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EXPERIMENTAL DETERMINATION OF SLIDING BEARING OPERATING TEMPERATURE

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ABSTACT: During operation, it is essential to know theoperating temperature of the bearing in order to determine the thermal stability of the sliding bearing. This paper presents results of measuring the operating temperature of the sliding bearing using FLIR camera, on the testing table in the Laboratory of Applied Mechanics and Mechatronics, in Mechanical Engineering Faculty in East Sarajevo. Experimental results are presented ona diagram, followed by their comparison with the values ofthe operating temperature obtained analytically. Based on the operating temperature obtained through experiments and analytical calculation, thermal stability of the sliding bearing hasbeen tested.
Keywords: Operating temperature, thermal stability of the sliding bearing, FLIR camera

1. INTRODUCTION

Under the concept of technical diagnostics it means scientific and technical discipline which includes the theory, methods and tools for recognizing the condition of technical systems. The main aim of technical diagnostics is to detect and prevent potential failure of technical systems.This is achieved by measuring characteristic or diagnostic parameters and on the basis of certain criteria it concludes if they are within acceptable limits or not. The usage of sliding bearings is very present in practice, because of very long lifetime. There are radial and axial types, but in this paper the radial sliding bearing has been considered, only. Radial sliding bearing load capacity isa force that radial bearing can transfer withinhis lifetime. According to previously mentioned, operating temperature must not be overstepped under that force, there must not be higher then allowed abrasion and cubical sliding couple material destruction [1]. Small problem in process oriented complex production system, as sliding bearing failure, can often cause long deadlocks during plant working, which resultsto huge financial costs in company business [2].
Processed temperature values using the disjunctive probabilistic (fuzzy) operator, as one of the two most important technical indicators of sliding bearings correctness, in addition to vibration velocity, which is measured during operation of the sliding bearing, are presented in the literature [2]. Monitoring and diagnostics sliding bearings failure are given in the literature [3].
In the beginning of bearing work, its temperature is rapidly increasing with the heating not only the sliding pair, but also the bearing housing. After that temperature increasing slowly because of heat transfer to the environment and, finally, after some time (3-5 hours) it has stabilized. There is a balance between produced and taken heat and the sliding bearing gets to its stationary temperature, in stationary conditions. Stationary temperature must not overstep a certain limit because it leads to phenomenons that disturb normal bearing work. These are, above all, harmful dilations and deformations of the shaft and bearing, gaps changes, lubricant viscosity decreasing and similar. Besides previously sliding bearing defects, there are also defects shown in literature, [4]. Usually, operating temperature is 50-60°C [1]. It is needed that energy losses due friction P_G are equal to natural and forcedly heat dissipation[2].

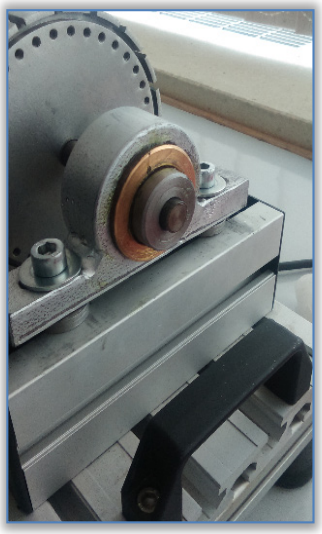

Figure 1. Sliding bearing made of CuSn legure

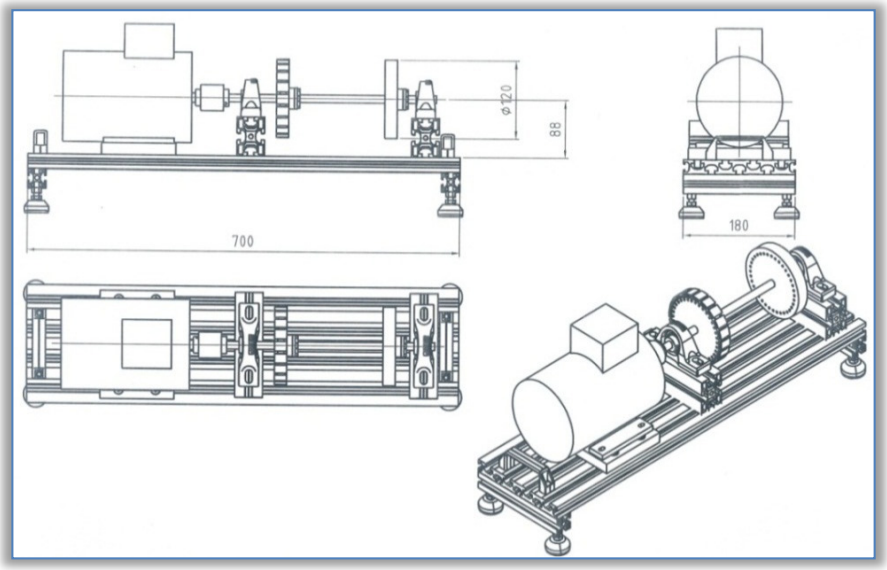

Figure 2. Basic dimensions of testing table

2. METHOD FOR EXPERIMENTAL DETERMINATION OF SLIDING BEARING OPERATING TEMPERATURE

The measurement of sliding bearing operating temperature was performed on the testing table in Laboratory of Applied Mechanics and Mechatronics on Faculty of Mechanical Engineering in East Sarajevo. The sliding bearing, made of CuSn legure, with dimensions BxDxd=27,6x30,022x30 mm (Figure 1) was lubricated with multifunctional Lithium lubricant, made by „Optima Modriča“ and was installed on position No. 2 of testing table (Figure 2). Basic dimensions of testing table are shown on Figure 2. Sliding bearing operating temperature was measured for the angular velocity value of 50 Hz (what is, actually, 477,71 rpm), using FLIR camera (Figure 3).

(a)

(b)

Figure 3 a) FLIR camera, b) temperature measuring

Starting the measuring from the sliding bearing room temperature, its operating temperature was recorded on every 30 s, until the moment of maximal value. After that, the tasting table electromotor was turned off and operating temperature was recorded during cooling of sliding bearing, also, on every 30 s and temperature diagram was formed.

3. DISCUSSION RESULTS

Based on previously mentioned measurement method of sliding bearing operating temperature, measured temperature values were imported into Excel and the temperature diagram was formed (Figure 5).

According to the diagram above, it is possible to be conluded that the sliding bearing started to worm up gradually from the temperature of

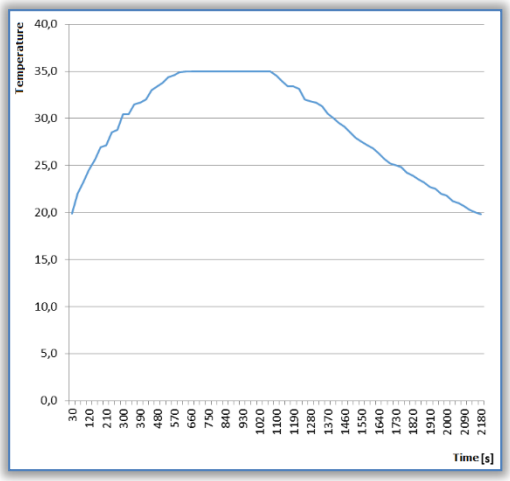

Figure 4. Sliding bearing operating temperature diagram

20°C to the maximal operating temperature of 35°C, that was reached after 10,5 min. The maximal temperature was constant for 7 min and, after electromotor turning off, sliding bearing was cooling off gradually to the room temperature. Total time of temperature measurement was 31 min.

4. ANALITICAL DETERMINATION OF SLIDING BEARING OPERATING TEMPERATURE

Sliding bearing operating temperature ϑ_L can be determined analitically using formulas for the termical bearing stabillity:

$$\vartheta_L = \vartheta_o + \frac{P_G}{k_c \cdot A} \tag{1}$$

respectively:

ϑ_o - environment temperature (that is $20^\circ C$ for normal working conditions)

k_c - heat transfer coeficient, $20^\circ W/m^2 K$

A - bearing housing area, through which heat is dissipated into environment

P_G - energy losses due friction , $P_G = F \cdot \mu \cdot v$

For chosen sliding bearing, area A is calculated using empirical formula from the book[1]: $A = \pi \cdot d \cdot B \cdot 6 = 15599,52mm^2 = 0,0156m^2$.

Bearing load force value was calculated using formula:

$$\frac{F}{B \cdot D} \le p_{doz} \tag{2}$$

Allowed specific bearing load,made of CuSn legure, is $p_{doz} = 7\,N/mm^2$, so,using the formula (2) and bearing dimension,the force becomes $F = 5800,25N$.

Sliding velocity v is calculated using formula:

$$v = \frac{\pi \cdot d \cdot n}{60} \tag{3}$$

and her value after data importing for chosen bearing is $v = 0,75m/s^2$. It is important to know Somerfield number S_0 , that is determined on the basis of dependence of mentioned number and relative film thickness δ [5] diagram, in order to determine friction coeficient μ .If assumed film thickness is $\delta = 0,5mm$ [1,6],it is resulted that $S_0 = 0,8$. Using following formula:

$$\mu = \frac{3 \cdot \psi}{\sqrt{S_0}} \tag{4}$$

where $\psi = 0,8 \cdot 10^{-3} \cdot \sqrt[4]{v} = 0,74 \cdot 10^{-3}$, result is $\mu = 0,00248$.

Importing all known parameters into (1),sliding bearing operating temperature becomes $\vartheta_L = 54,44^0 C$.

Radial sliding bearing operating temperature, calculated analitically, was considered for the maximal allowed specific load due to impossibility of real load sliding bearing determination on the testing table because of shortage of testing table characteristics. If measurement mistakes and instruments inaccuracy were neglected, it can be stated that experimentally determined sliding bearing temperature of 35°C lower for approximately 20°C with regard to analitically determined operating temperature, which was expected since the bearinginstalled on the testing table was not loaded with the maximal force. Based on previous, it can be concluded that chosen bearing is termically stable, with regard that its measured temperature is not higher than analitically determined operating temperature.

5. CONCLUSION

The paper shows experimental determination method of sliding bearing operating temperature, installed on testing table, and its termical stability is determinated by FLIR camera. Using analitically formulas for bearing temperature determination during work, the maximal temperature of 54,44°C was calculated. It can be concluded that bearing temperature is not higher than analitically calculated temperature, based on experimental diagrams. Thus, it is clear that tested bearing is termically stable and there were no interruptions to the normal work of

bearing, such as harmful dilatations and deformations of shaft and bearing, gaps changes,lubricant viscosity decreasing and similar. This paper, among the other, confirmes the correctness of experimental method of operating temperature measuring, which enables many possibilities for further examinations in this field. One of the following examinations can be the check of sliding bearing temperature to number of revolutions dependence.

Note: This paper is based on the paper presented at The 12th International Conference on Accomplishments in Electrical and Mechanical Engineering and Information Technology – DEMI 2015, organized by the University of Banja Luka, Faculty of Mechanical Engineering and Faculty of Electrical Engineering, in Banja Luka, BOSNIA & HERZEGOVINA (29th – 30th of May, 2015), referred here as [7].

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