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COMPARATIVE ANALYSIS OF THE MANOEUVRABILITY PERFORMANCE FOR A 9000 TDW CHEMICAL/OIL TANKER

Ana Maria AGACHE
"Dunarea de Jos" University of Galati,
Faculty of Naval Architecture, Galati, Domneasca Street, No. 47, 800008, Romania,
E-mail: anamaria.agache2010@yahoo.com

Radu BOSOANCA
"Dunarea de Jos" University of Galati,
Faculty of Naval Architecture, Galati, Domneasca Street, No. 47, 800008, Romania,
E-mail: radu.bosoanca@ugal.ro

ABSTRACT

The concept of manoeuvrability is very important for efficient ship operation but also in ship safety. The aim of this paper is to test and perform a comparative analysis of manoeuvrability performance of a 9000 tdw chemical/oil tanker. The comparative analysis has been performed between the results obtained based from two software's, namely PHP and MPP, but also between the results obtained in the sea trials with the output data from MPP. In this way it will be shown the differences (if any) in terms of manoeuvrability., and if the two used platforms are effective for providing preliminary determination of performances of manoeuvrability.

Keywords: manoeuvrability, turning circle, preliminary, estimation, sea trials

1. INTRODUCTION

Manoeuvrability studies the motion of free-surface vessels in the horizontal plane [1]. The concept of manoeuvrability encompasses several distinct nautical qualities, including: course stability (the ability of the vessel to maintain its course), manoeuvrability itself (the ability of the vessel to change course rapidly) and the change of speed (including stopping).

The ship whose handling characteristics we will test in this paper is called Mayouri.

The Mayouri [2] is a double-hull, double-bottom chemical tanker built in Romania, in Constanta shipyard in 2017 under Bureau Veritas classification. She is currently sailing under the French flag. It is a vessel with a maximum length of 119.43 metres; width of 21.6 metres and weight of 9000 tdw.

The vessel is outfitted with a Wartsila-produced diesel engine having an installed power of 4080 kW. Additionally, it features a bow thruster, enhancing its manoeuvrability significantly.

Figure 1. Mayoury vessel

The main dimensions of the vessel are shown in the table below.

Ship's Data		
Tipul navei	*9000 dwt Twin screw double hull oil / CHEMICAL TANKER*	
Lungimea maxima	[m]	*119.43*
Lungimea între perpendiculare	[m]	*115.00*
Lungimea la plutire		*117.67*
Lățimea teoretică	[m]	*21.6*
Înălțimea	[m]	*8.64*
Echipaj		*14 persoane*
Tonaj	[tdw	*8900*
Pescaj (design.)	[m]	*6.2*
Viteza	[kn]	*13*
Coeficientul bloc		*0.7775 f(Lwl)*
Coeficientul bloc		*0.7955 f(Lbp)*
Puterea MCR [kW]:		*2x2040*
Motorul principal		x 2
Producator		*Wartsilla*
Tipul		*6L26*
Motor în 4 timpi		*6/4T*
Reductor		*Wartsila*
Tipul		*SCV 68-P46*
Raport de		*1 : 4.45*
Turația motorului [rpm]:		*1000*
Montantul motorului		*Resilient*
Elice		*Wartsila*
Tipul		*4 F1000*
Numărul de pale		*4*
Diametru [m]:		*3*
Puterea nominală [rpm]:		*224.7*
Tip elice		*CPP Elice cu pas reglabil*
Autonomie		7000 Mm

Figure 2. Main characteristics

2. ESTIMATION OF THE MANOEUVRABILITY PERFORMANCE IN PHP

The estimation of the manoeuvrability performance of the studied vessel were carried out using two software platforms, one of which was designed and developed by the Faculty of Naval Architecture, Galati.

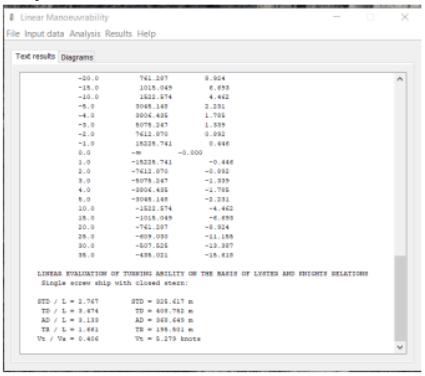

Figure 3. Results of manoeuvrability estimation for portside manoeuvre in PHP

The first software that will initialize the estimation of handling performance is called PHP [3] (Preliminary Hydrodynamics Performance), implemented by the Faculty of Architecture Naval Architecture, Galati within the Faculty's Research Centre. For the proper functioning of the program and for the accuracy of the results, several essential data were introduced in the process of estimating the manoeuvrability performance.

A rudder angle of 35° shall be used to calculate port manoeuvrability performance.

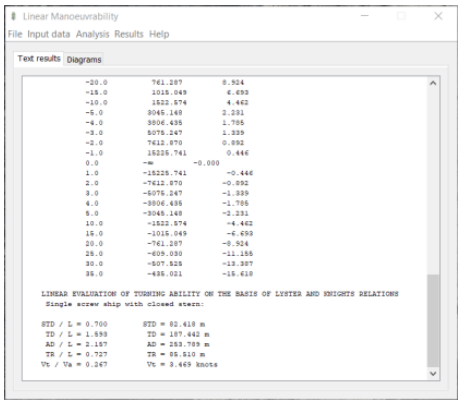

Figure 4. Results of manoeuvrability estimation for starboard manoeuvre in PHP

3. ESTIMATION OF THE MANOEUVRABILITY PERFORMANCE IN MPP

The second tool that will serve as a working platform in estimating the performance of manoeuvrability performance is the MPP [4] (Manoeuvring Prediction Program) developed by Professor M.G. Parsons, of the University of Michigan, USA.

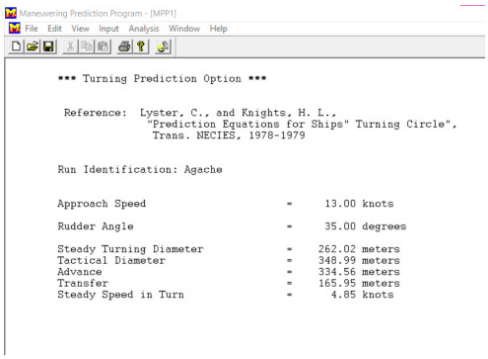

Figure 5. Results of manoeuvrability estimation for portside manoeuvre in MPP

A first step in estimating the results is to create a new project, with the ship whose performance we are testing. Then the necessary input data is added to obtain the results. To estimate the manoeuvrability performance on the port side, the rudder angle will be 35° and for the starboard side -35°.

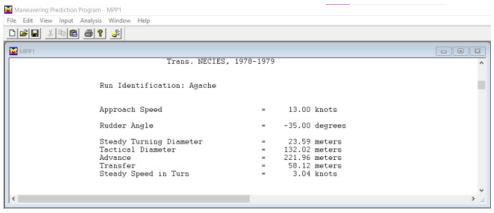

Figure 6. Results of manoeuvrability estimation for starboard manoeuvre in MPP

4. RESULTS FROM THE SEA TRIALS

In order to achieve the desired result, the Excel platform was a final tool in the whole process. A series of gps coordinates were transformed into Cartesian coordinates from degrees, minutes, seconds into metres, through a series of specific formulas.

The table shows the recordings from the sea trials at the turning manoeuvre to port side, which were recorded from second to second, starting at 15:29:30. The 9 recordings are part of a total of 408.

Index	UTC	Lat	Lon	SoG	CoG
0	15:29:30	43.99791	28.90612	5.41	1.23
1	15:29:31	43.99796	28.90613	5.33	0.47
2	15:29:32	43.99801	28.90613	5.36	0.18
3	15:29:33	43.99805	28.90613	5.48	0.04
4	15:29:34	43.9981	28.90613	5.51	0.3
5	15:29:35	43.99815	28.90613	5.41	0.36
6	15:29:36	43.9982	28.90613	5.33	0.97
7	15:29:37	43.99825	28.90613	5.4	0.79
8	15:29:38	43.9983	28.90613	5.5	359.78
9	15:29:39	43.99834	28.90613	5.43	359.57

Figure 7. Main table of port turning coordinates

Index	UTC	Lat	Lon	SoG	CoG
0	15:21.0	43.98134	28.90137	5.49	357.75
1	15:22.0	43.98139	28.90137	5.58	358.29
2	15:23.0	43.98144	28.90137	5.62	357.78
3	15:24.0	43.98149	28.90136	5.53	356.27
4	15:25.0	43.98154	28.90136	5.5	355.53
5	15:26.0	43.98159	28.90135	5.57	356.06
6	15:27.0	43.98164	28.90135	5.61	356.79
7	15:28.0	43.98169	28.90135	5.55	357.74
8	15:29.0	43.98174	28.90134	5.53	359.03
9	15:30.0	43.98179	28.90134	5.56	359.23

Figure 8. Main table of starboard turning coordinates

The table shows the recordings from the sea trials at the turning manoeuvre to starboard. These were generated second by second, starting at 15:21:00. The 9 recordings below are part of a total of 450.

Based on the records from the sea trials centralised in tables, a series of the representative charts were created for the port and starboard turning.

In figure 7, we can see that the port turning manoeuvre, carried out during the sea trials, underwent changes in terms of the turning circle. Influences of environmental factors had a major impact on it.

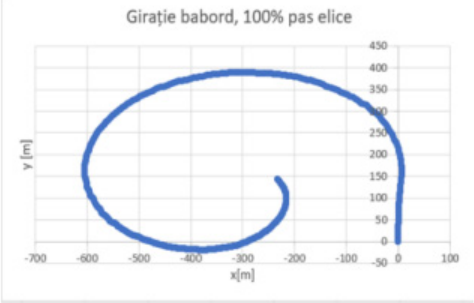

Figure 9. Port turning diagram

In figure 8, we can see that environmental influences had a major impact on the conduct of the trials. When turning to starboard, the diameter of the turning circle intersects the initial direction of travel of the ship.

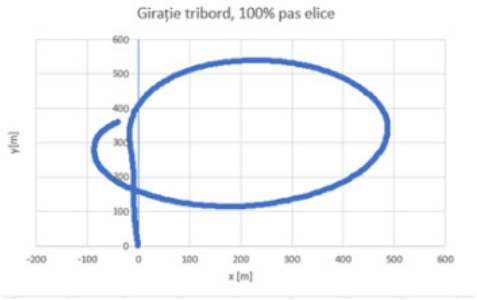

Figure 10. Starboard turning diagram

Environmental factors are a very important parameter in terms of the sea trials because they have a very big influence on them.

In the ship's sea trials, the environmental factors present were as follows:

Forţa vântului	3° Beaufort
Direcţia vântului	30°
Înălţimea vântului	1 m
Direcţia valurilor	30°
Adâncimea apei	35 m

Figure 11. Environmental factors from sea trials

5. COMPARATIVE ANALYSIS OF EMPIRICAL VS. SEA TRIAL RESULTS

The comparative analysis of empirical vs. natural results was performed with the purpose of verifying the results so that the results behind the mathematical model are as close as possible from the sea trials.

The preliminary design platforms studied do not consider the influence of environmental factors, considering ideal calm water conditions, this requires further examination. Results analysis shows whether the manoeuvrability performance is in line with or not within IMO conditions [5] and regulations.

Giraţia la babord	PHP	MPP	Probe de mare	Criterii IMO
Avansul	3.2	2.9	3.4	$4,5^{*}L_{pp}$
Diametrul tactic	3.6	3.0	4.3	$5^{*}L_{pp}$

Figure 12. Compliance with IMO criteria

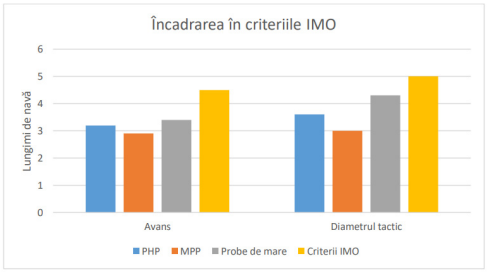

Figure 13. Comparative diagram of the results obtained from the design platforms and IMO criteria

In the above figure 12, the parameters of the turning manoeuvre have been transformed into ship lengths using specific formulae for comparison with IMO criteria. After obtaining the results it can be noticed that these parameters do not exceed the values of 4.5 hull lengths for the advance and 5 ship lengths for tactical diameter which leads to compliance with IMO criteria.

From the diagram above, it can be observed that the parameters of the turning manoeuvre fall within the IMO criteria.

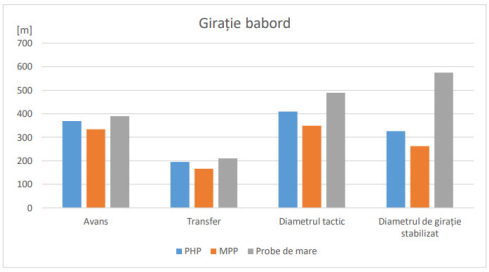

Figure 14. Results of portside handling performance estimation

The results obtained from the MPP preliminary design platform were not satisfactory in relation to those obtained from the sea samples. From this point of view, the following will be analysed only the results obtained from the PHP platform.

- As far as the vessel's advance is concerned, it can be seen from the figure above that result obtained using the PHP platform is very close to that obtained in the sea trials, with an error of only 5.8%.
- Regarding the ship's transfer, it can be observed, from the above figure, that the result obtained through the PHP platform is very close to the one obtained during the sea trials, with an error of only 7.1%.
- As far as the tactical diameter of the vessel is concerned, it is noticeable that the result obtained by means of the PHP platform is lower than the one obtained in the sea trials, by 19.6%.

This difference may also be due to environmental conditions (wind, wave, currents).

- The results obtained using the PHP platform for stabilized turning diameter, are lower than the results from the large samples by 76.4%.

6. CONCLUSION

In the study case, "Comparative analysis of the manoeuvrability performance of a 9000 $m3$ chemical tank" preliminary manoeuvrability performance estimation programs were used, such as PHP and MPP. These platforms generated a series of parameters corresponding to the manoeuvrability port and starboard turning with a 35° rudder angle, respectively -35°.

The results acquired were compared with the results from the sea trials, so we can conclude the following:

- The preliminary design platforms studied do not take into account the influence of environmental influences, which is quite important considering the ideal conditions of calm water, so errors occur at an early stage.
- In the PHP platform, the gained results for the vessel advance as well as the transfer are relatively close to the results from the sea trials, but the differences in stabilised turning diameter are substantially larger than for the trials, which suggests that the results are inconclusive.
- In MPP and PHP platforms, when turning to starboard at an angle of rudder, the limitation of the programmes makes the results greatly underestimated compared to the sea trials, which suggests inconclusive results.

The preliminary design programs studied have some limitations in terms of ship manoeuvrability, but nevertheless demonstrate their usefulness in such cases when quick results are needed.

In general, initial design programs overestimate the values of the results, however, in the case of "Comparative analysis of the manoeuvrability performance of a chemical tanker of 9000 $m3$", the results were underestimated.

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