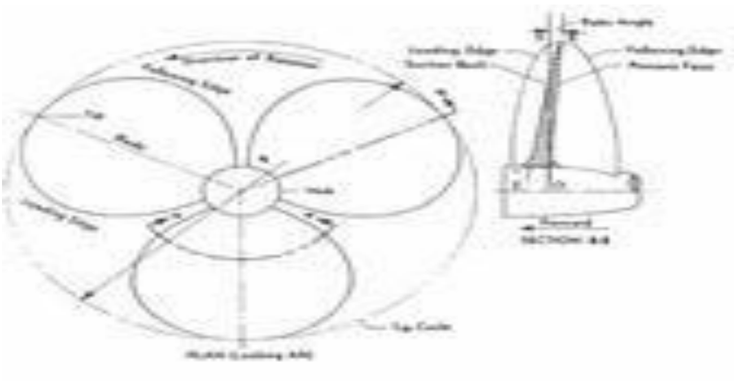

Fig 3. Sketch Of Ship Propeller

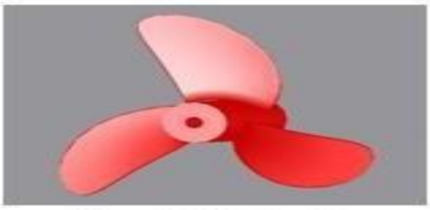

Fig 4. 3 Blade Propeller

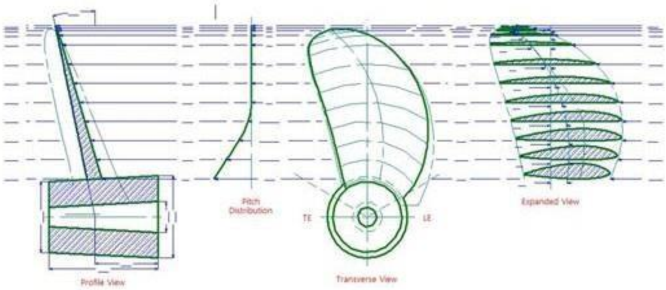

Fig 5 Propeller of Two

I.4. Characteristic of Propeller

The load characteristics of the propeller or propeller can be displayed graphically by several coefficients in the form of sizes. The diagram gives torque and thrust as a function of speed. The propeller characteristics consist of the thrust coefficient (KT), torque coefficient (KQ), and advanced coefficient (J) as in the following equations. (KT) =

$$\frac{T}{pn^2 D^4} \quad (5)$$

$$(KQ) = \frac{TQ}{pn^2 D^5} \quad (6)$$

$$\frac{Va}{nD} \text{ (J) } = \quad (7)$$

Where :

p = Density of Fluid ($kg\ m^{-3}$) D
= Diameter of propeller (m) n
= Rotation of Propeller (rpm) Va
= Advanced Speed (m/s)

T = Thrust of Propeller (N) Q=
Torque of Propeller (Nm) J =
Coeffisient of Advanced

For the propeller efficiency value in open water given the formula:

$$Ꝺo = \frac{JKT}{2\pi KQ} \quad (8)$$

Where :

ŋo = Propeller Efficiency in

Open T ter Conditions
J Thrust Propeller (kN)
Coefficient of Advanced (J)

KQ Coefficient of Torque
KT Coefficient of Thrust

And the results of the propeller design can also be made in two dimensions as shown in Figure 5. In our research, the planned design for the number of propeller leaves is 3 leaves like the shape of the propeller shown in Figure 4.

II. Methods

The methodology used in this study is to apply propeller laboratory equipment that has been designed to obtain accurate data results and approximate the results of the propeller thrust estimation.

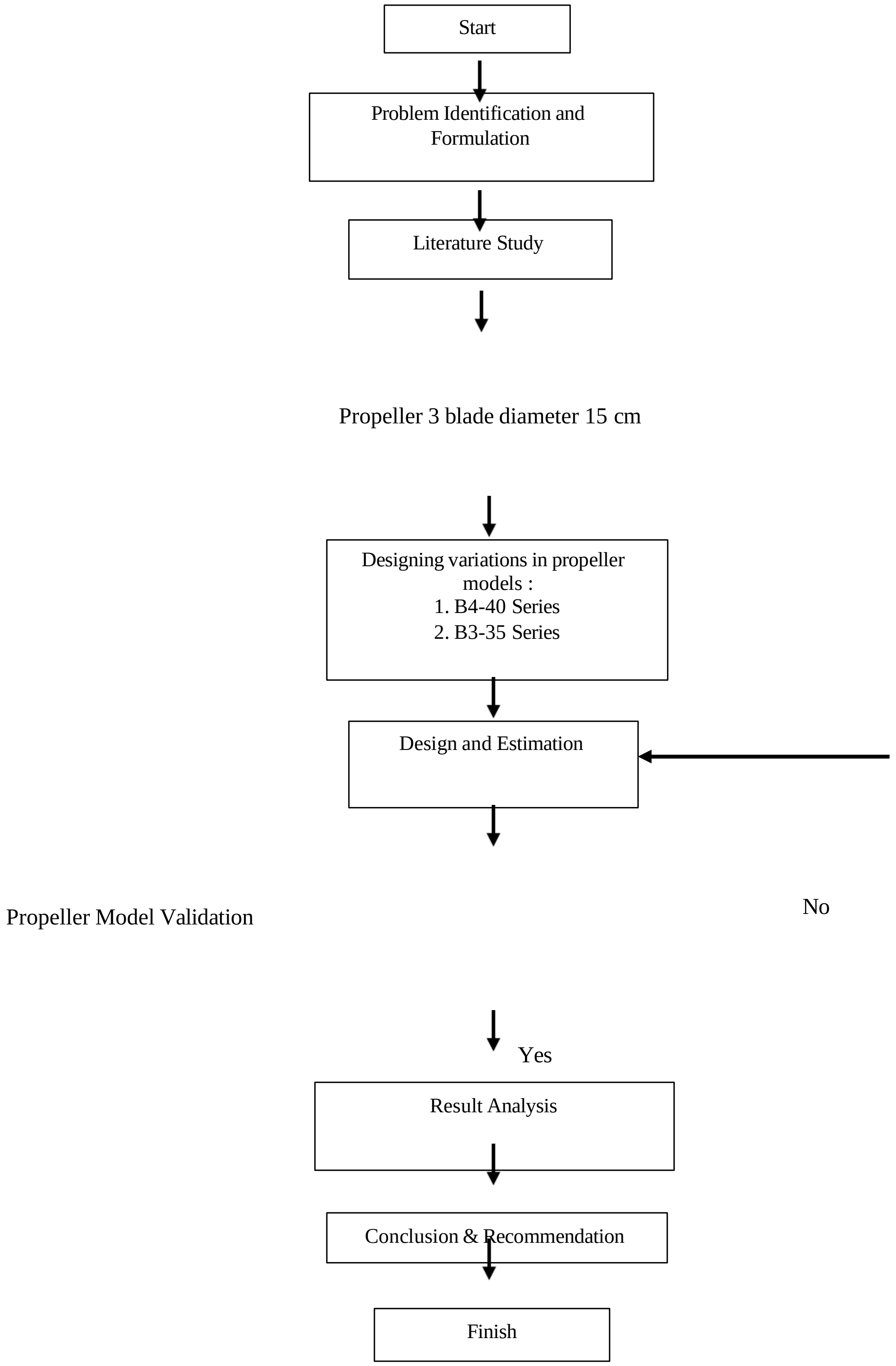

Fig 6. Diagram of Flowchart

III. Discussion and Result

Ship data for conducting our research will be provided as in table 1 below.

No.	Spesification	Dimension	Unit
1.	LPP of Ship	28	M
2.	Rotation of Propeller (N)	290,000	RPM
3.	Correction of Propeller Rotation (Nk)	284,200	RPM
4.	Shaft Horse Power (SHP)	452,503	HP
5.	Wake Fraction (w)	0,134	

Tabel 1. Data of Ship Spesification

II.1. Tipe B4.40 Series

From the 6-speed variation set for the B4.40 propeller type, it can be obtained that the Bp value for ship speed (Vs) shows a decrease below the number 50 at a speed of 9 knots as shown in Figure 8. Meanwhile, the propeller efficiency for speed also shows that decrease as shown in figure 7-10.

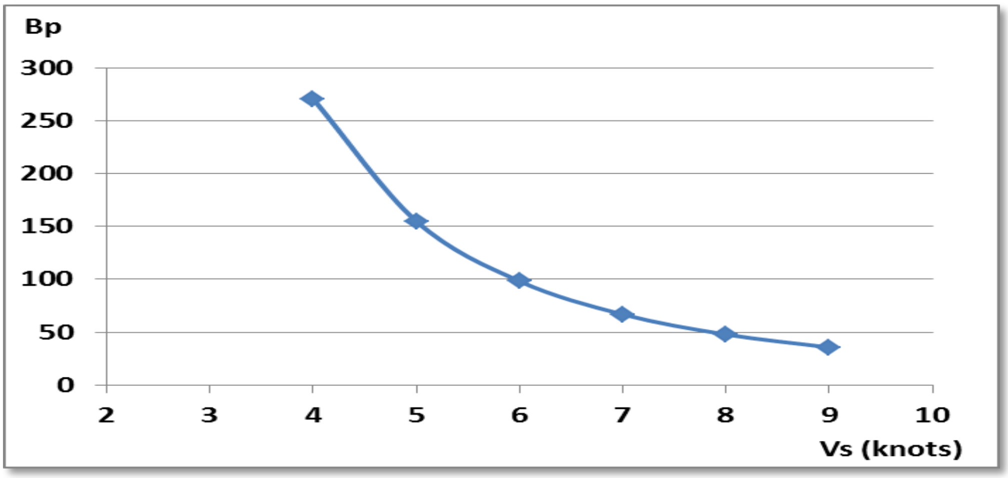

Fig 7. Bp – Vs

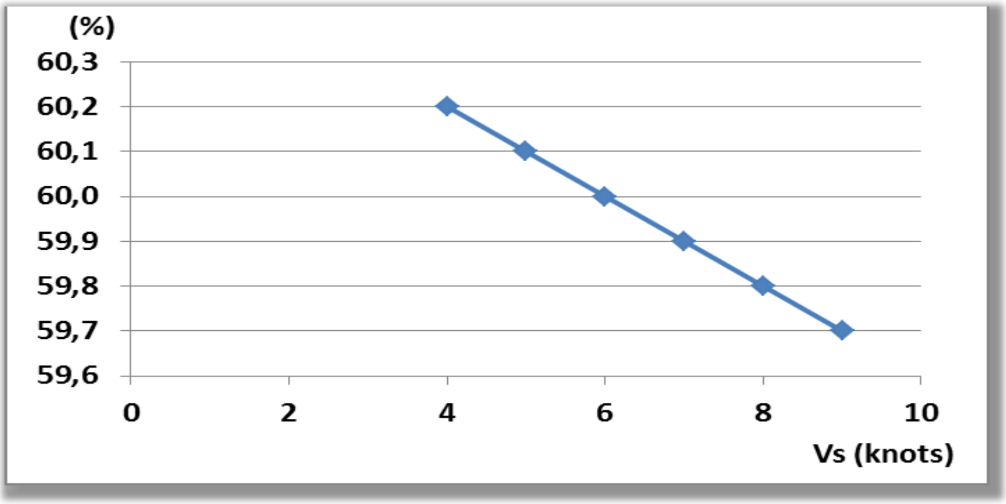

Figure 8. Propeller Efficiency – Vs

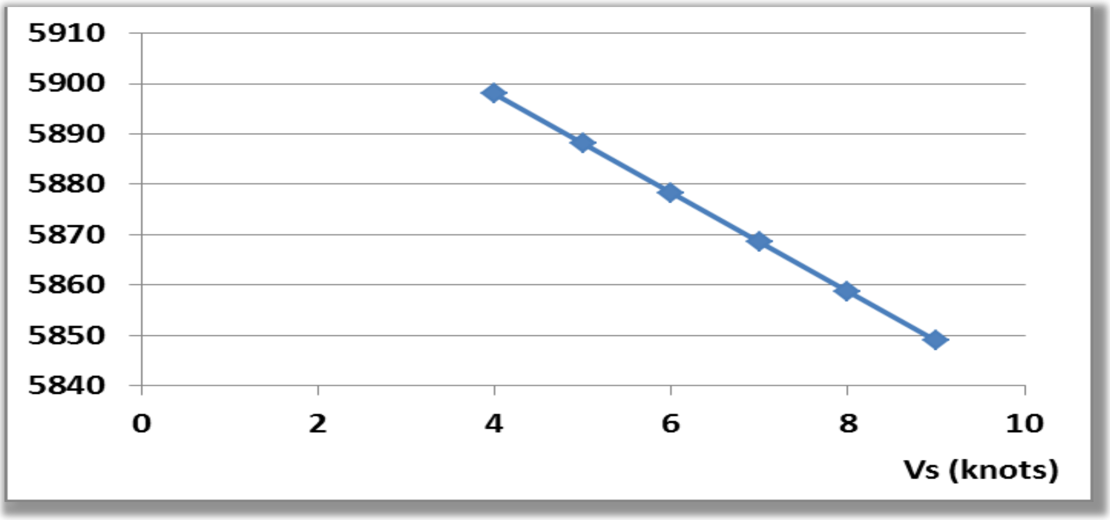

Fig 9. Thrust – Vs

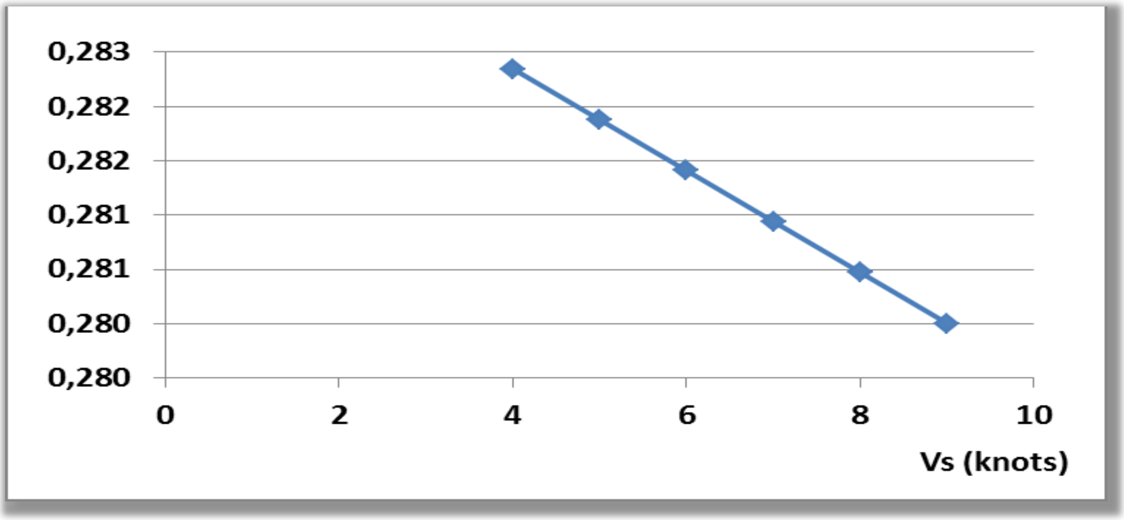

Fig 10. Thrust Coefficient - Vs

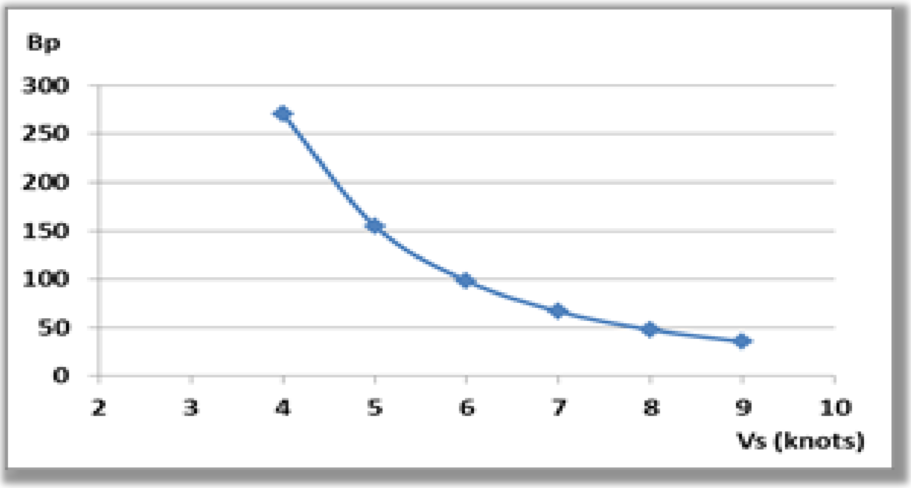

Fig. 11. Bp – Vs

II.2. Tipe B4.55 Series

For types B4.55 and the same given a 6- speed variation, the Bp value for ship speed (Vs) can be produced which shows a decrease from the number above 250 to below the number 50 at a speed of 9 knots as shown in Figure 11. Meanwhile for the propeller efficiency on speed also shows a decrease as shown in Figure 12. While the thrust and thrust coefficient also decreased as shown in Figures 13 and 14.

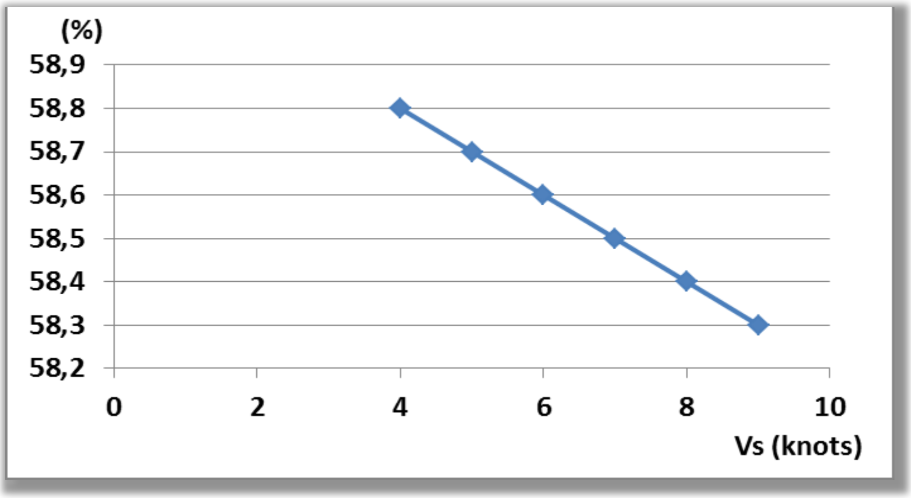

Fig. 12. Effisiency of Propeller - Vs

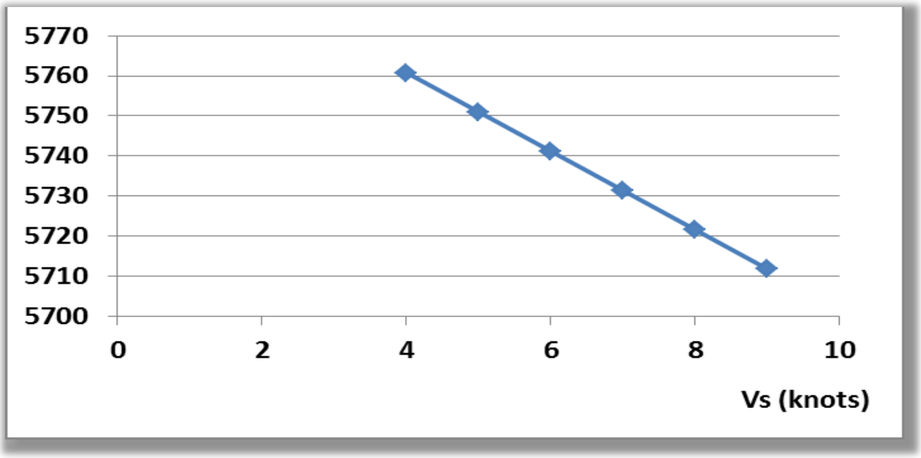

Fig. 13. Trust Coefficient – Vs

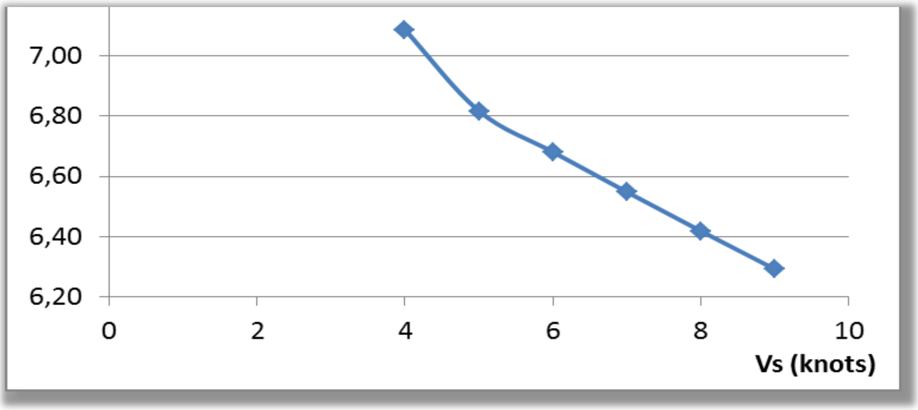

Fig. 14. Ship of Trust – Vs

IV Conclusion

From the two models of ship propeller types, namely type B4.40 and type B4.55, an explanation is given based on the results of the study that for variations in ship speed given data such as length perpendicular (LPP) 28 meters, propeller rotation (N) 290 rpm and a shaft horse power (SHP) of 452.5 Hp by setting a speed value varying from 4 knots to 9 knots, the average propeller efficiency for the B4-40 type is 60% while for the average trust or thrust the ship is 5873.5 kg and the average trust coefficient is

0.28. Likewise for the B4-55 type, the average propeller efficiency is around 58.6%, then the average thrust for the ship is 5736.3 kg and the thrust coefficient for the ship is

6.6. So it can be concluded that for the propeller type B4.40 based on the estimation results the trust or thrust is greater than the type B.55.

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