Study on the construction of the shaft used in naval propulsion

F Kmen and S Macuta

1 Mechanical Engineering, Dunarea de Jos University, Galati, România
2 Mechanical Engineering Dunarea de Jos University, Galati, România
E-mail: silviu.macuta@ugal.ro

Abstract. Ship building industry is evolving internationally facilitating the transport of goods in large quantities at low cost. The marine environment is a challenge for engineers in the field because it also calls for intensive hull and propulsion system. This article is a comparative study of a constructive element of the axial line (shaft) which was used in connection radius. The study is based on the requirements of classification societies in the field and ends with finite element analysis using a CAD environment SolidWorks2010.

1. Introduction.
In recent years, structural analysis has emerged as a means of checking the current buildings eligible low-cost technique, including shipbuilding. For sizing shaft it is necessary to know the ship towing power provided by the engine propulsion efficiency of the propulsion system, the default engine torque and average torque that will be transferred at the shaft. The ship which has been done is a study of 25,000 dwt ore carrier built in shipyard in Constanta, Romania.

To perform the test it was used a CAD environment. CAD environment used is SolidWorks, and the method of calculation was "Finit Element Method" (FEM). [1, 2, 3]

The results from the analysis are compared with the limit values of stresses and displacements accepted. [5, 6]

2. General concepts of strength of materials.
Twisting is the predominant application of intermediate shafts. This request is made by forces that do not meet the bar axis respectively are not parallel to it. The effort that produces twisting is the torque, having directed axis the vector bar.

Intermediate shaft generally presents two attachment flanges (the shaft and pushing the shaft propeller) of different diameters that apply the general definition of moments twist: a section sum of the moments of twisting the left section are equal the right section, taken with the opposite sign. [4]

The problem of the rolling means determining how stress is distributed in the section and setting a relationship between the torque and amount of stress. [4]

3. The theory of the strain energy
This theory is part of theories of resistance, which establish relationships between the main stresses $\sigma_1, \sigma_2, \sigma_3$, leading to the attainment of one or other of the five sizes characteristic of the limit state. Through these relationships it establishes a limit stress equivalent $\sigma_{ech}$ state plane or space that allows...
comparison with the stress limit state the extent of simple $\sigma_e$. After determining the equivalent stress is taken as a permissible limit state resistance. [4]

4. Dimensioning shaft
The piece which forms part of the structure of the propulsion plant, shaft that was subjected to stress, displacement and effort.

The outcome of that inspection was trying shaft with both the radius of curvature coupling flange connection, and without it, observing substantial differences.

For this check to be convincing it is considered one of the ends recessed, which is basically similar to the case for the engine block, so a maximum when the propulsion developed.

For an analytical expression of the rotating machine torque is:

$$M_t = \frac{30 \cdot P}{\pi \cdot n}$$

(1)

The introduction of power in [kW] and speed in rpm when expressed in [kN ∙ m]. $P = 8825.6$ [kW], $n = 122$ [rpm].

![Diagram torque and average moment.](image)

**Figure 1.** Diagram torque and average moment.

Chosen as a building material of the shaft 35 OLC. Limit stress flow chosen is the normal stress $\sigma_c = 320$ [MPa].

Predimensioning shaft will be made exclusively by considerations of torque. It adopts tangential intake $\tau_a = 100$ [MPa] is determined using the values set out above polar section modulus $W_p$.

$$W_p = \frac{M_t}{\tau_a}$$

(2)

Literary expression modulus torsional rigidity is:

$$W_p = \frac{\pi \cdot (D^4 - d^4)}{16D}$$

(3)

The first stage of verification shaft was built in Solidworks, strictly respecting its constructive dimensions.

The shaft was introduced radius of curvature R60, the contact between the flange and shaft coupling with the engine block itself, so to make a comparison on the tensions and displacements that occur in the structure of the material in the two cases.

Finite element, the intermediate shaft is meshed into elements linked only to nodes.
5. The study stresses
For stress analysis, shaft built without radiused subjected torque from the engine, considering the recessed propeller shaft flange.

Following this analysis notes that the equivalent stress criterion von Mises $\sigma = 106$ [MPa], this is an acceptable solution because $\sigma_e = 320$ [MPa] request most pronounced is in the red, the contact
between the flange and the cylinder shaft. Also it is noted that the highest stress occurs at the contact between the flange and shaft, where $\sigma = 85$ [MPa].

The absolute difference between the two peaks is 20 [MPa], a difference of 19%.

6. The strain study

Making this study strain is absolutely necessary to know the deformations that occur in the material from which the shaft was made.

Similarly previous chapter, analyzes shaft, both with and without connection area to see the differences between them.

![Figure 8. Study shaft strain without radiused.](image1)

![Figure 9. Study shaft strain with radiused.](image2)

When using the radius of curvature of movements is a decrease in the area most exposed to this phenomenon. The resulting translation is the absolute difference of 1665 [mm] to 1.644 [mm], that is 0.021 [mm], the resulting translation is reduced by 1%.

7. Conclusion

To check the values previously determined, shaft was modeled and analyzed with FEM in SolidWorks 2010. It is subject to torque developed its thermal conditions under which an intermediate shaft flange is recessed (does not have any degree of freedom), it simulates extreme loading - blocking the propeller. After verifying the high voltages is observed in the connection between the flange and shaft, so to subtract these tensions have built a connection between the two. Checking movements conditions shall be admissible values are greater than 1 [mm]. They develop in the peripheral area of the flange connection, seeing a drop in business travel when using the shoulder portion. Resistance theory used SolidWorks to calculate stress is equivalent energy theory of variation in shape (5th Theory), Huber-Mises-Hencky. Sectional shape ring adopted is more advantageous, observing only stress and strain in the outer fibers of the material.

8. References

[1] Blumenfelt Maty 1995 *Introducere în metoda elementelor finite* (București)
[2] Gârbea D 1990 *Analiză cu elemente finite* (București)
[3] Pescariu I 1985 *Elemente finite. Concepte. Aplicații* (București)
[4] Buzdugan G 1986 *Rezistența materialelor* (București)
[5] Scurtu I C, Onciuc V, Garcia D I and Babiuc B 2015 *Stress and strain analysis of heave plates* *Constanța Maritime University Annals XIV(22)*
[6] Scurtu I C, Pricop M and Babiuc B 2015 *Study of offshore structure design related to ANSYS stress, displacement and vibration modes* *Constanța Maritime University Annals XIV(22)*
[7] Pricop M 2001 *Structuri elasticiz. Elemente de teoria elasticitatii.Vibrații* (Constanța)
[8] Costică A 1991 *Mașini și instalații navale de propulsie* (București)
[9] Maier V 1987 *Mecanica și construcția navei – Dinamica navei* (București)
[10] Kmen F 2012 *Elemente de proiectare a motorului principal al unui mineralier de 25.000 TDW și analiza structurală a unui element component* (Constanța)
[11] Kmen F and Macuta S 2015 Analytical studies for checking structure elements engine parts
[12] Kmen F and Macuta S 2016 Numerical simulation by finite element analysis is method of checking structure elements propulsion system components *LIAIST* 46

[13] Kmen F, Scurtu I C and Hanu C 2015 Study of shipyard intervention based on Ansys software *Constanța Maritime University Annals* XIV (22)

[14] Popovici O, Ioan A and Domnişoru L 1991 *Construcţia, amenajarea şi exploatarea navei* (Galaţi: Universitatea “Dunărea de Jos”)

(Piston Head) *International Scientific Conference Garbovo III* pp 198-204