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EXPERIMENTAL MEASUREMENT OF SLIDING BEARING TEMPERATURE USING THERMOGRAPHY

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Abstract: In this paper is shown an example of the use of thermography in the measurement of temperature of the sliding bearings. The temperature is very important by sliding bearings, so it is necessary to measure frequently and the contactless gauges allow it in a very simple way. This paper shows that the measurement is bit dependent on the manufacturer of the camera that measures the temperature, it is important that the camera is intended for such measurements and that the basic parameters such as emissivity and measurement distance are well adjusted. Different camera manufacturers enrich accessories, which certainly helps users to handle the camera more easily, but from the aspect of temperature accuracy, cameras of the same characteristics give approximately similar results.

Keywords: thermography, temperature, sliding bearings

1. INTRODUCTION

The bearings are machine elements whose task is to enable the relative movement of the rotary parts while simultaneously transmitting the load between them and securing their position [1]. 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 is a force that radial bearing can transfer within his 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 [2].

The most important part of the sliding bearing is a sliding pair. In the radial bearing, the slip pair consists of the shaft sleeve (1) and the bearing sleeve (2) (Figure 1). The basic dimensions of the radial sliding bearing are the diameter of the sleeve d , the internal diameter of the split diameter D and the length of bearing B .

Frictional heating and the temperature rise in a sliding contact is a fascinating, and often passionately debated, area of study [2,3,4]. To obtain a more quantifiable indication of temperature, direct contact thermometers are often used; a safer method than using the back of your hand, but with some similar safety concerns. Infrared thermometers are often used for hazardous and difficult to access applications. However, infrared thermometers measure the average temperature of an area and, for accurate measurements, the user often has to be close to the application. Thermography allows you to visualize heat. The application's infrared radiation is converted by a thermal camera to a visual image. The different temperatures are indicated as different colors or shades of grey. Thermal cameras allow temperature comparisons over a large area, allowing potentially troublesome hot spots to be found quickly. If cost of the thermal camera is offset against savings in reduced downtime and maintenance costs, generally a short payback period is realized [5, 6]. In this paper is shown an example of the use of thermography in the measurement of temperature of the sliding bearings using two different IR Camera.

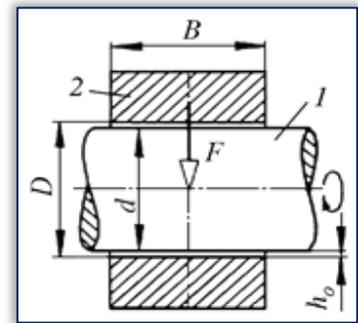


Figure 1. Schematic of radial sliding bearing

2. MATERIAL AND METHODS

The measurement of sliding bearing operating temperature was performed on the testing table in Laboratory of Applied Mechanics and Mechanical construction on Faculty of Mechanical Engineering in East Sarajevo.

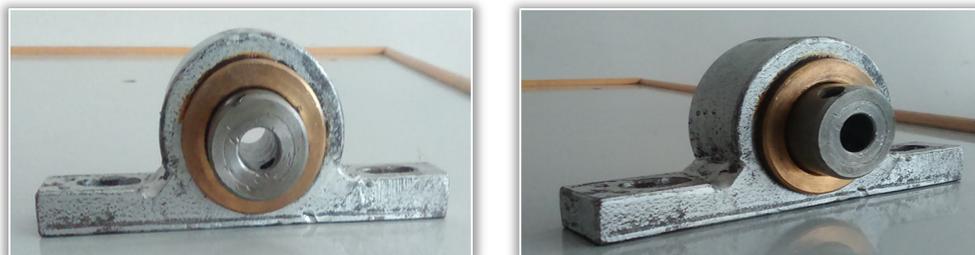


Figure 2. Radial sliding bearing

Basic characteristic of slider bearing used for this study (Figure 2) are:

- Material: The sliding bearing, made of CuSn legure,
- Dimensions: BxDxd=27,6x30,022x30 mm
- Lubricate: Multifunctional Lithium lubricant, made by „Optima Modriča“ (temperature range -20°C to 120°C)
- Method of lubrication: The lubrication of the bearing was carried out manually, only once before the test

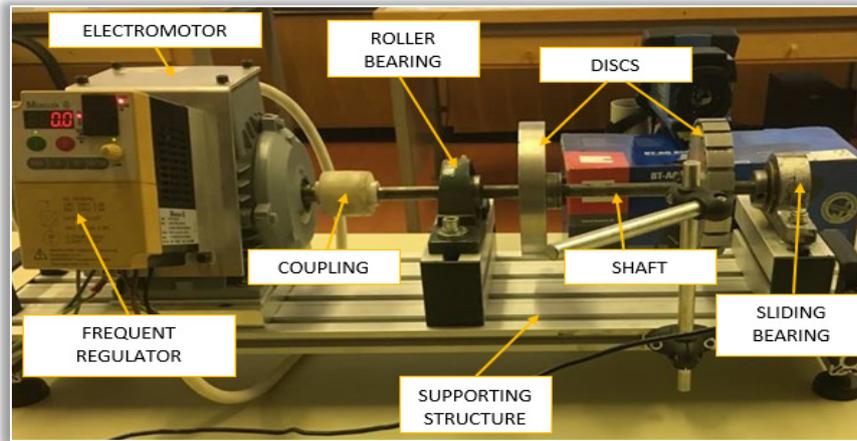


Figure 3. Test table with the basic elements

The speed of the shaft on test table is regulated by the frequency regulator connected to the electric motor. The shaft of the electric motor is connected via a claw coupling to the shaft on which the known load is located. The shaft is supported in one place via the roller bearing type SKF IAR 203 / 12-2F, and on the other via the aforementioned sliding bearing for which the temperature is measured. Sliding bearing is positioned at position 2 of the test table. Basic elements of the test table are showed on Figure 3.

For the contactless measurement of the temperature of the slide bearing, two IR (Infrared) cameras, one manufacturer of the FLIR (model E4), and the other SKF (model TKT131) were used (Figure 4). The basic characteristics of the FLIR camera are shown in Table 1 and of SKF camera in Table 2.



Figure 4. Thermal cameras: FLIR (left) and SKF (right)

Table 1. The basic characteristics of the FLIR camera [7]

| | | |
|---|-----------------------------|--------------------------------|
|  | IR Resolution | 80x60 |
| | MSX Resolution | 320x240 |
| | Thermal Sensitivity/NETD | <0,15 °C |
| | Display | 3.0 in. 320 × 240 color LCD |
| | Field of view (FOV) | 45° × 34° |
| | Operating Temperature Range | -20° to 250°C |
| | Accuracy | ±2% or 2°C |
| | Spotmeter and Area | Center spot; box with min./max |
| | Emissivity | from 0.1 to 1.0 |

Table 2. The basic characteristics of the SKF camera [8]

| | | |
|---|-------------------------------------|---|
|  | Thermal detector (FPA) | 384 x 288 uncooled FPA microbolometer |
| | Theoretical spatial resolution IFOV | 3.46 mrad |
| | Thermal sensitivity | NETD ≤60 mK (0.06 °C) at 23 °C (73 °F) |
| | Display | 3.5 in. color LCD |
| | Field of view (FOV) | 25 x 19° |
| | Operating Temperature Range | -20 to +180 °C , Standard mode 100 to 600 °C, High temperature mode |
| | Accuracy | ±2% ot 2°C |
| | Measurement modes | Up to 4 movable spots. Up to 3 movable areas and 2 movable lines (maximum, minimum and average temperatures). Automatic temperature difference. Hot and cold spots. Visual and audible alarms. Isotherms. |
| | Emissivity | from 0.1 to 1.0 |

3. EXPERIMENTAL TESTING

For the purpose of simultaneous measurement of temperature on the slide bearing, the IR cameras are positioned one against the other at a distance of 0.3 m from the sliding bearing. The operating temperature of the sliding bearing is measured for an angular velocity of 25 Hz. The emissivity on both IR cameras is set to a value of 0.8.

Starting the measuring from the sliding bearing room temperature, its operating temperature was recorded on every 20 s, until the moment of maximal value. After that, the taster table electromotor was turned off and operating temperature was recorded during cooling of sliding bearing, also, on every 20 s. The temperature was manually read, i.e. the operator read and recorded the temperature from the camera screen (Figure 5), so it is necessary to take into account possible errors of reading the operator.



Figure 5. IR camera screen during measurement

The test lasted a total of about 2 hours and 30 minutes, with the preparation of a test table, lubrication of the bearings, adjustment and positioning of the cameras, and finally by measuring the temperature. The measurement process lasted 6540 s, which is 1 hour and 49 minutes.

4. RESULTS AND DISCUSSION

During measurements of the temperature of the slide bearing on both cameras, IR images were made to clearly indicate that the measurements were performed at the highest temperature location. After 400 seconds, the first images were made, showing that the temperature measured with the FLIR camera was 27.7°C (Figure 6a) and the temperature measured by the SKF camera was 25°C (Figure 6b).

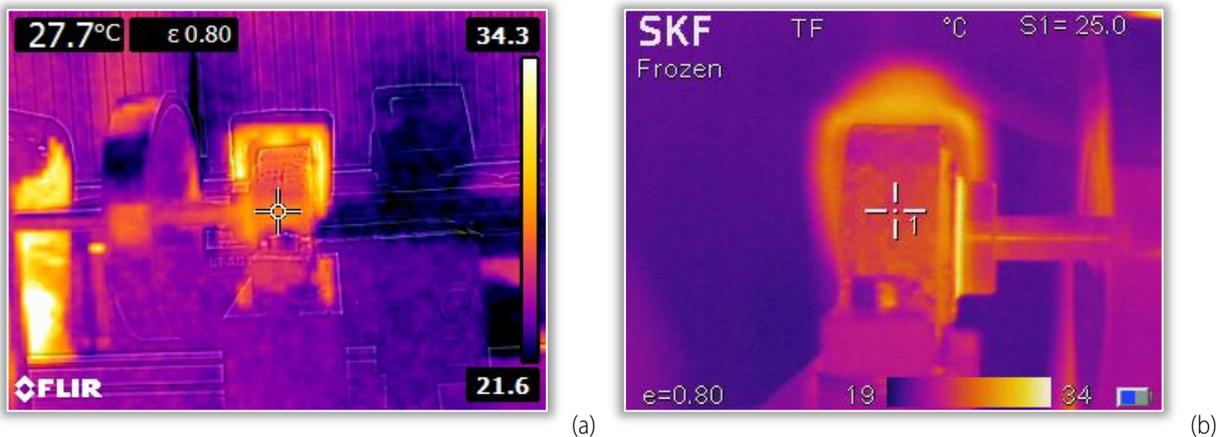


Figure 6. IR sliding bearing image after 400 s operating: a) received by FLIR camera; b) received by SKF camera

Using the same methodology was made the images after 1800 s (Figure 7), 3800 s (Figure 8) and 4800 s (Figure 9) operating. The selection of the moment of imaging is random, and the showed images were not processed in image processing software.

Before analyzing the images themselves, it should be noted that the temperature range around the sliding bearing is not from the temperature bearing than from the opposite IR camera, so it can be ignored. Temperature recording is performed at points so that the influence of external elements on the measurement is minimized.

Observing the images, it can be clearly concluded that the image obtained by the SKF camera with higher resolution and better quality, the reason is reflected in the fact that the SKF camera has optical adjustment and focus, i.e. is not a free type of focus, but a manual. A better resolution of the image does not necessarily mean more precise measurement, because the images only serve to display the measurement results.

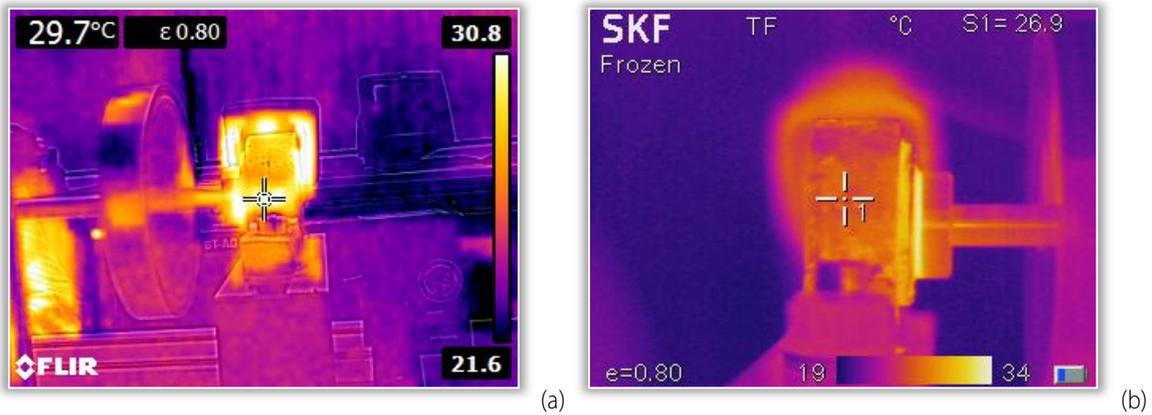


Figure 7. IR sliding bearing image after 1800 s operating: a) received by FLIR camera; b) received by SKF camera

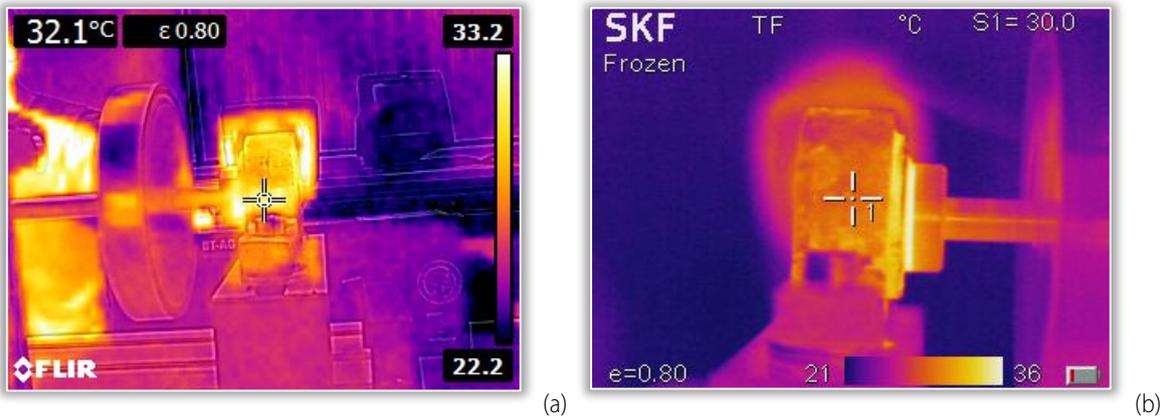


Figure 8. IR sliding bearing image after 3800 s operating: a) received by FLIR camera; b) received by SKF camera

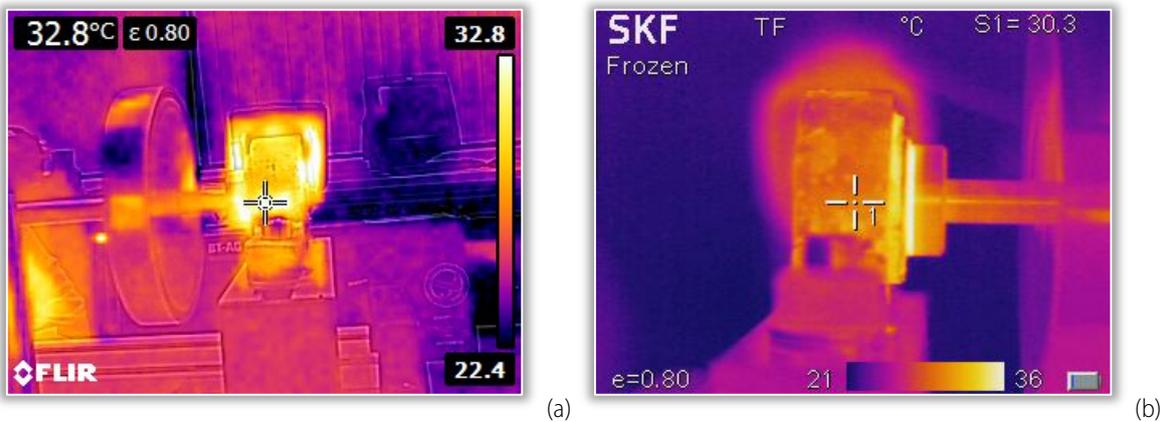


Figure 9. IR sliding bearing image after 4800 s operating: a) received by FLIR camera; b) received by SKF camera

The aim of this experiment was, on the one hand, to determine the possible difference in temperature measurement using an IR camera from two different manufacturers of very similar characteristics, and also the aim was to determine whether the sliding bearing is evenly heated on both sides. In order to see more clearly the difference in the obtained temperatures, the temperatures obtained by measuring, using MS Excel, show the temperature diagram shown in Figure 10.

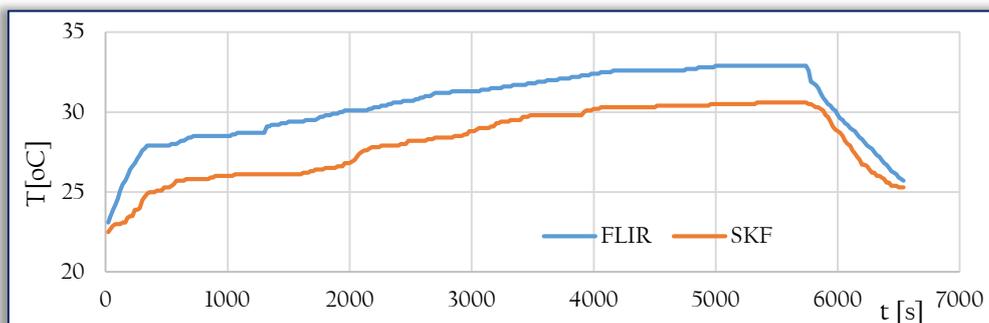


Figure 10. Slide bearing operating temperature diagram obtained with FLIR and SKF IR cameras

The measurement started with a room temperature of a sliding bearing of 22.5°C, and both diagrams (Figure 10) clearly show the warm-up time, the thermal stability, and then the cooling period of the bearing. The bearing temperature thus obtained shows that the bearing is in good condition and is well lubricated. It should be noted that the temperature is only one of the parameters for determining bearing failure.

With the diagram it can be noticed that the temperature obtained with the FLIR camera is about 3°C higher than the temperature obtained with the SKF camera. If it is known that the accuracy of both cameras is about 2°C then this difference is acceptable. It is interesting to note that the difference all the time was constant with less falls, which also indicates possible uneven heating of the bearing. On the other hand, if it is to analyze the reasons why there is a difference in temperature, then the following reasons can be stated:

- possible operator errors in the measurement;
- due to manual lubrication, lithium fat did not evenly spread through the bearing;
- the cameras were fixed, but due to the large vibrations during operation, it is assumed that the cameras were moving a little;
- advanced camera settings have not been checked, so differences in these settings are possible;
- due to the influence of external elements.

5. CONCLUSIONS

The main advantage of using thermographic cameras is the quick and easy detection of errors, where a long-term process of checking and correcting errors can be avoided. Errors can be detected before equipment failure or other types of losses occur. This reduces maintenance costs, increases the lifetime of equipment and productivity.

This experiment shows an example of the use of thermography in measuring the temperature of the sliding bearings. Temperature is very important in the case of a sliding bearings, it is often necessary to measure it, and the contactless gauges make it very simple and precise. This paper shows that the measurement is bit dependent on the manufacturer of the camera that measures the temperature, it is important that the camera is intended for such measurements and that the basic parameters such as emissivity and measurement distance are well adjusted. Different camera makers offer extra accessories, which certainly helps users to handle the camera more easily, but from the aspect of temperature accuracy, cameras of the same characteristics give approximately similar results. It is recommended that contact heat meters are used to control contactless temperature gauges if more accurate measurement is required.

The future research should be planned so that on the same side of the bearing, and again under the same conditions, the same examination is performed in order to confirm in another way the previous hypothesis. Also, for the purpose of a clearer identification of all influential parameters on thermography, i.e. measurements using an IR camera, it is necessary to perform tests on several different technical systems, and in order to verify these results, use contact heat meters.

Note:

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