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# CONSIDERATIONS ON THE DYNAMIC RESPONSE OF THE PROPLLER IN OPERATING CONDITIONS

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***Abstract:*** *This work presents some questions about naval propeller dynamic. In this study were identified fourteen possible conclusions, what have to base direction of fluid flow around the propeller.*

***Key words****: propeller, blades*

## 1. Introduction

This paper started from the situation of a river propeller, which during the operating time suffered some deviations from designed parameters and debated upon a series of issues that appeared from the hydrodynamic stress while handling the ship. The propeller discussed although it technically corresponds to the planned rate of output, practically is unable to withstand the hydrodynamic stress during exploitation and suffers severe blade distortions. This calls for a more profound study on the phenomenon involved in the working of naval propellers in order to find a method that assures the elastic steadiness of the blades as long as these methods don't lead to sensible reductions of the propulsion system's efficiency where you can find the naval propeller.

Thus, as a result of trying to obtain higher efficiencies when using a naval propeller for propulsion, the designers have adopted a series of solutions:

-Increasing the diameter, lowering the thickness of the blade, lowering the number of blades used, lowering the number of revolutions, the introduction of nozzle blades.

All these factors lead to the growth of the propulsive efficiency and are being taken into consideration usually on the normal functioning regime, considering the constructors are respecting the account book rules.

For large ships the cruise usually takes place at a constant speed and are being aided by tug boats when entering/leaving a seaport resulting in rare situations in which that blade is being overstressed.

In contradiction to this military ships are obliged to fulfill varied maneuvers (imposed by the battle missions, entering / leaving seaport at a specific hour, avoiding obstacles, fast maneuvering) enforced by the existing situation on the river/sea maneuvers leading to dangerous hydrodynamic regime, following the inverse of the propeller's rotary motion. More than that river navigation implies that one part of the year the propeller must work in floating ice, in which case it has a chance of being deformed.

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## 2. Experimental measurement

The naval propeller that drew attention on the modifications of the designed characteristics, more precise the distance and it's increase is the propeller that was exploited on a tug boat and which suffered due to the phenomenon mentioned before meaning the reversal of the march direction and navigation through floating ice.

The effect of the distance increase value has major implications in the functioning of the propulsion system and from this we can distinguish two distinct situations based on the propellers initial design plan:

- if the propeller was a light one from its design(it's characteristics are not chosen for the all the power consumption it's engine offers) and the propulsion engine has enough power reserves than it can offer enough power without the appearance of an overload.;
- the propeller had a good design but due to the modification of it's characteristics it becomes heavy, the engine will suffer from overload on a normal work regime.

Although the first situation seems reasonable due to the fact the propulsion mechanism has a power reserve, the fact that the propeller has deformed and it's distance is larger than initially planned will lead to a higher cavity regime that in time will destroy the propeller. Still, from the measurements made (table 3) we find out that the blades are unequally deformed, a fact that implies further vibrations in the shaft line, that are being conveyed to the ship's body.

The second situation is much more severe due to the fact that the propulsion engine is overloaded and it's revolution speed will have to be decreased in order to avoid a engine overheating. This will make the propulsion mechanism unable to perform at the efficiency it was designed to.

The main characteristics of the distorted propeller are presented in table 1.

Table 1

| | | |
|---|---|---|
| 1 | Propeller type | B4-85 Wageningen |
| 2 | Diameter of the propeller | 1980 mm |
| 3 | Number of blades | 4 |
| 4 | Disk ratio | 0,850 |
| 5 | Tread ratio | 0,800 |
| 6 | The generator angle | 100,00 mm |
| 7 | Composition | OT type 1 RNR |
| 8 | Rotary direction | Left |
| 9 | Power(M.P.) | 832 Kw/750 r.p.m. |
| 10 | Number of revolutions per minute | 300 r.p.m |

Starting from the normal value of the propeller's distance (1584 mm) actions were taken for each of it's blades from which considerable distortions were found thus making the naval propeller unable to function properly.

Table 2

| r/R | Measurements taken after usage | | | |
|---|---|---|---|---|
| | Blade no 1 | Blade no 2 | Blade no 3 | Blade no 4 |
| 0,6 | 1596 | 1590 | 1578 | - |
| 0,7 | 1628 | 1622 | 1576 | - |
| 0,8 | 1692 | 1650 | 1611 | 1760 |
| 0,9 | 1896 | 1776 | 1716 | 1884 |

The constant afterglow deformations, reported in initial project, are different (their values are written in table 3), necessary implicating a detailed study on the causes that brought this state.

Table 3

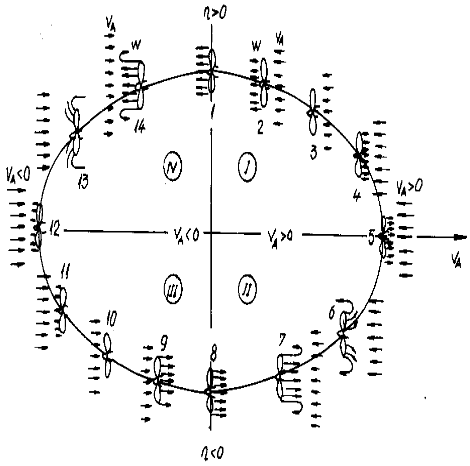
| r/R | The constant differences reporting to the propeller's initial step | | | |
|---|---|---|---|---|
| | Blade no 1 | Blade no 2 | Blade no 3 | Blade no 4 |
| 0.6 | 12 | 6 | 6 | 0 |
| 0.7 | 44 | 38 | 8 | 0 |
| 0.8 | 108 | 66 | 27 | 176 |
| 0.9 | 312 | 192 | 132 | 300 |

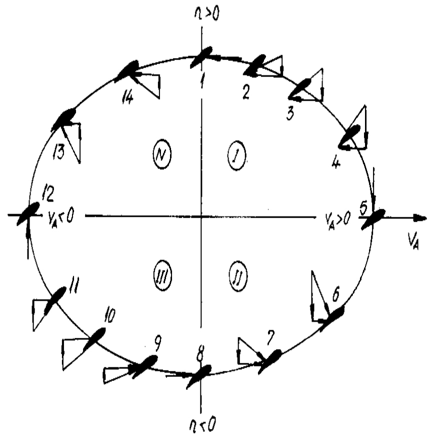
As we can see from table 3, the values of the afterglow deformations are not constant, resulting that the pushing forces developed on each hall are not uniform and the momentum introduced by these in the stems line.

## 3. The Dinamics of the Naval Propeller

In the first figure are represented schematically the possible operating of the naval propeller, reporting to the speed of advance Va and the value of revolution, that can occure at different maneuvers of the ship. Referring to these, the sign of the advance speed Va and the sign of revolution are considered conventionally as positive for the ship's forward movement and negative for the ship's backward march [1].

Concerning the dynamic action of liquid on the propeller's blades, in the second figure are represented the speed's directions of the liquid current Va and of the relative speed w, on the element of hall, the so called action on the propeller and, as wise, the type of auctioning. In this figure 2, it is represented a complete scheme from the point of view of the hall element's work. The linear speed of the hall element is represented with horizontal arrows in his rotation movement, and with vertical arrows it is represented de advance speed of the propeller Va [2].





The two figures (1 and 2), bring out the possible cases of working and a first conclusion ca be tapped, tied up on the distributions of hydrodynamic pressure that ocurre in the naval propeller's functioning.

According with the speeds triangle of ones from these 14 illustrated cases (figure 2) and reporting the orientation of the advance speed, at the orientation of the pushing force, the working regimes can be classified this way [3], [4]:

II. The ahead marching behavior:
2. Of maneuver: $V_a = 0, n > 0, T > 0$, $Q > 0$
3. Of march: $V_a > 0, n > 0, T > 0, Q > 0$,
4. Of wing: $V_a > 0, n > 0, T < 0, Q > 0$,
5. Of turbine: $V_a > 0, n > 0, T < 0, Q < 0$
6. Stopped propeller: $V_a > 0, n = 0, T < 0$, $Q < 0$

II. Inversion behavior with forward movement, on astern march:
1. Reverse backwater behaviour: Va>0, n<0, T<0, Q<0;
2. Priming behaviour: Va>0, n<0, T<0, Q<0;

III. Astern movement behavior:
1. Of maneuver: $V_a = 0, n < 0, T < 0$, $Q < 0$
2. Of march: $V_a > 0, n < 0, T < 0, Q < 0$
3. Of wing: $V_a < 0, n < 0, T > 0, Q > 0$
4. Of turbine: $V_a < 0, n < 0, T > 0, Q > 0$
5. Of stopped propeller: $V_a < 0, n = 0$, $T > 0$, $Q > 0$

IV. Inversion behavior with backward movement, on ahead march:
1. Reverse backwater behavior: $Va < 0, n > 0, T > 0, Q > 0$
2. Priming behavior: $Va < 0, n > 0$, $T > 0, Q > 0$

## 4. Conclusions

1. The study of dynamic regimes has great importance for the projectors of the naval propeller, as well as for the marine officers, maritime and fluvial, which carries their exploitation, because it points out the cases on naval propellers functioning in permanent case, as well in transient load case.
2. The 14 cases of functioning (see figure 1 and 2) are not usually found at the propulsion installations exploitation and that's why a eventual not knowledge of the afferent causes of these kind of maximum effort regimes, can have unwanted effects on the propeller and on the entire propulsion system as well.
3. From the triangle's of speed study, we can observe, in the seventh case (figure 2, the priming behavior), when the propeller makes the passing from an active break (the ship is moving ahead), the hall is on heavy loading, because the hydrodynamic pressure on the hall has a specific distribution, with a peak of loading on the attack board.

The situation mentioned on the third paragraph results the hall's loading, especially in the case of propellers with a big report disc ($\Theta \geq 0{,}7$) can cause some deform, can overcome the elastic domain, deformations that have compromising afterglow effects on the functioning of the propeller and the functioning of the propulsion installation.

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