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EXPERIMENTAL METHODS FOR DETERMINING THE CHARACTERISTIC QUANTITIES OF UNCONVENTIONAL NAVAL PROPELLERS

C. M. Nita [1], P. Bocanete [1], I. C. Scurtu [2]

[1] Constanta Maritime University, 104 Mircea cel Batran Street, 900663 Constanta, Romania

[2] Naval Academy Mircea cel Batran, Constanța, Romania

Abstract. Basin research involves the practical realization of the scale structure and the analysis of the results according to the studied models and working frequency. The obtained measurements are close in value to those of the numerical simulations, this confirming the numerical results obtained with Ansys Fluent.

The analysis carried out on the non-conventional naval propulsion includes all the calculation elements to be able to expand the understanding of this type of propulsion to be able to find the most suitable ones for use in the naval field and not only.

The research carried out in this paper presents numerous elements of analysis of the unconventional naval propulsion system. By plotting and validating the thrust functions for a blade, a complete analysis of how this propulsion works is achieved.

Keywords: propulsion, naval, test, basin measurement.

1. Organization of measurements to determine the characteristic sizes of non-conventional naval thrusters

The measurements were carried out in the laboratories of the Maritime University of Constanta. For the measurements we used the test basin and we used the clamping mechanisms and sensors described below.

To complete the study of non-conventional naval thrusters, the hypotheses and theoretical calculations regarding the flow of water, the values of the parameters resulting from the numerical simulation with Computational Fluid Dynamics ANSYS-Fluent, were experimentally validated.

The main objectives of the validation activity on the completed models were:

- Measurement of thrust forces created for different working frequencies.
- Calculation of working amplitudes for test models
- Comparison of the results obtained through numerical simulation with ANSYS Fluent CFD, with those obtained during real tests.
- Choosing the optimal constructive model among the studied models and explaining the selection.
- Determination of the pressures and dynamics around the "Dolphin tail" propeller blade.

2. Description of the test stand

The test stand is made of an electric motor with 2 speed steps that drives the test models in oscillatory motion according to the diagram in figure 1.

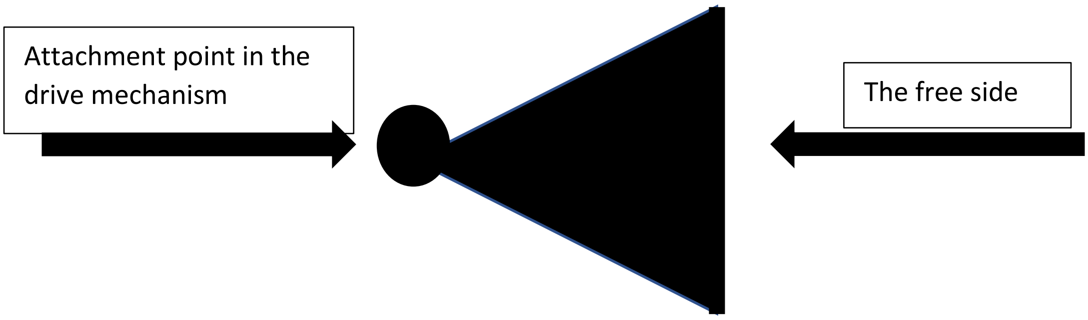

Figure 1.: Clamping scheme in the test stand

5 different models were mounted on the test stand:

- 4 equilateral triangles with size l - side of: 5,10, 15 and 20 (black color),
- an additional model with a side of 20 cm (blue).

It is observed that the thrust force has almost constant values when the non-conventional propulsion is stabilized during the test. Higher or lower values are observed when the propulsion blade changes its angle of inclination with respect to the horizontal. That is why in all tests the blade is kept in a horizontal position to avoid these effects.

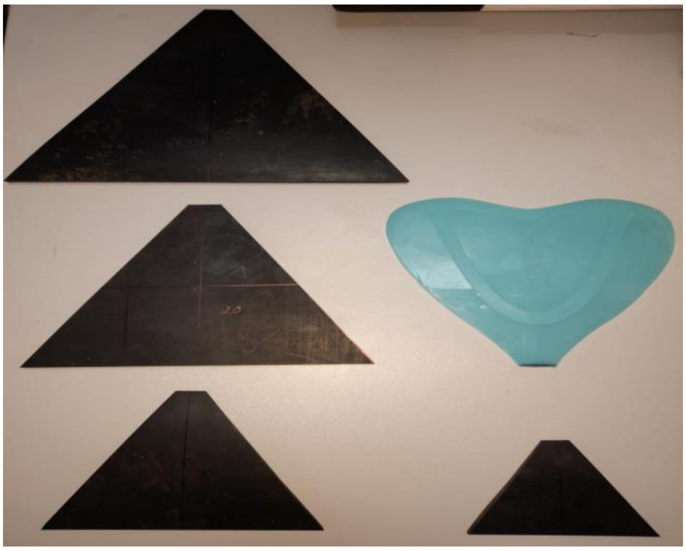

Fig. 2. Physical models for basin tests

Fig. 3. The mechanical realization of the conversion of circular motion to oscillatory motion

Fig. 4. Motion testing and calibration as required for pool testing

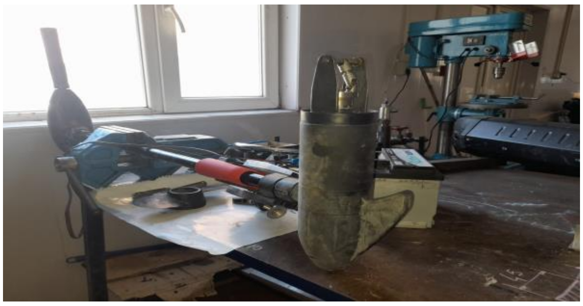

Fig. 5. Propulsion modification and adaptation for the "Dolphin Tail" system

Fig. 6. Fixing mechanism for the "Dolphin Tail" propulsion system

3. The method of measuring the characteristic sizes of non-conventional naval thrusters

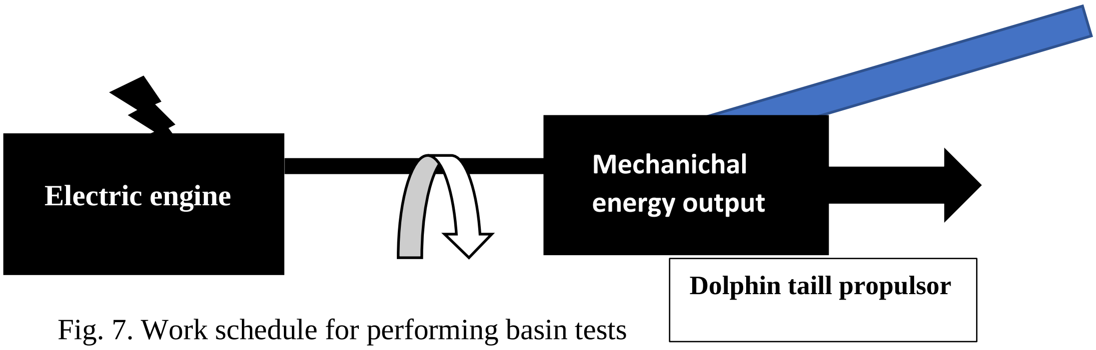

Fig. 7. Work schedule for performing basin tests

Fig. 8. Initial testing with standard propellers for comparative analysis

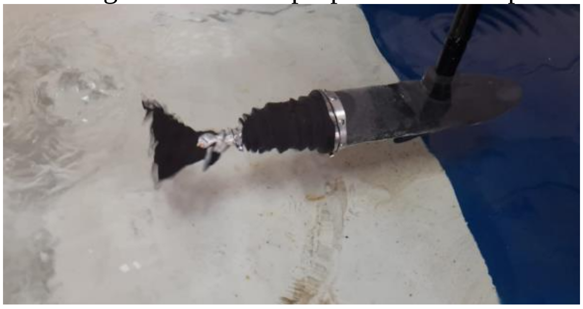

Fig. 9. Measurement of the characteristic sizes of non-conventional naval thrusters

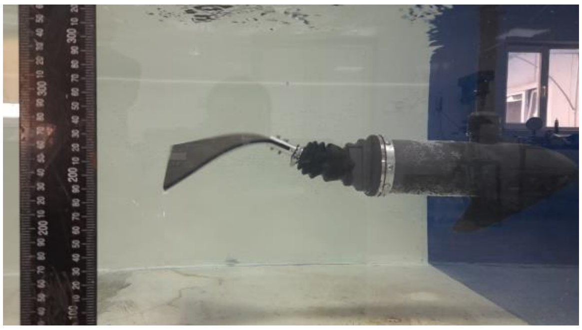

Fig. 10. Measurement of pala_z movement amplitudes (test 1)

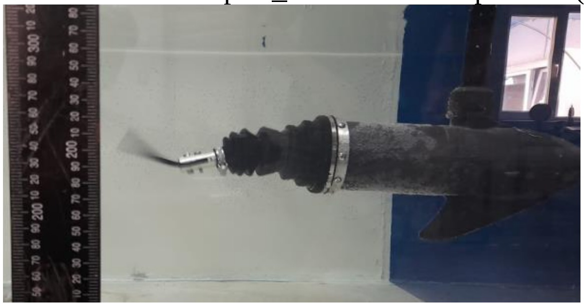

Fig. 11. Measurement of pala_z movement amplitudes (test 2)

Fig. 12. Measurement of pala_z movement amplitudes (test 3)

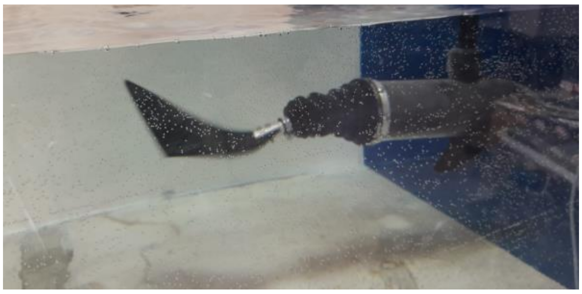

Fig. 13. Measurement of pala_z movement amplitudes (test 4)

Fig. 14. Measurement of pala_z movement amplitudes (test 5)

3. Measurement results of the characteristic sizes of non-conventional naval thrusters

Below all data measurement data is presented in tables for future comparison with other models and thrusters.

Tabel 1. Measurement results of the characteristic sizes of non-conventional naval thrusters

	Model 1 thruster 15/15/15	Model 2 thruster 20/20/20	Model 3 thruster 25/25/25	Model 4 thruster albastru ABS 20/20/20	Model 5 thruster standard
Speed 1 [Kg]	1.285	0.210	0.495	0.805	7.000
Speed 2 [Kg]	0.565	0.865	1.777	0.965	10.000
Speed 1 [%]	18.357	3.000	7.071	11.500	100.000
Speed 2 [%]	5.650	8.650	17.770	9.650	100.000

Tabel 2. Electrical power measurement results of tested non-conventional naval thrusters

	Model 1 Coadă 15/15/15	Model 2 Coadă 20/20/20	Model 3 Coadă 25/25/25	Model 4 Plastic albastru ABS 20/20/20	Model 5 elice standard
Speed 1 [W]	70.700	79.770	102.480	69.310	62.830
Speed 2 [W]	121.400	160.800	180.000	162.000	120.000
Speed 1 [%]	112.526	126.962	163.107	110.314	100.000
Speed 2 [%]	101.167	134.000	150.000	135.000	100.000
Speed 1 [η]	1.818	0.263	0.483	1.161	11.141
Speed 2 [η]	0.465	0.538	0.987	0.596	8.333

Figure 15 graphically presents the thrust measurement results [kg] of non-conventional naval thrusters for the 4 test models according to table 1.

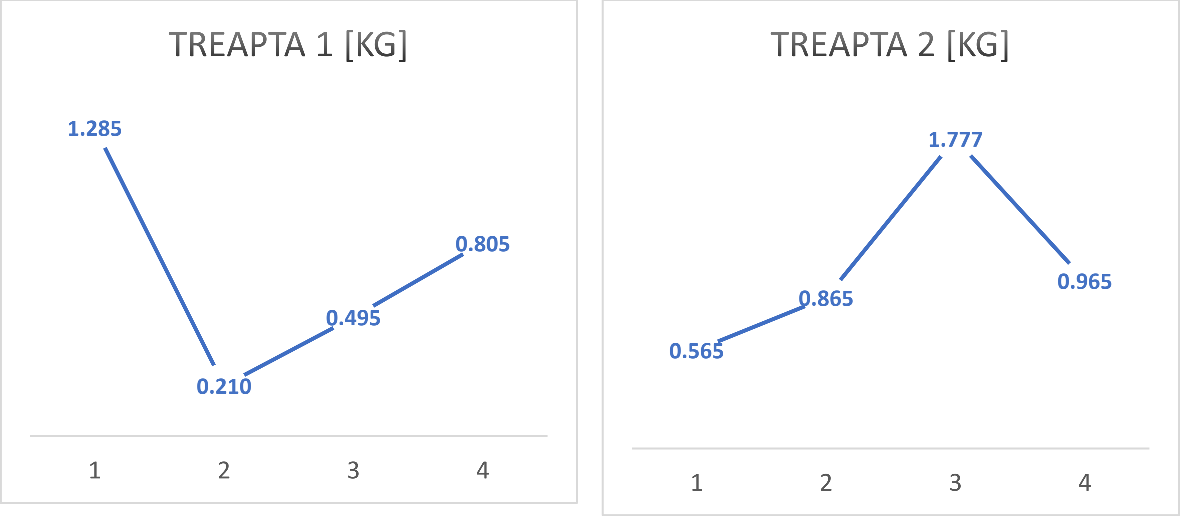

Fig. 15. Graphical thrust measurement results [kg] of non-conventional naval thrusters

Figure 16 graphically shows the thrust measurement results [%] of non-conventional naval thrusters compared to propeller thrusters for the 4 test models according to table 1.

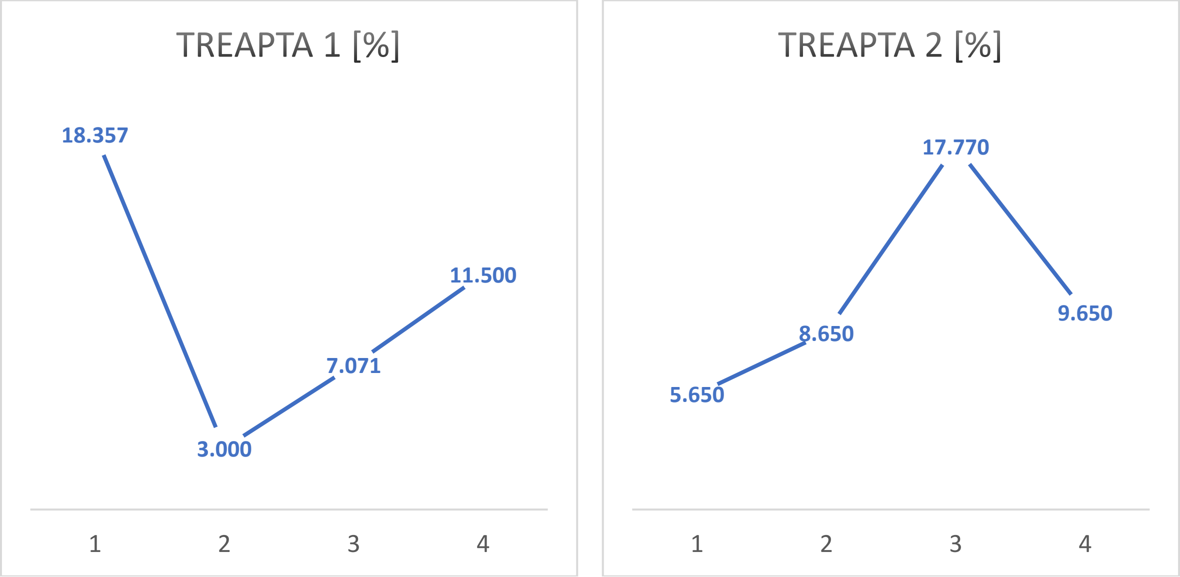

Fig. 16. Graphic results of thrust measurement [%] of non-conventional naval thrusters compared to propeller thrusters

Figure 17 shows graphically the measurement results of power consumption [W] of non-conventional naval thrusters for the 4 test models according to table 2.

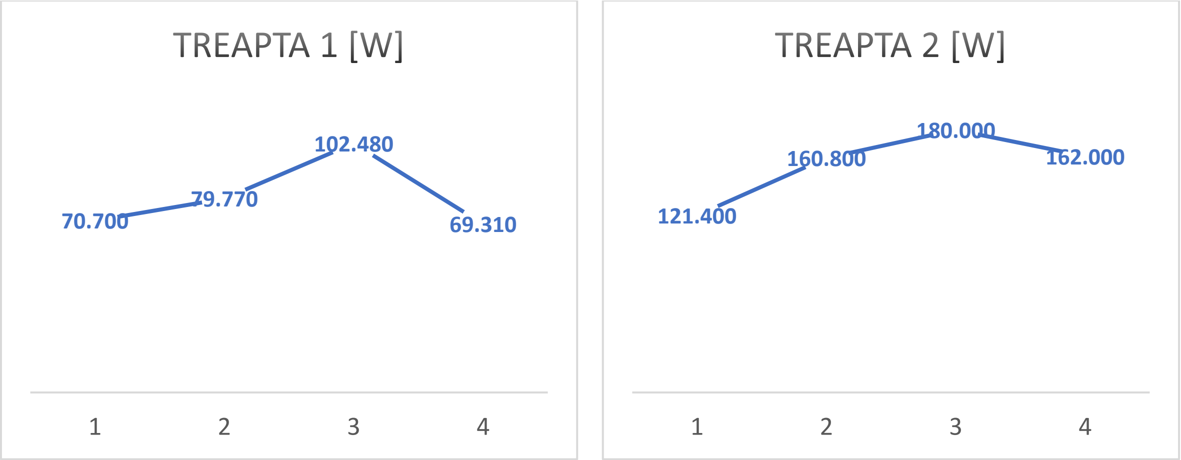

Fig. 17. Graphic results of measuring power consumption [W] of non-conventional naval thrusters

Figure 18 shows graphically the results of measuring the power consumption [%] of non-conventional naval thrusters compared to propeller thrusters for the 4 test models according to table 2

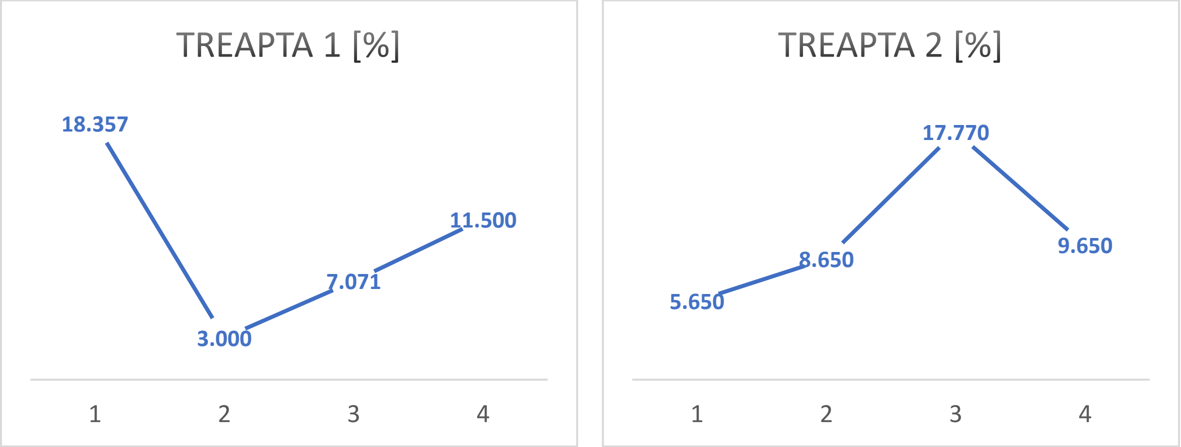

Fig. 18. Graphic results of measurement of power consumption [%] of non-conventional naval thrusters compared to propeller thrusters

Figure 19 shows graphically the measurement results for the efficiency [η] of non-conventional naval thrusters according to table 2

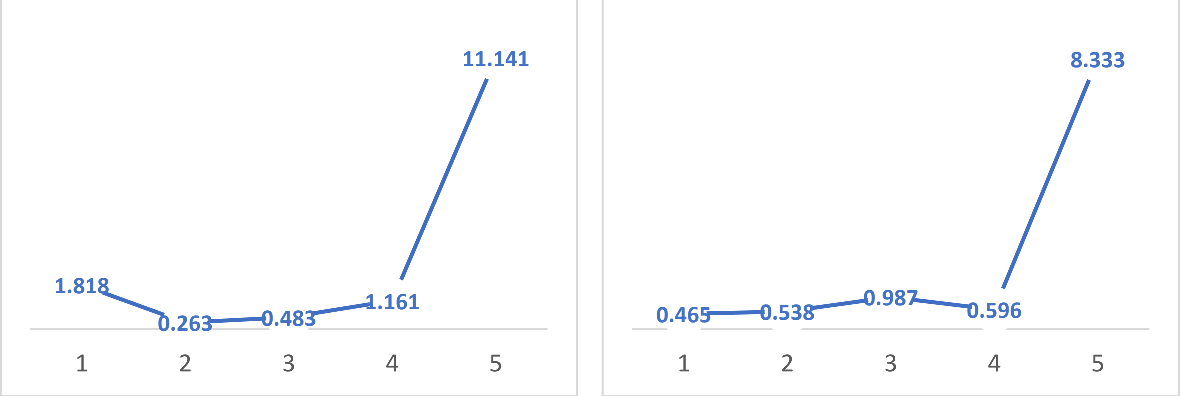

Fig. 19. Graph of measurement results for the efficiency [η] of non-conventional naval thrusters

4. Conclusion

To reduce the vibrations emitted in the marine environment, the non-conventional propulsion system can be configured for the propulsion of small boats, the limitation being given by the strength of the materials from which this propeller is made. Energy efficiency is presented for various non-conventional systems and can be used for greening shipping.

According measurements values for thrust force varry according frequency and amplitude as presented in graphs. That is necesssary to study each propeller type in order to get the maximum efficiency in ude of energy.

Basin research involves the practical realization of the scale structure and the analysis of the results according to the studied models and working frequency. The obtained measurements are close in value to those of the numerical simulations, this confirming the numerical results obtained with Ansys Fluent.

The analysis carried out on the non-conventional naval propulsion includes all the calculation elements to be able to expand the understanding of this type of propulsion to be able to find the most suitable ones for use in the naval field and not only.

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