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VIBRATION STUDY FOR A SUBASSEMBLY – PART OF HYDRAULIC TURBINES

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Abstract: *A common problem with hydraulic turbines is the rupture of turbine horizontal shaft in the area between the rotor and its bearing, caused by different stresses [1], as well as problems caused by excessive bearing wear, vibration caused by instability of lubricant film from bearings, lubrication supply interruption of hydrodynamic bearings, gripping, decrease of bearing stiffness due to fatigue of supporting structures. In addition, during operation, vibration appear depending on exciter forces or bearing type. In present paper we present an analysis of vibrations measured on a subassembly found at hydraulic turbines. For the experimental subassembly was used a straight-lined shaft, having variable cross-section, and a sliding type bearing. The tests were made for bearings of different dimensions and materials. Vibrations were measured on two axes for established case studies and results were compared.*

Keywords: vibration, bearing, deva.tex, stresses, hydraulic turbines

1. Introduction

Considering frequent malfunctioning issues at a hydraulic turbine are bearing related we made in the present paper a vibration analysis of different case studies consisting in tests were sliding bearings having different characteristics were used[1-7]. When building experimental stand we took into account main conditions the subassembly components should satisfy, as: high wear, corrosion and fatigue resistance, bearing must have two to four times less resistance than shaft, high stiffness, friction coefficient as low as possible, good lubricating conditions and thermal conductivity, simple and low cost maintenance, small differences between dilatations of bearing elements in order to remain close to the initial clearance [8-14].

2. Experimental Stand Build-Up

For the case studies described in this paper experimental stand shown in figure 1 was build. The shaft (1) was made from OL45, straight-lined, with variable cross-section, by turning and rectifying support areas where sliding bearings will be mounted. Shaft is fixed on motor drive which in this case is a turning machine (2).
An assembly structure was setup, consisting of upper body (4) with balance pan (3) and bearing support hole (5), OL60 springs (7), fixed rolls with elastic rubber bands (6),base body (8) for fixing the structure on drive machine. This subassembly is designed for loading different stresses in the form of weights on pan and maintaining the system in balance.

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For sliding bearings were chosen two dimensions with ratio length/diameter of 1.5, respectively 2.5. The sleeves were made of phosphorous bronze or OLC45, coated with a 2 mm ribbon of composite material based on polytetrafluoroethylene, deva.tex 541.

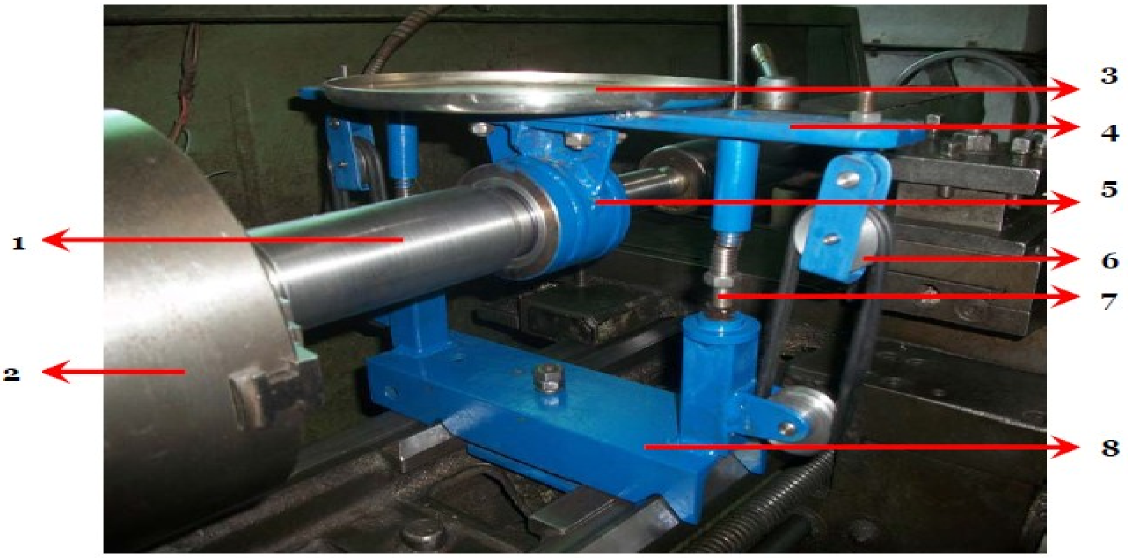


Figure 1: Experimental Stand

3. Case Studies and Results

For measuring vibrations on sliding bearing VibroTest 60 vibrometer was used, a portable appliance that enables data acquisition for further analysis[15-18]. By measurements we determined RMS (root mean square) values of axial and transvers displacements of bearing, using a dedicated piezoelectric accelerometer, AS-065, which operates on a wide range of frequencies, with an error less than 1%, connected to VT60 through AC-436 cable.

Vibration case studies involve using OLC45 coated with deva.tex 541 sliding bearing and phosphorous bronze coated with high viscosity lubricant.

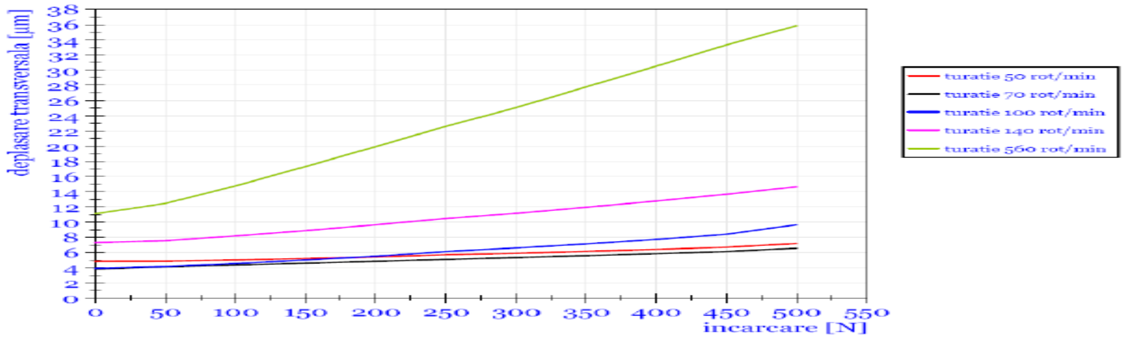
Deva.tex 541 is a composite material based on polytetrafluoroethylene, solid lubricant, reinforced with fiberglass, ensuring high tribological characteristics, as: low friction coefficient and high wear resistance both in dry and humid environment, doesn't require additional lubrication, good behaviour in static and dynamic loading and corrosive environment, suitable for rotational, oscillation and linear applications, not sensitive to impact, shocks or vibrations [19-21].

For tests various loadings and transitory regimes were applied. Values chosen for loadings were: 100N, 200N, 300N, 400N, 500N. Values for rotational speed were: 50rpm, 70rpm, 100rpm, 140rpm, 200rpm, 560rpm.

3.1. Case study 1-OLC45 coated with deva.tex 541 sliding bearing

Two dimensions were considered for sliding bearings: bearing 1 - diameter of 50mm and bearing 2 - diameter of 30mm. Results obtained for bearing 1 are shown in figure 2 and for bearing 2 are shown in figure 3.

For bearing 1 can be concluded that RMS values have a linear increase with load at constant rotational speed and a relative linear variation with increase of rotational speed, best behaviour is obtained for 70rpm.



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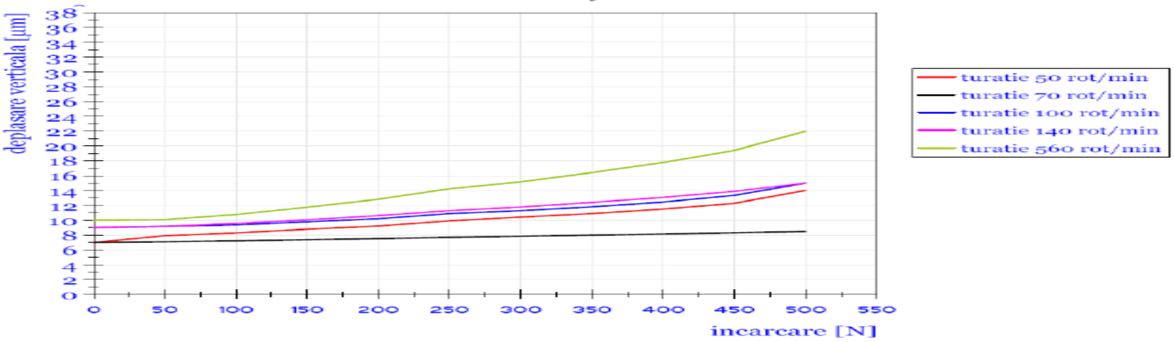
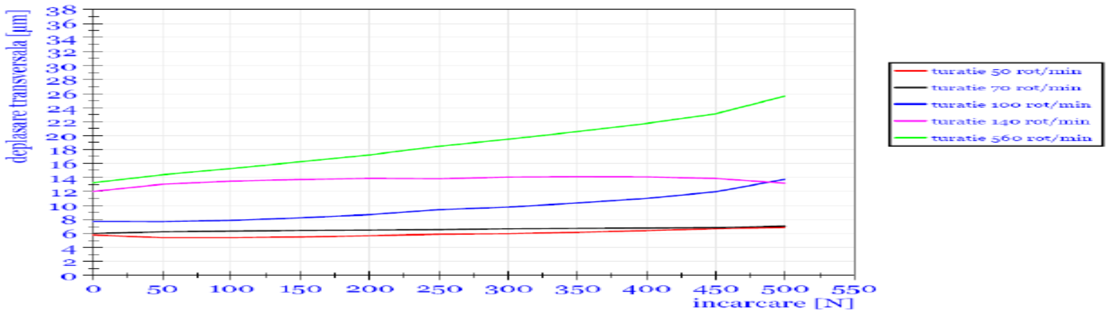


b)

Figure 2: Bearing 1 - RMS for a) transversal; b) vertical

Considering data collected for bearing 2 can be observed that for transversal measurements RMS values increase linear with load at constant rotational speed but for vertical measurements results show instability with load increase, as well as with rotational speed increase, although values obtained for this case study are lower than determined at bearing 1 tests.



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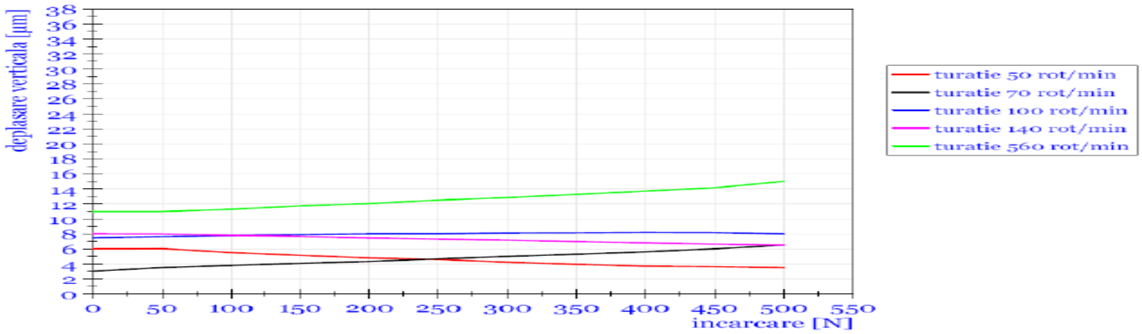

Figure 3: Bearing 2 - RMS for a) transversal; b) vertical

3.2. Case Study 2 –Phosphorous Bronze Coated with High Viscosity Lubricant in Comparison with OLC45 Coated with Deva.tex 541 Sliding Bearing

For this case study we maintained dimensional characteristics of bearing 2, being under discussion only the change of material. Therefore, case study involves two bearings of 30 mm diameter, but with different material types: bearing 3-OLC45 coated with deva.tex 541 and bearing 4 - phosphorous bronze coated with high viscosity lubricant. For relevance reasons we will show only significant results. We will highlight the results for cases with low, medium and high values for rotational speed and likewise for load values. Figure 4 shows comparison between values of displacement measured for 50 rpm speed and no load, where, though there are no significant differences between vibration values, there can be noticed the instability of lubricant film.

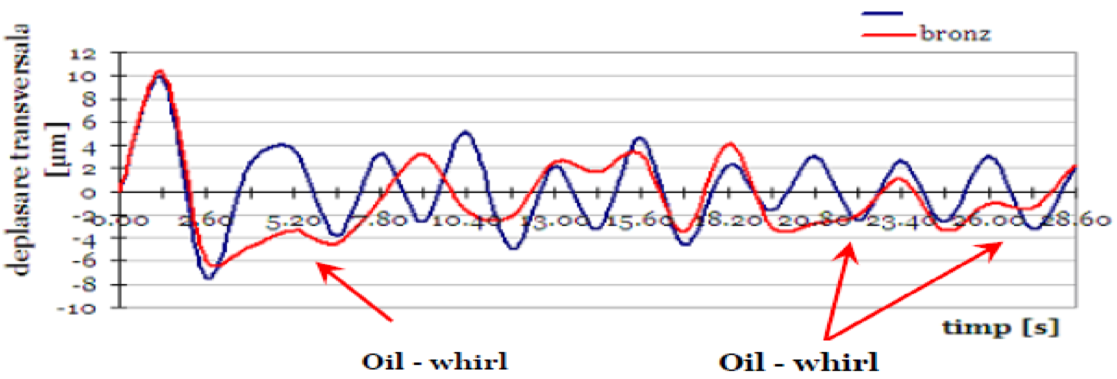

Figure 4: Displacements for 50rpm and no loading

Testing the two bearings at 200rpm and using a load of 300 N we obtained graphical representation from figure 5 where it can be noticed that displacement variation for bronze bearing is unstable still, though values for both bearings are close for this case conditions and for former case as well.

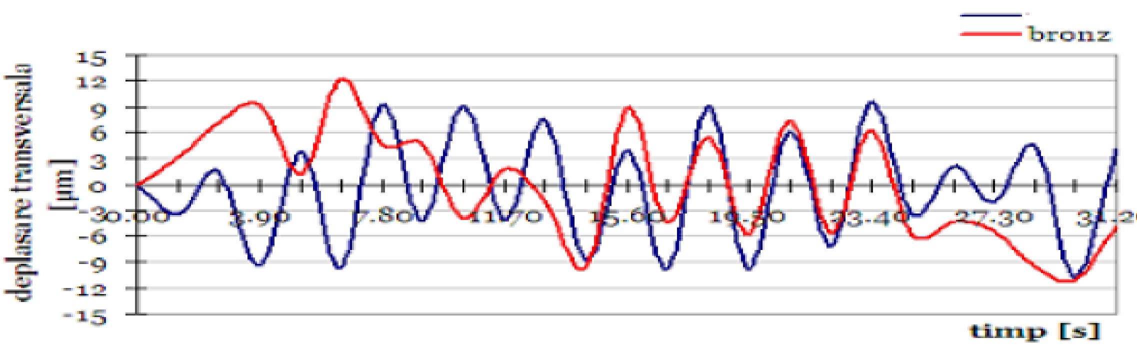

Figure 5: Displacements for 200rpm and 300N

Last case study needed for drawing conclusions is for 560rpm and 500N load. It can be observed in figure 6 that with load and rotational speed increase vibration values will result to be higher. Nevertheless, in all situations we can see the presence of instability of lubricant film at bronze bearing. Although rotational speeds have low values, they were chosen because these values are used at small hydraulic turbines.

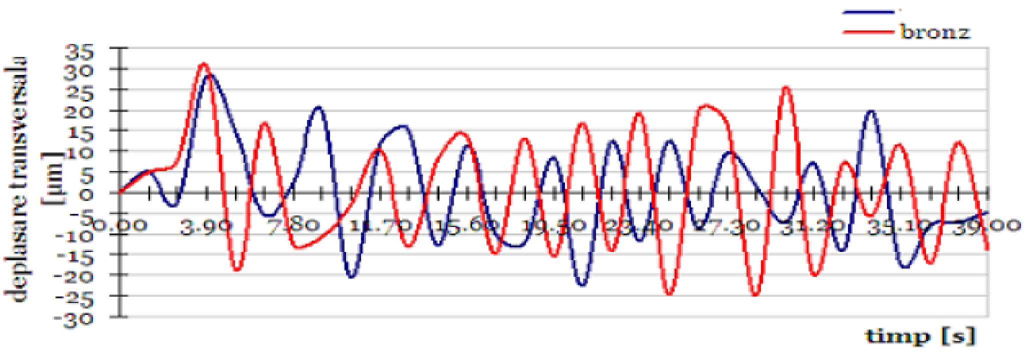

Figure 6: Displacements for 560rpm and 500N

4. Conclusions

The purpose of the studies in discussion was to establish whether it is suitable to consider replacing sliding lubricated bearings with material composite coated sliding bearings at small dimension hydraulic turbines. Composite material used in tests under discussion shows a good behaviourand in comparison with classical materials have better characteristics and respond a bit better to loads and solicitations in terms of vibrations. If we consider costs and maintenance we can consider that, for cases discussed in present paper, sliding bearing coated with this composite material is suitable to be used.

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