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Performance of VLCC Ship with Podded Propulsion System and Rudder

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ABSTRACT

Podded propulsion system becomes common installed in ships due to high maneuvering. The purpose of this paper is to discuss performance of both VLCC ships with podded propulsion and rudder. As initial offset data, published ship (SR221A) was used for generating hull form of a podded propulsion ship using Maxsurf software by maintaining the principal dimension: length, breadth, and draft. In order to suit installation of podded house, the stern part was modified. The hydrostatic data of both ships with podded propulsion and rudder are transferred to Ship Resistance and Propulsion Simulation software to determine the running speed by given same power. It was found that running speed produced by a ship using pod propulsion system lower than the speed produced by a ship using rudder.

KEY WORDS: *Rudder; Podded Propulsion System; Very Large Crude Oil Carrier*.

NOMENCLATURE

R_T	Total craft drag
R_f	Friction resistance
R_w	Wave making resistance
R_p	Podded resistance due to podded house
R_{body}	Resistance due to podded body
R_{strut}	Resistance due to podded strut
R_{fin}	Resistance due to podded fin
R_{inter}	Resistance due to interference
R_{whir}	Resistance due to whirling

1.0 INTRODUCTION

Propulsion is one of the important role should be considered during the ship design and construction because it will be affected on the ship manouvering, ship speed and the efficiency of the ship. Nowadays, researchers try to adapt the new technology of propulsor system that more efficient by using the electrical system such as podded propeller. The word POD means by propulsion with outboard electric motor. The podded propulsion being introduce since the middle of 1990. There are two company that mainly produce or manufactures the podded propulsion system which ABB and Rolls-Royce.

For the podded propulsion system, the propulsion and the steering system is combine together which means not using a rudder anymore to maneuver the ship. The podded propeller can be rotate at 360 degree of direction which improving the use of rudder. Podded propulsion system consists of the motor that connected directly to the podded propeller through the motor shaft. The podded propeller been using for variety types of ship such as ferries, cruise vessel, yachts, arctic tanker, drilling rigs, offshore supply vessels and icebreaker.

The most study nowadays is focus on the function or interaction of podded propeller as icebreaker which known as double acting tanker. Double acting tanker sail ahead at normal open sea and sail astern in ice. The main purpose of using double acting tanker is to reduce the cost that have been paid for using ice breaker when the tanker pass through the ice sea region such as at russia and arctic. The first double acting tanker be made is M.T. TEMPERA in 2002 and been propel by podded propeller.

This study focuses on the performance of the podded propulsion VLCC. The objectives of this study are to modify conventional hull design to be used for podded propulsion system, to determine resistance components of podded propulsion system, to determine speed of a podded propulsion system ship and compared with conventional ship at same BHP and RPM.

2.0 PODDED PROPULSION SYSTEM ON DOUBLE ACTING SHIP

Early 1990's, podded propulsion had been introduced as new electrical technology in marine and the originally concept was to improved the performance of icebreaker. Instead of using podded propulsion for icebreaker the naval architect had design a double acting ship hull that suitable for open water and ice condition by using the advantages of podded propulsion system.

The main role of the double acting tanker with the podded propulsion system is to go through the ice condition of sea. Without the double acting tanker, the vessel cannot break through the ice and without the podded propulsion system the vessel cannot propel in the stern position.

Therefore double acting tanker and the podded propulsion system are need each other to perform in ice condition and open water sea. Before this system are design, there are many of ways to overcome the problem during ice operation such as at Russian arctic but not reliable which are:

- Using transhipment which uses different types of vessel for different types of journey.
- Using icebreaker to be assistance for tanker pass through the ice.

Figure 1: Double acting ship run head in open water and astern in ice condition [marine.com].

The traditional method of using icebreaker vessel as assistance is not reliable because ship owner needs to spend extra money and its very costly rather than using DAT with podded propulsion system. DAT is very efficient in open sea and also in ice condition which perform ahead with open sea and astern in ice condition. There are some consideration should be taken during design process of double acting tanker with podded propulsion which are stern shape, ice loads on propulsion and hull, behaviour in ballast condition and number of propeller.

3.0 NUMERICAL SIMULATION OF PODDED PROPULSION VLCC PERFORMANCE

Simulation of podded propulsion ship performance was firstly hull and podded body and strut design using Maxsurf and then resistance and propulsion were estimated using Ship Resistance and Propulsion software as shown in Figure.2.

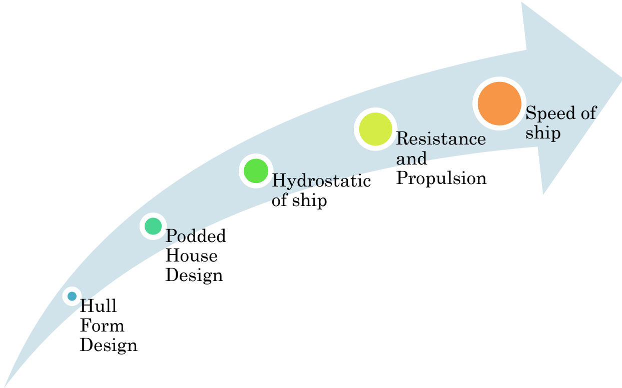

Figure 2: Flow chart of simulation of podded propulsion ship performance.

3.1 Hull Form Design

The principal dimensions of podded propulsion VLCC as shown in Table 1 are maintained for both conventional and podded propulsion ships.

Table 1: Principal dimension of podded propulsion VLCC.

Principle Dimension	meter
Length overall (LOA)	335.115
Length waterline (LWL)	325.528
Length between perpendicular (LPP)	320.00
Breadth moulded (B_m)	58.00
Depth moulded (Dm)	30.00
Draft	19.30

The design of hull was based on the existing design of SR221 as shown in Figure.3. There are 10 major stations for the offset but in the stern and the stem parts, the major stations were divided into small stations because to produce more accurate shape and produce smooth line which most of the stem and stern design are nonlinear lines. Accuracy and smooth of shape basically depend on number of waterlines and stations whereby more points to draw produce more accurate shapes.

Some modification on stern part is required to suit podded house installation as shown in Figure.4. The change of design should be considered all the hydrodynamic characteristics of hull because it will effect on the powering calculation. For this research, there are 45 waterlines for each station which was added from the conventional design to make sure the enough draft and depth for podded house to be installed. The additional points can be determined by using mathematical method which is graphical method by derive the line equation and determine the points that required. The fairing hull form is shown in Figure.5. The hydrostatic data of the hull form was estimated using the Maxsurf software as shown in the Figure.6.

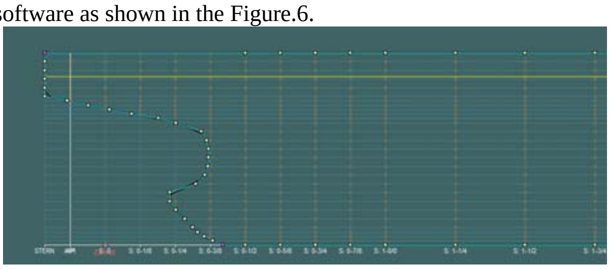

Figure 3: Stern hull design for conventional ship (rudder).

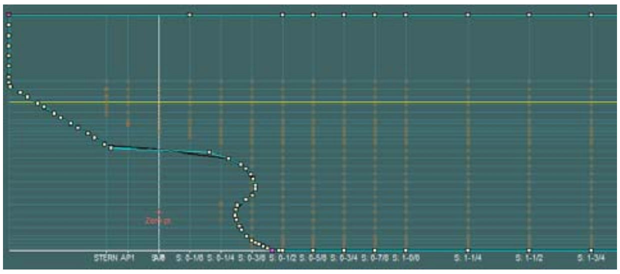

Figure 4: Stern hull design for podded propulsion system.

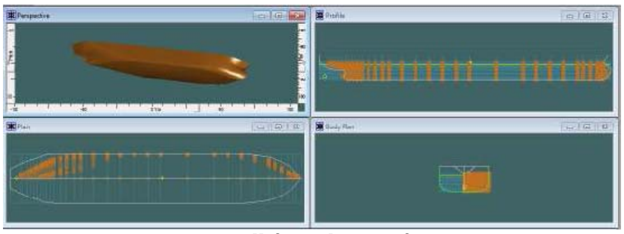

Figure 5: Hull form design of VLCC.

Hull Coefficients		Propeller	
C.block	0.785	No.Blade	5.000
C.prismatic	0.789	Prop.Dp	8.96
Cp.after	0.756	Prop.Pd	0.7699
Cp.fore	0.861	Prop.AE	0.4469
C.midship	0.995	Cav.No	0.7757
C.water plane	0.892	Prop.Weight	39
LCB (% LPP)	2.839	Prop.Moment	164270
Hull.Cor	0.000	Water Depth	100

Figure 6: Input data of podded propulsion ship used in the Ship Resistance and Propulsion Simulation software.

3.2 Podded House Design

Body and strut are main components of podded propulsion system. The design of these two components very important to make sure the system will produce more efficient power and less resistance.The offset data of podded house was draw based on the actual podded propulsion system. The actual pod house has been scaled to the size required and sketch it using excel. Based on the design and shape, the modification should be done on the each point by using mathematical method to smooth it. The critical modification has done on the linear and polynomial region at front and back pod body shape. The design of pod body will affect on the resistance and flow of water that effect on powering estimation. Therefore, modification on the design should be done to make sure no extra power required because of form drag effect.

Strut profile uses the rudder's offset of basis ship because of the shape of strut same as the shape of rudder but different in size. Basically the profile of the strut is called aerofoil shape which has standard shape. The different shape of aerofoil depends on the angle of attack and the chord length. The different between the aerofoil using in aircraft and the rudder of ship is rudder have same length of upper and lower chamber which is symmetry. The design of a podded house used in the present study was shown in the Figure.7.

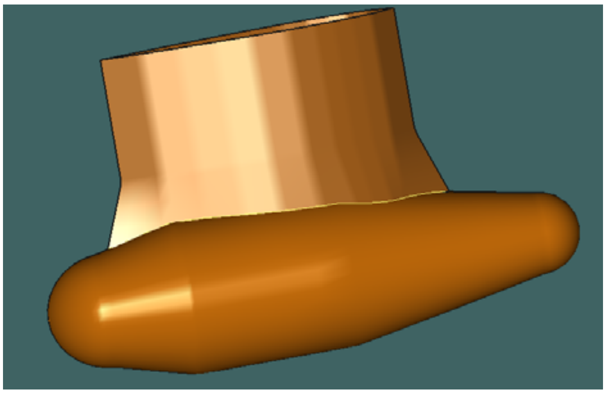

Figure 7: Podded house design.

After modification, the pod design be drawn an attached to the VLCC hull to estimate either the hull design suitable with the pod design or not. For improvement the design and shape of podded house, the podded house should be drawn and divided into small compartment and combine each compartment to be one shape of pod body. The podded house installed into the hull form is shown in the Figure.8.

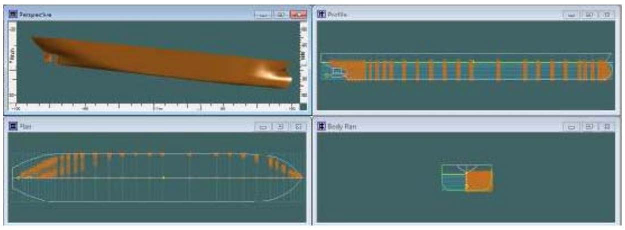

Figure 8: Hull and podded propulsion system.

3.3 Resistance and Propulsion of Podded Propulsion Ship

Basically, resistance of a ship with podded propulsion system (R_T) is similar to other ships, but the only different is additional resistance due to podded house (R_{pod}). The total resistance of the podded propulsion ship (R_T) can be written as

$$R_T = R_f + R_w + R_{pod} \quad (1)$$

The podded resistance (R_{pod}) consists of resistances at body, strut, fin, due to interference and whirling as written below:

$$R_{pod} = R_{body} + R_{strut} + R_{fin} + R_{intfe} + R_{whir} \quad (2)$$

4.0 RESULTS AND DISCUSSION

The resistance test is required to get the resistance data that very important to estimate the powering. There are many methods to determine the resistance data and for this study, using the numerical method to calculate and estimate the resistance parameter. The numerical method was run by the Naval-Offshore Simulation software which need input data such as principal dimension of the ship, offset data of design and hydrostatic data. Basically, the components that been calculated were the resistance of pod body, strut and hull.

In the simulation, a propeller with five blades of 8.9 meter of propeller diameter was selected. Based on the Figure.10, there are four major resistance component should be consider which are friction, delta, wave and additional resistance. Frictional resistance be the most high percentage of total resistance which about 86 percent and followed by correction resistance, wave resistance and additional resistance which are 8 percent, 3 percent and 3 percent respectively.

This study was focusing on the additional resistance which consists of the pod body, strut, interaction and whirling resistances. The fin resistance did not be considered because of there was no fin included in design the pod propulsion system for this study. From the Figure.9, the high percentage on additional resistance is strut resistance which about 77 percent. Then, body only provides about 20 percent of additional resistance due to high form drag rather than skin friction. Interaction resistance is resistance produce by the interaction between pod body and strut which about two percent. Next, about one percent is resistance produced by whirling effect which the resistance produce by vibration of the pod body and strut in the water.

Basically in design works, there are two conditions of propeller performances should be considered which are performance of propeller itself without effect of hull and the performance of propeller when installed behind hull. The performance of these two conditions actually gives different value of performance. The performance of the propeller behind hull is very important factors should be detail study because to show either the stern hull design will affect on the propeller performance or not which one of the main objective of this study.

The design of the propeller was based on the basis ship and from the basis data, the open water propeller performance can be calculated using the Naval-Offshore Simulation program. Also, the performance of the propeller behind of the hull can be calculated by using the offset data, principal dimension of hull and open water propeller performance data. This program uses numerical method to calculate the propeller performance behind the hull. Figure.10 shows the propeller efficiency of podded propulsion ship.

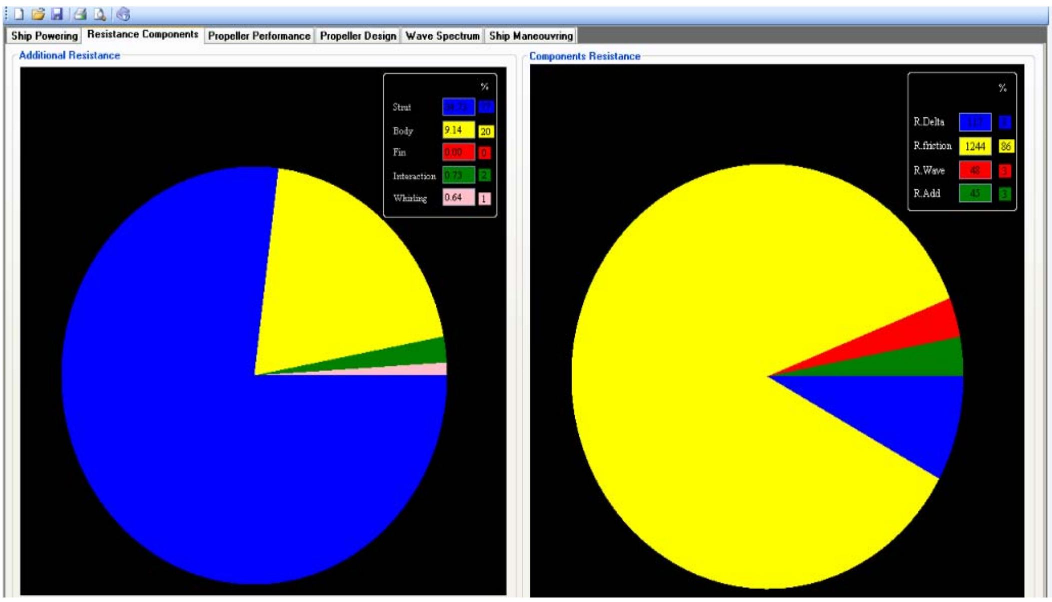

Figure 9: Resistance of a ship [Right] and component resistances of podded [left].

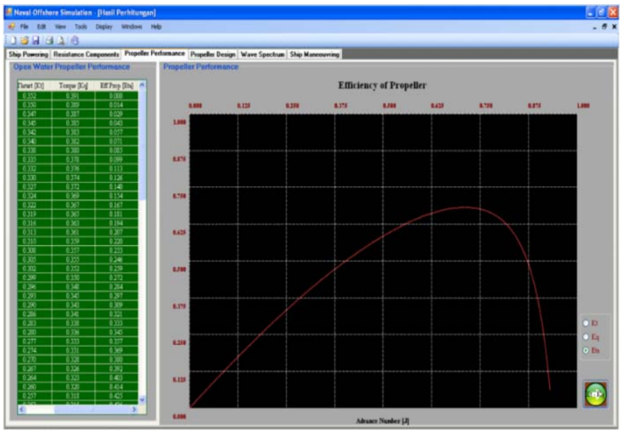

Figure.10: Estimated propeller efficiency of podded propulsion ship.

The efficiency of the podded propulsion system can be determined by doing the comparison of output data between the pod propulsion system and ship using rudder. The parameter that been used to compare was speed of the ship produced at same BHP and RPM conditions.

Based on the Figure.11 and Figure.12, at condition Maximum Continuous Rating (MCR) of engine there were different speed between conventional ship and ship using pod system. At same BHP and RPM, the speed of design ship produced by the conventional and the pod propulsion system was different which were 14.22 knot for the conventional and 13.97 knots for the pod propulsion ship. There are some losses due to resistance that make the ship slow in speed. But, there was some study on the resistance effect of form drag which because of pod shape. There are some losses due to resistance created by podded house and electrical losses. Other than that, based on the total area required for a ship using rudder and ship using pod propulsion system there were some different that effect on total resistance of both types of ship.

Table 2: Performance of ships with rudder and podded propulsion.

Type of ship	BHP (kW)	RPM	Speed (knot)
Ship with rudder	20006	76	14.22
Ship with Podded Propulsion System	20006	76	13.97

Other than that, based on the total area required for a ship using rudder and ship using pod propulsion system there were some different that effect on total resistance of both types of ship. Assume that the total area of the ship hull same for both ship but different in area of added components such as rudder, body and strut. Comparing with conventional system using rudder, the area of the podded house is higher about 30 %, as shown in Table.3, mostly from body.

Table.3: Total area of component

Type of ship	Components	Total Area (m^2)
Ship with rudder	Rudder	240.578
Ship with Podded propulsion	Body and Strut	315.601

For ship resistance, basically, there are there major resistance components should be considered which are friction, wave making and additional from podded system. It shows that 3 percent of total resistance contributed from podded propulsion. For podded resistance, five resistance components should be considered as follows: strut, body, fins, interaction between podded house and strut and whirling. The simulation shows that seventy seven percent of total resistance was contributed from the strut and twenty precent from the body.

Basically, for ship with rudder, there are only two components should be considered for resistance which are hull and rudder. But for the pod propulsion system, there are three main components should be considered which are strut, body and hull. Some additional resistances should be considered as well such as resistance produced by interaction between the strut and body. Therefore, generally podded propulsion system produces more resistance than using ship with rudder. Strut component contributes higher resistance than the body even though the total area of body is more than strut area which is 77 percent of total podded resistance as shown in the Figure.9. For this case of study, resistance divided into two main components which are frictional resistance and form drag resistances. Where, resistance of the body was mostly based on the form factor which shape of the body. But for total resistance, frictional resistance was mainly contributed resistance rather than form drag resistance.

5.0 CONCLUSIONS

Based on the result and analysis of the study, the conclusions are obtained. Design of podded propulsion VLCC ship using Maxsurf has been done. There are some modification has been done on the stern hull design to suit it with the pod body and strut design. The resistance of the podded propulsion system has been divided into four components of resistance which are pod body, strut, interaction between them and whirling effect. Based on the result, the strut resistance contributes high percentage of additional resistance which about 77 percents and the pod body only contribute about 20 percent of additional resistance. The resistance components of podded house have been successfully calculated using Ship Resistance and Propulsion Simulation. Speed of the VLCC ship using podded propulsion system has been determined by using Naval-Offshore Simulation program and compared with the conventional ship using rudder. The speed produced by the ship using pod propulsion system lower than the speed produced by conventional ship using rudder which V_{con}=14.22 knots and V_{pod} = 13.97 knots at same BHP and RPM condition.

Figure 11: Result of Pod propulsion system

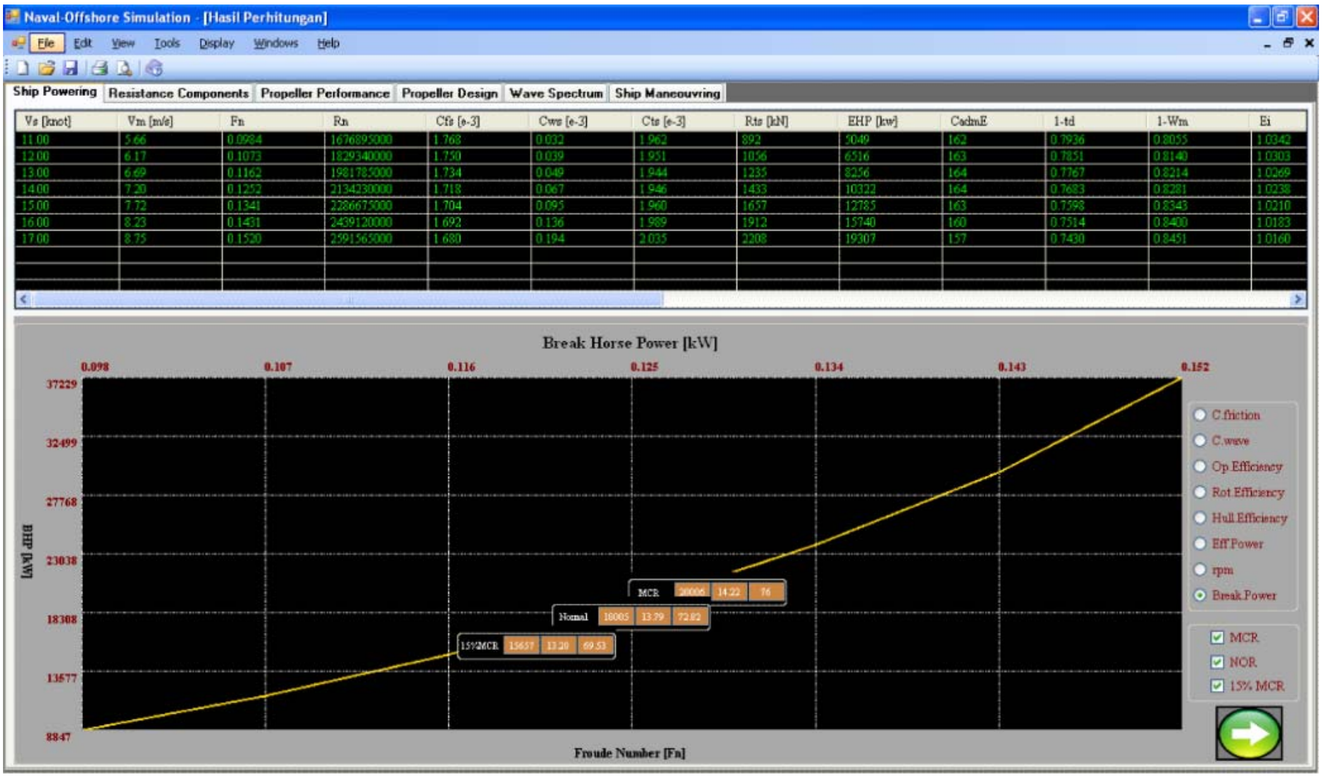

Figure.12: Result of conventional ship using rudder.

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