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The Experimental and Numerical Study of the Appendage DRAG Influence on Resistance of Ship

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ABSTRACT

The Resistance and power prediction is based on the result of CFD tools and model experiments. Appendages resistance is significant for high speed vessel. This paper discusses the significant increment of appendages resistance of high speed vessel. The model was tested with appendages and without appendages in the Ship Model Towing Tank at Marine Hydrodynamics Centre, Myanmar Maritime University. CFD analysis is also carried out and the results are compared for ship with skeg. The comparison of results shows that the coefficient differences are less staggered at higher speeds.

Keywords: Ship model experiments, CFD, Towing Tank

NOMENCLATURE

LOA	Length overall (m)
B	Breadth Moulded (m)
D	Depth Moulded (m)
T	Draft (m)
LWL	Length waterline (m)
▽	Volume of displacement (m3)
S	Wetted surface area (m2)
Δ	Displacement (tons)
VS	Speed of ship (knot)
PE	Effective power (kW)
M	Notation for model testing
P	Notation for program
Rt	Total resistance (kN)
CT	Total resistance coefficient
CF	Frictional resistance coefficient
CR	Residual resistance coefficient
Fn	Froude's number

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1. Introduction

Resistance calculation and power prediction are important in designing high speed vessel. Traditionally model testing is used to predict the resistance and power of the new design vessel. The use of appendages will alter the total resistance of the vessel. Appendages resistance is important for prediction of the resistance of high speed vessel. The increment of appendages resistance for high speed vessel is studied and compared with the resistance of ship with skeg.

Now a day CFD tools are widely used for prediction of ship's resistance and power. However the flow around the ship's hull is complicated, so that model experiments are still the most reliable data source on ship resistance determination. The model experiments are carried out in the Ship Model Towing Tank at Marine Hydrodynamics Centre, Myanmar Maritime University. Towing tank size established 2011 made in UK (CUSSON Technology) is 60m in length, 4m in breadth and 4m in depth. Maximum carriage speed is 4 m/s. CFD codes are also used in design step, validation of the results is carried out by comparing the model test results.

2. OBJECTIVE

This paper focuses on comparing the total resistance of high speed ship with and without appendages and to make verification for model tests results of the ship with skeg and CFD.

3. STUDY AREA

The total resistance of the ship of 81.33m in length with skeg is calculated by using CFD tools and then required is power predicted. Model of 2.42 m in length is fabricated and tested in model basin at Myanmar Maritime University. Total resistance of the ship is calculated from the towing test results by using Froude's Law of Comparison. In order to calculate the ship resistance non-dimensional coefficients have been used:[1, 2]

$$CT = CF + CR$$

Friction component of resistance is calculated by using ITTC'57 correlation line.

4. METHODOLOGY OF STUDY

4.1 DETERMINING THE MAIN DIMENSIONS

Main hull forms is round bilge symmetric displacement type with transom stern. The vessel has a centreline skeg. The main characteristics of the ships are listed in Table 1 below-

Table 1. Characteristics of ship

Main Particulars	Full Scale	Units
LOA	81.33	m
B	11.39	m
D	7.50	m
T	3.34	m
▽	1317.07	m^3
Δ	1350	tons
S	911.91	m^2

4.2 MODEL MAKING

The scale of ship model is 33.6 and wooden model of 2.42 m in length with centreline skeg is fabricated by CNC. For the prediction of appendages resistance, shafts, struts, bilge keels and two rudders are attached to the model. Stabilizers are also attached to the both sides of the model. The main particulars of the model at design condition are described in Table 2.

Table 2. Main particulars of model at design condition

Main Particulars	Model Scale	Units
LOA	2.420	m
B	0.339	m
D	0.223	m
T	0.099	m
▽	0.035	m^3
Δ	0.0356	tons
S	0.808	m^2

Fabricated wooden model with appendages are shown in figures below. Figure 1 shows the model with centreline skeg and Figure 2 is the installation of stabilizer to the model.

Figure 1. Model with centreline skeg

Figure 2. Installation of stabilizer to the model

5. EXPERIMENTAL APPROACH

Two test case studies have been carried out for the speed range of 1.04 to 2.174 m/s (Ship speed of 12 to 25knots). The appendages attaches to the model are listed in Table 3 below for each case.

Table 3. Model test Conditions

Test No.		1	2
Appendages	Rudder	☑	
	Shafts	☑	
	Shafts Brackets	☑	
	Stabilizer Fins	☑	
	Bilge Keels	☑	
	Skeg	☑	☑
	Strut Bossings	☑	
	Hull Bossings	☑	

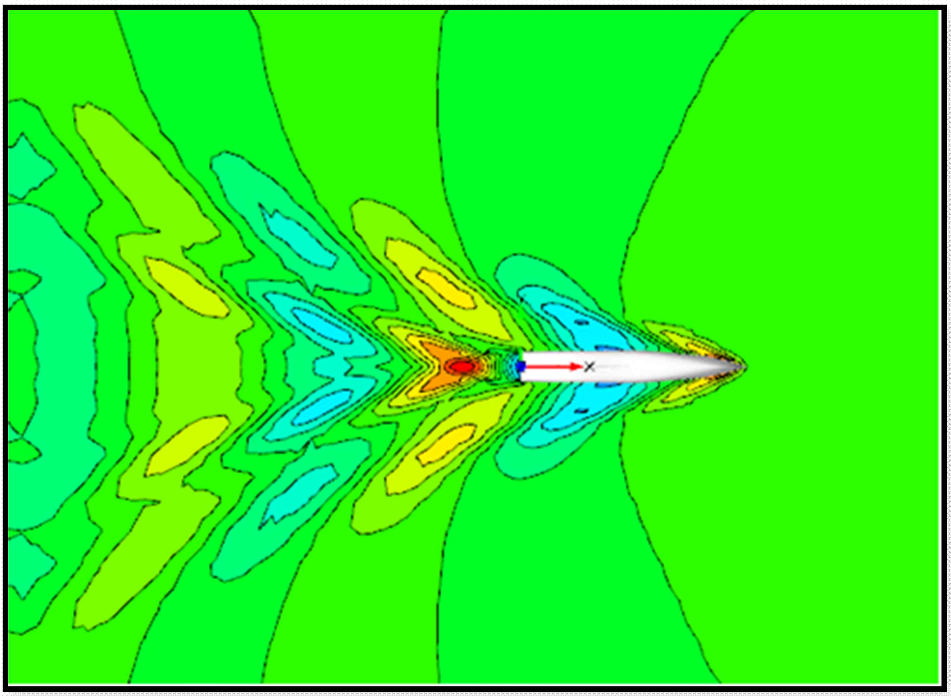
6. NUMERICAL APPROACH

The complexity of the flow around ship's hull, model experiments are still the most reliable data source on ship resistance determination; nevertheless, numerical methods have strongly advanced in this field, so that a combined use of both model tests and CFD codes can be very useful for ship design and for understanding the ship hydrodynamics [3].

Numerical computations are carried out around vessel using the code *SHIPFLOW*. The three software packages *XMESH, XPAN and XBOUND* are used for simulations. The main hull has 140 grid sections and 16 grid points. The free surface is panelled by 98 stations in longitudinal direction and 16 grid points.

CFD simulation is carried out for the ship hull with centreline skeg from the speed range of 12 knots to 25 knots. Figure 3 shows the CFD simulation of ship at a speed of 23 knots.

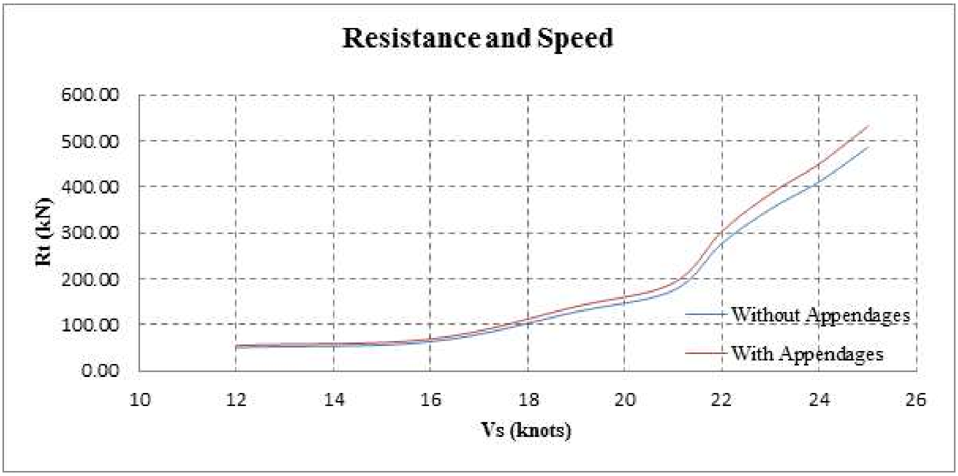
Figure 3. CFD simulation of ship at a speed of 23 knots



7. RESULT COMPARISON

The resistance comparison of the ship with appendages and ship with skeg is carried out for the speed of 12 to 25 knots. The comparison results show that when the speed of ship becomes higher, the total resistance of ship with appendages become higher than ship without appendages. Resistance difference is 8% at 12 knots and 9.5% at 25 knots. Figure 4 shows the resistance comparison of two tested conditions.

Figure 4. Resistance of ship with and without appendages



When No.2 model experiments data is selected to compare results as estimated by CFD, following results are found. For residual resistance coefficient, model towing test results are higher at most of the speeds. Differences are mostly from 1.5 to 6.5%. At the speed of 16 knots (Fn = 0.3) the residual resistance coefficient difference is about 15% (Fig. 5).

Figure 5. Residual resistance of CFD and towed model

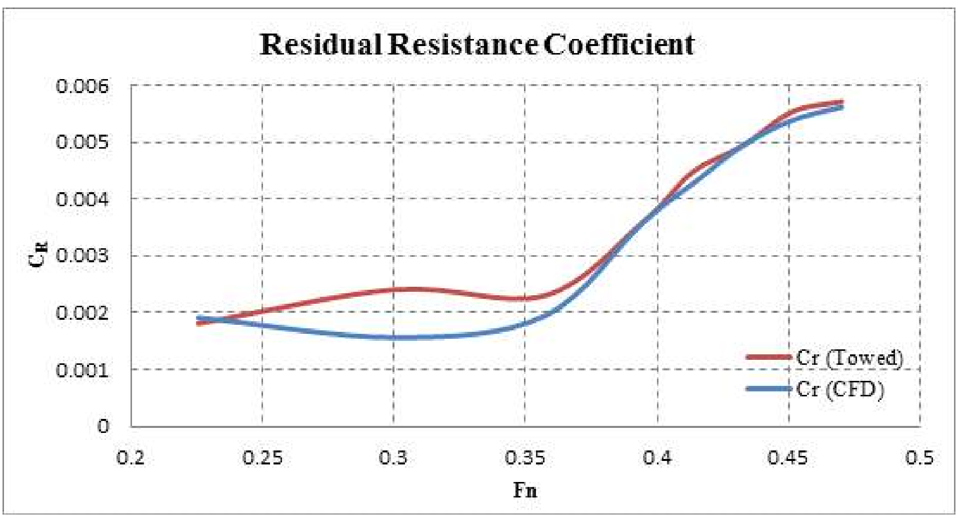


Figure 6. Resistance comparisons of CFD and towed model

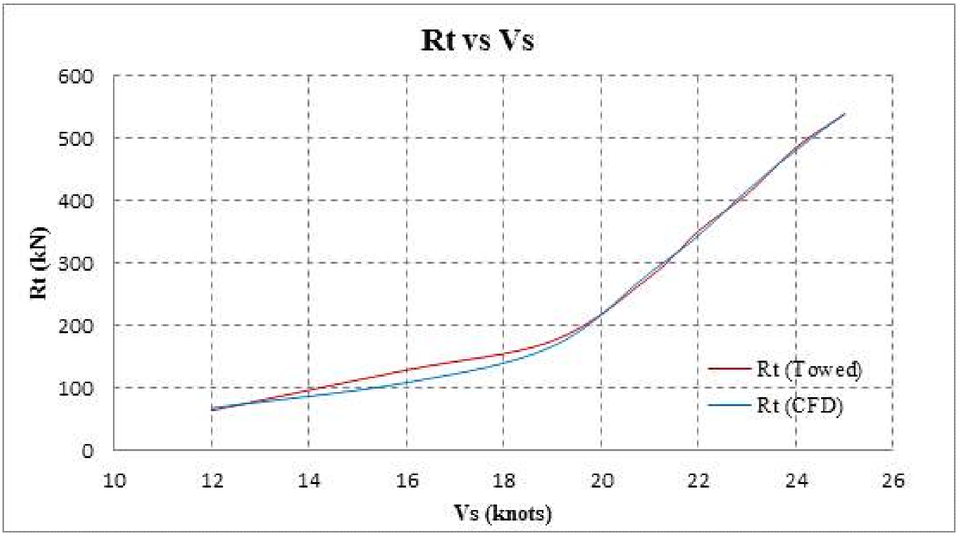
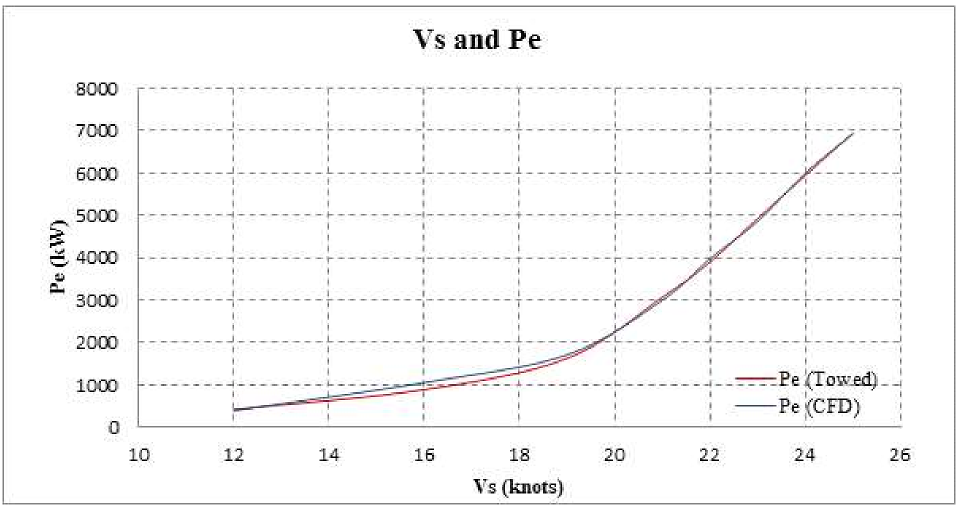


Figure 7. Effective powers of CFD model and towed model



8. CONCLUSION

Towing test analysis was carried out for the model with two conditions. Test no.1 is with all appendages without propeller and test no.2 is bare hull with centreline skeg. The higher the speed, the more the total resistance of the ship with appendages becomes. The results of test no.2 are compared with CFD results and the comparison shows that experimental results and CFD results have good agreement. At higher speeds, the coefficient differences show less staggered. But it is still need to carry out self-propelled test numerically and compared with the model test result.

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