Propeller excitations inducted to the shafts of the naval engine

LIVIU CONSTANTIN STAN
Department of Marine Engineering
Constanta Maritime University
104, Mircea cel Batran Street, 900663, Constanta
ROMANIA
liviustan14@yahoo.com

Abstract: - In the last decade, the continuous growth of the commercial ship’s dimensions and the power of propulsion installations raise a lot of technical problems to the projectors and ship builders. One of the most important problems is the vibrations on board of the ship. Vibrating phenomenon is of high interest because they affect simultaneously: the endurance of different parts of the structure of the ship, the technical condition of several machines and devices on board, the comfort of the crew.
The main sources of excitations on board are: the main engine, the propeller and the effects of the sea. The propellers can stimulate vibrations to the ship in two different ways: forces and torques, transmitted to the hull through the line of shafts and by fluctuating the pressures on the aft submerged side. A very good analysis on this phenomenon is conducted with the help of the program CATIA, in which by giving values to several re-established parameters we can observe the simulation of the vibrations, torques and critical points exercised on the line of shafts during the operation of the main engine.

Key-Words: - vibrations, wiping, springing, marine engines, propulsion systems, finite element analysis

1 Introduction
The study concentrates on the excitations transmitted to the line of shafts. At the origin of the fluctuations of forces and the torques transmitted by the propeller is the wake in which the propeller works.

Considering the action of the rolling on the hull as a source of excitation that can generate vibrations of its structure we must mention that the main interest of the study will focus on the vertical vibrations of the ship. Considering this actual orientation in the conception of the ships we can distinguish two types of excitations: wiping and springing.

Of high interest in the study will be also a practical demonstration, sustained by drawings and prints from the program CATIA.

2 The turbionary model of the propeller

2.1 Notions regarding the theory of the finished wing span
The flow of one fluid in this case is different from the flow on the unfinished span most of all by the shift from the bi-dimensional to the three-dimensional movement.

In this way, a movement is generated by a parallel a current, from the center to the extremities on the inside and from the extremities to the center on the outside as per figure 1.

![Fig. 1 The turbionary model of the propeller](image_url)

In this is way a plain thin net is created, in which the speed passes from the value \( v \) on the inside to the value \(-v\) on the outside. The system of vortexes that is created in turn of the wing, parallel with the speed of the general current and has the form of an unlimited free strand.

In conformity with the turbionary theory, this system of vortexes does not remain isolated; it sticks to the systems of vortexes located on the wing, named connected vortexes.
The conclusion that is drawn and which stands to the base of the theory of the finished wing span elaborated by Prandtl is that the finished span wing is equivalent with a system of connected vortexes, $\Omega_a$, located on the outside and inside of the wing, on a direction parallel with the span, and a system of free vortexes, $\Omega_l$, which detach from the running board and extend parallel to the current speed, creating a net of vortexes that reaches until infinitely downstream.

The phenomenon is illustrated in the figure 2, being also indicated the instability of the mentioned discontinuous surface.

On the basis of the model presented it was deduced the theory of the carrying line, which consists in the reduction of each profile of the wing to a single point on the wing span.

2.2. The turbionary model of the propeller based on the theory of the carrying wing
The study of the propeller function ability is based on the theory of the carrying wing, so on the flow around the profiles.

The turbionary model of the propeller with a finished number of paddles is made from nets of vortexes which detach from each paddle as per in the figure 3.

2.3. The determination of the excitations inducted by the propeller in the line of shafts of the main engine
The indefinite shape of the wake has a series of unpleasant consequences, the functioning of the paddle in different speed zones generating forces and torques which are transmitted through the water and the propeller shaft bearing to the hull of the ship and to the line of engine shafts. These results to be the most important source of excitations for the shaft line vibrations. The phenomenon is specific for the ships.

Using the program CATIA we can observe the variations. The following figures show the tensions created in the shaft calculated using the method of finished elements and the presentation of the free vibrations calculated using the same method for the crank shaft.
3. The experimental testing of the mathematical model proposed for the calculation of the vibrations inducted by the propeller in the line of shafts of the naval engine

The tests on scale models can give several data necessary for the testing of calculation and finding solutions where the theory can not bring them yet. The experimental results and the conclusions are not applicable yet on the prototype, unless the data that define these two matters satisfy a number of relations named laws of mechanic resemblance.

The main principles if resemblance between the model and the prototype in the hydrodynamic area are: the geometrical resemblance, the cinematic and the dynamic resemblance. To apply in practice the results obtained on models and to determine the performances of the ships it is necessary to establish some criteria deducted with the help of dimensional analyses.

For the naval propellers the functional parameter, the traction, can be function of: the density of water, the advance water speed, the gravitational acceleration, revolutions of the propeller, pressure of the water, the dynamic or cinematic viscosity coefficient of the water. Using the computer a demonstration was made to show the limit condition of the entire axial line for the SULZER 6RND90 engine on which vibrations was excited (Fig 6).

4 Conclusion

The analyses of the excitations of the shaft lines for maritime engines, allows the calculation of forced vibrations that are exercised on the shafts. Therefore, the tangent forces excited the torsional vibrations, the radical ones excited the flexure vibrations, and the ones inducted by the propeller excited mainly torque and axial vibrations on the line of shafts.

The first two types of vibrations are determined in the geometrical and mass identity hypothesis of the mechanisms on each individual cylinder.

The third category of excitations, the vibrations inducted by the propeller, was determined using an integral banality method, with the condition of knowing the geometrical and functional characteristics of the propeller.

The main working hypothesis was based on the idealization of the flow, considering that the nets of the free vortex are perfectly helical. Also a very particular attention is directed to the calculation of coupled vibrations of the lines of shafts with several numeric methods. The model of load added to the line of shafts is presented in the Fig. 7.

![Fig. 6 The limit condition of the entire axial line for the SULZER 6RND90 engine](image)

**Fig. 7 The model of load added to the line of shafts**

**References:**


