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EXPERIMENTAL MODEL TESTS TO IMPROVE A TANKER RESISTANCE PERFORMANCE

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ABSTRACT

The ship resistance is one of the most important hydrodynamics performances, being related to the contractual ship speed. The experimental model tests can be used to measure and improve the resistance performance. In this paper, the possibility of using the experimental techniques in order to improve a tanker model resistance is demonstrated, based on a bulbous bow modelling solution. In this context, the results obtained in the Towing Tank of the Naval Architecture Faculty of "Dunarea de Jos" University of Galati, related to a tanker model resistance with and without bulbous bow are presented. The bulbous bow form was realised based on the hydrodynamics principles adapted to the bow forms of the tanker. In the case of the bulbous bow solution, a significant reduction of over 8% of the tanker model resistance was obtained, in the design speed domain.

Keywords: tanker model resistance tests, bulbous bow solution.

1. INTRODUCTION

In order to obtain the contractual ship speed, the resistance performance must be studied and optimized.

The experimental techniques specific to the Towing Tanks can be used to measure the ship model resistance with a necessary level of accuracy. Depending on the model resistance results, distinct solutions based on the hydrodynamics principles can be applied to increase the resistance performance.

In this paper, a bulbous bow solution was studied to reduce a tanker resistance in the design speed domain.

In this context, the results obtained in the Towing Tank of the Naval Architecture Faculty of "Dunarea de Jos" University of Galati, related to a tanker model resistance with and without bulbous bow are presented.

The main dimensions of the Towing Tank are: length=45 m, width=4 m and depth=3 m (Photo 1). The towing carriage with the maximum speed of 4 m/s has a specific data acquisition and analyzing system.

Photo 1. Towing carriage

The tanker has an inclined stem line, open stern, full shapes with high block coefficient and two shaft lines with propellers and specific appendages (rudders, brackets and skegs).

The main dimensions of the tanker and of the experimental model at the design draught are presented in Table 1.

The values of the main dimensions ratios of the tanker are L_w/B=5.45 and B/T=3.48, where L_W is the length of waterline, B is beam and T is the draught.

The experimental model was manufactured according to the ITTC Recommended Procedures and Guidelines 7.5-01-01-01 [2], on a scale of 1:38 (Photo 2). A wire of 0.8 mm in diameter mounted in the forward part of the model solves the turbulence stimulation problem.

The experimental model tests were performed by using the ITTC Recommended Procedures and Guidelines 7.5-02-02-01 [3], the trim and the sinkage of the model being unrestricted. The wave pattern was recorded.

Table 1. Main dimensions of the tanker

Main characteristics	Full scale	Model scale 1/38
Length of waterline, L_W [m]	117.674	3.097
Beam, B [m]	21.6	0.568
Draught, T [m]	6.2	0.163
Longitudinal center of buoyancy from the aft perpendicular, LCB [m]	58.266	1.533
Volumetric displacement, ∇ [m^3]	12252.0	0.223
Wetted surface (bare hull), S [m^2]	3208.1	2.222
Block coefficient, C_B	0.7775	
Midship section coefficient, C_M	0.9954	
Waterline coefficient, C_W	0.8526	

Photo 2. Experimental model of the tanker

The next chapter analyses the results of the experimental model tests.

2. MODEL TESTS RESULTS

The results of the experimental model resistance tests, in the case of the tanker without bulbous bow solution are presented in Table 2 [1]. A speed range between 8-16 Kn, at full scale was considered.

The following notations were used: v_s is the ship speed at full scale, v_m is the model speed, F_n is the Froude number and R_{Tm} is the model resistance of the tanker (without bulbous bow solution, in this case).

Table 2. Tanker model resistance results without bulbous bow solution

Test no.	v_s [Kn]	v_m [m/s]	F_n	R_{Tm} [N]
1	8	0.668	0.121	2.996
2	9	0.751	0.136	3.610
3	10	0.834	0.151	4.354
4	11	0.918	0.167	5.390
5	12	1.001	0.182	6.996
6	13	1.085	0.197	8.266
7	14	1.168	0.212	9.746
8	15	1.252	0.227	11.540
9	16	1.335	0.242	14.575

The diagram of the tanker model resistance, without bulbous bow solution, depending on the model speed is presented in Figure 1.

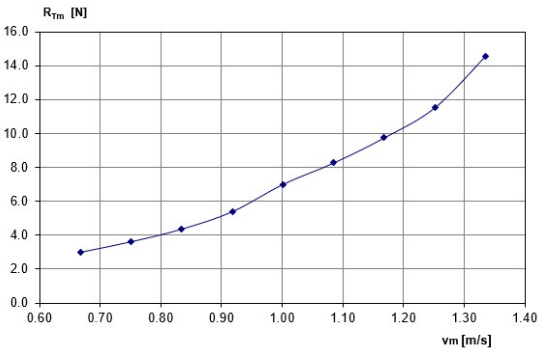

Fig.1. Tanker model resistance diagram, without bulbous bow solution

A local increase of the tanker model resistance was observed, in the speed range between 11-13 Kn at full scale (corresponding, at model scale, to the domain 0.918-1.085 m/s).

The wave pattern depending on the ship speed is presented in Photos 3-11 [1], for the case of the tanker model without bulbous bow solution.

Due to bluntness of the bow part of the tanker, a typically horseshoe vortex occurs, with breaking waves and vortical structures, amplified by the increased speed [1].

Photo 3. Wave pattern, v_s=8 Kn

Photo 4. Wave pattern, v_s=9 Kn

Photo 5. Wave pattern, v_s=10 Kn

Photo 6. Wave pattern, v_s=11 Kn

Photo 7. Wave pattern, v_s=12 Kn

Photo 8. Wave pattern, v_s=13 Kn

Photo 9. Wave pattern, v_s=14 Kn

Photo 10. Wave pattern, v_s=15 Kn

Photo 11. Wave pattern, v_s=16 Kn

In order to reduce the tanker model resistance, the bulbous bow solution was applied, according to the hydrodynamics principles. In this case, it was modelled a bulb having a circular shape in the middle line plan, with relative small cross-sectional area and reduced length. The bulb was placed below the design waterplan.

The forward part of the tanker model with bulbous bow solution is presented in Photo 12.

Photo 12. Bulbous bow solution

The bulbous bow efficiency has been checked in the speed range between 12-14 Kn at full scale (corresponding, at model scale, to the domain 1.001-1.168 m/s). The results of the experimental model resistance tests with bulbous bow solution are presented in Table 3.

Table 3. Tanker model resistance results with bulbous bow solution

Test no.	v_s [Kn]	v_m [m/s]	R_{Tm} [N]		Diff. [%]
			Without bulb	With bulb	
1	12	1.001	6.996	6.394	-8.6
2	13	1.085	8.266	7.574	-8.4
3	14	1.168	9.746	9.266	-4.9

The comparative diagram of the tanker model resistance, with and without bulbous bow solution, depending by the model speed is presented in Figure 2.

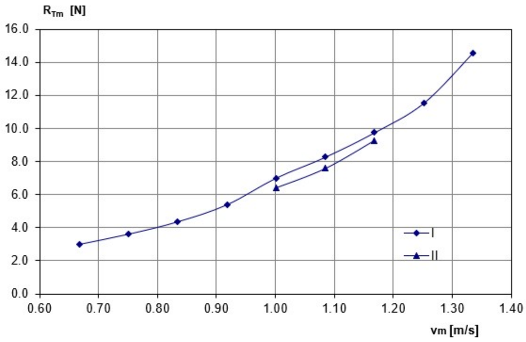

Fig.2. Comparative diagram of the model resistance: I-without bulb; II-with bulb

A significant percentage reduction between 4.9%-8.6% of the model resistance (noted in Table 3 with Diff.) can be observed in the tested speed range.

Photos 13-15 show the wave pattern in the speed range between 12-14 Kn at full scale, for the case of the tanker model with bulbous bow solution.

The reduction of the horseshoe vortex occurs, with moderate breaking waves and vortical structures, due to the bulbous bow solution.

Photo 13. Wave pattern, v_s=12 Kn

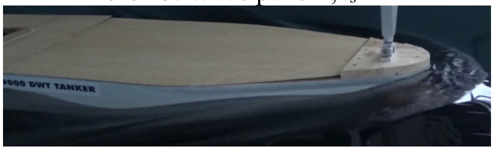

Photo 14. Wave pattern, v_s=13 Kn

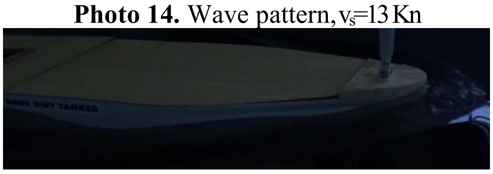

Photo 15. Wave pattern, v_s=14 Kn

4. CONCLUDING REMARKS

In order to improve a tanker resistance performance, a bulbous bow solution was adopted, with circular shape in the middle line plan, reduced length and relative small cross-sectional area.

A significant reduction of over 8% of the tanker model resistance was obtained in the design speed domain.

Acknowledgements

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