EXPERIMENTAL MODEL TESTS TO IMPROVE A TANKER RESISTANCE PERFORMANCE

Dan Obreja
“Dunarea de Jos” University of Galati,
Faculty of Naval Architecture, Galati,
Domneasca Street, No. 47, 800008, Romania,
E-mail: dan.obreja@ugal.ro

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 $L/\omega=5.45$ and $B/T=3.48$, 

© Galati University Press, 2021
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, $V$ [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     |                  |

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       |

![Photo 2. Experimental model of the tanker](image)

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 (correspond-
ing, 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 re-
sistance, the bulbous bow solution was ap-
plied, according to the hydrodynamics prin-
ciples. 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 waterplane.

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] | $R_T$ [N] | Diff. [%] |
|----------|-------------|------------|----------|-----------|
|          | With bulb   | Without 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.

![Photo 13. Wave pattern, $v_s=12$ Kn](image13)

![Photo 14. Wave pattern, $v_s=13$ Kn](image14)

![Photo 15. Wave pattern, $v_s=14$ Kn](image15)

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**

The research was supported by Negrea Ilie PFA from Romania, project number 641/2014, for which it is greatly acknowledged.

**REFERENCES**

[1]. Obreja, C.D., Domnisoru, L., Pacuraru, S., “Model resistance tests – 9000 dwt Tanker”, Research Project no. 641, 2014.

[2]. ITTC Recommended Procedures and Guidelines 7.5-01.01.01, “Ship models”, 26th ITTC, 2011.

[3]. ITTC Recommended Procedures and Guidelines 7.5-02.02.01, “Testing and Extrapolation Methods. Resistance Test”, 23rd ITTC, 2002.

*Paper received on October 30th, 2021*