Serbian Tribology Society

SERBIATRIB '17

15th International Conference on Tribology

Faculty of Engineering University of Kragujevac

Kragujevac, Serbia, 17 – 19 May 2017

EXPERIMENTAL DETERMINATION OF THE WEAR FACTOR OF THE SLIDING BEARINGS MADE OF POLYMER BASED COMPOSITE

Miloš STANKOVIĆ[1]*, Aleksandar MARINKOVIĆ[2], Radivoje MITROVIĆ[2], Žarko MIŠKOVIĆ[2]

[1]Innovation Center of the Faculty of Mechanical Engineering, Serbia

[2]Faculty of Mechanical Engineering, University of Belgrade, Serbia

*Corresponding author: mstankovic@mas.bg.ac.rs

***Abstract**: Wear intensity is very important in terms of determining life cycle of machine elements. Experimental analysis of wear factor of certain material in contact with other specific materials are inevitable for this prediction. This paper provides two methods of determination of wear factor of polymer based sliding bearings – volume loss method and mass loss method. Volume loss method is based on capturing wall thickness before and after wearing process. The capturing was performed by means of 3D microscope. On the other hand, mass loss method is based on measuring mass of bearing sample before and after wearing. This measuring was performed by means of high accuracy balancing device. Afterwards, it was performed comparison of the results by connecting mass and volume through density. The tested specimen is sliding bearing of PTFE-Polyamide composite. The wearing was performed on the machine USL 5-30. Operational parameters are: velocity - 1m/s, pressure - 1MPa and sliding distance - 20000 m.*

***Keywords**: wear factor, experimental wear determination, polymer based composites, sliding bearings*

1. INTRODUCTION

Sliding bearings made of polymer based composites are widely applied, especially when it comes to the special requirements, such are self-maintaining, absence of lubrication or some dimensional constraints [1]. Only some examples of applications of these bearings are in food industry or in production of household appliances. Their application is economically justified due to quite low price if compared to metal, roller bearings. But their disadvantage is significantly lower load capacity.

Since these bearings operate in sliding contact, usually with sleeve made of steel, their tribological properties are essentially important for proper functionality. In this paper it was presented two methods to determine wear factor of these sliding bearings. The wear intensity was evaluated through mass loss, and volume loss determination.

2. EXPERIMENT DESCRIPTION

Experiment could be divided into 3 stages:

1. Pre-wear stage
2. Wear stage
3. Post-wear stage

In the first stage it was performed balancing of the samples, in order to determine mass of the unworn bearings. There were also taken the high magnification photographs of the bearing wall in the zone of expected wear occurrence in order to determine wall thickness of the unworn bearing.

The second stage assumes the wearing process of specimens under predefined conditions. Those conditions are to follow:

- Radial load of 1 MPa applied onto the specimens outer cylindrical surface
- Sliding velocity of the sleeve in contact 1 m/s
- Sliding distance between specimen and sleeve during one experiment - 20 km.

Consequently, the duration of the wearing process was 20000 seconds. The experiments were conducted under the room temperature.

Before the second stage, the samples are initially lubricated with one single drop of lubricant. Besides the experiment runs in dry sliding conditions. During the experiments it was monitored the temperature in sleeve-bearing contact, by means of thermocouple fixed onto the outer surface of the bearing. It was also monitored the friction torque in this tribo pair in order to evaluate friction coefficient, by means of straingauges.

After the process of wearing, the samples are cleaned in ultrasonic cleaner. As the cleaning fluid it was used gasoline at the temperature of 50°C.

In the post-wear stage there were retaken the magnified photographs of the worn zone and the samples were rebalanced in order to calculate worn volume and worn mass.

2.1 Specimen description

PTFE Polyamide combines a thermoplastic as a base material, with PTFE additives and glass-fibre, which results in self-lubricating and low wear performance. They are designed for dry operation, but their performance could be improved by initial lubrication. With a supply of grease, oil, water or other liquid, the operating speed of these bushings can be increased. These bushings are resistant to most lubricating oils and greases. They offer many features and advantages such as:

- Maintenance-free operation
- Cost efficiency
- Excellent resistance to corrosive conditions
- Electrically insulating properties

Dimensions of examined bushings are Ø20x Ø23x20 mm. Additional properties of these bearings are given in Table 1.

Figure 1. PTFE polyamide bushing

Table 1. Characteristics of PTFE polyamide bushing

Permissible load, N/mm^2 (dynamic/static)	40/80
Permissible sliding velocity, m/s	1
Friction coefficient μ	0.06..0.15
Temperature range, °C	-30..+110
Density, kg/m^3	1380

2.2 Description of the equipment

For the first and third stage of the experiment (mass and volume measurements), there were used high precision balance with accuracy of 1x10^{-3} g (Figure 2) and 3D microscope (Figure 3).

Figure 2: Balancing device "RADWAG" (accuracy 1x10^{-3} g)

Figure 3: HIROX KH-7700 3D Microscope

The second stage, i.e. tribological experiments on composite sliding bearings are conducted by means of custom made equipment USL 5-30. This equipment was described in more details in one of the previous papers [2]. The principle of its functioning could be seen at the Figure 4.

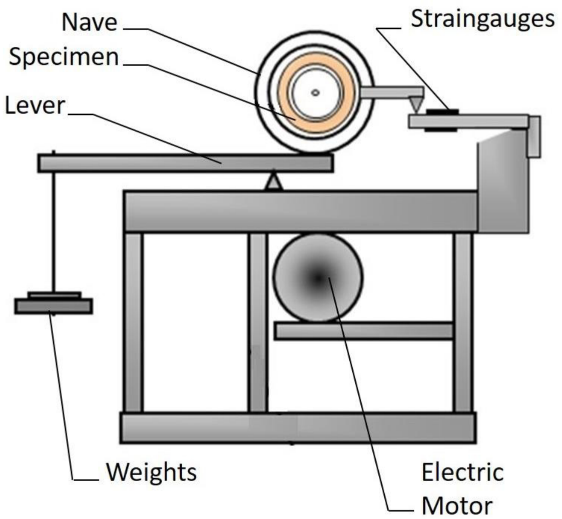

Figure 4: USL 5-30 test rig system

The shaft which is in contact with specimen is driven by means of electric motor and belt transmission. The radial load is applied through the lever. One end of the lever is in contact with nave in which the specimen is placed, while on the other end of the lever there are hanged the weights. The ratio of lever ends is 10:1. The radial load could be varied by applying different combination of weights, while the rotation speed of shaft could be also varied through the frequency inverter.

3. RESOULTS AND ANALYSIS

The masses of 3 bearing samples before and after process of wearing is presented in Table 2. There can be noticed excellent repeatability of the results, but values of the worn mass are very low (7-8 mg). Since the polymers are usually well-known for high humidity absorption, these values should be carefully taken into account, since there is possibility of mass increase due to liquid absorption. In another words it is very likely that the worn mass of specimen is partially replaced by the amount of mass of the fluids (lubricant and gasoline) absorbed by specimen.

Table 2: Measured mass of specimens in different stages of the experiment

Specimen Number	Before wear [g]	After wear [g]	Decrease [g]
1	2.833	2.825	0.008
2	2.81	2.802	0.008
3	2.812	2.805	0.007

Analysing the other method of wear intensity evaluation, volume method, it could also be seen excellent repeatability for all of the samples. What was actually measured, it was a wall thickness of the sample before and after wearing (Figure 5), and through it was calculated inclination of the shaft into the specimen. Assuming that the profile of worn volume is uniform along the specimen, measuring inclination makes it possible to calculate the worn volume. The flow of this method was actually the assumption of the uniform wear distribution along specimen. At the moment, this assumption cannot be confirmed.

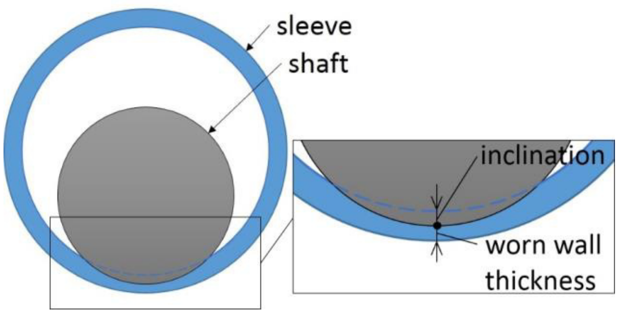

Figure 5 : Wall thickness after wearing process

Finally, these two methods are comparable by connecting appropriate values of mass and volume with already known density.

$$m = \delta \cdot v \quad (1)$$

Taking into account values of volume from the Table 3 and the density of examined bearings ρ=0.00138 g/mm^3, it was calculated the masses of worn volume and compared to masses from Table 2. The compared results are presented in Table 4.

Table 3: Wall thickness before and after wearing process

Speci-men Number	Before wear [mm]	After wear [mm]	Inclina-tion [mm]	Volume [mm^3]
1	1.544	1.247	0.297	93.99
2	1.576	1.278	0.298	94.37
3	1.570	1.260	0.310	98.86

Table 4: Comparison of measured and calculated masses.

Specimen Number	Measured mass [g]	Calculated mass [g]	Ratio m_m/m_c [%]
1	0.008	0.130	6.1
2	0.008	0.130	6.1
3	0.007	0.136	5.1

Analysing the results from Table 4, it could be noticed huge deviation of masses obtained by two different methods. This is explained by previously mentioned flaws of each methods. Since the “mass method” is giving the lowest possible value of wear (probably additionally decreased for the value of absorbed liquids), and the “volume method” is giving the highest possible value of wear (the assumption of uniform wear distribution along the specimen gives the highest value of wear), this deviation is expected in a certain way. What we can claim for sure, is that the wear in above specified conditions is not less than the one determined by “mass method”, and not greater than the one determined by “volume method”.

4. CONCLUSION

In this paper it was presented determination of wear intensity of polymer based composite sliding bearings by two different methods: “mass method” and “volume method”. Although the repeatability of the results of wear determination by two methods is excellent, the comparison between them did not give good superposition. Anyway, having the frame in which the wear intensity is placed could be considered for a certain progress.

Further improvement in wear intensity determination is planned for the future investigation by means of high precision 3D scanner able to scan the worn surface in 3 dimensions. That will certainly improve the “volume mass” results obtained in this investigation.

AKNOWLEDGEMENT

This work has been performed within the projects TR-35021, TR-35011 and TR-35029. Those projects are supported by the Republic of Serbia, Ministry of Science and Technological Development, which financial help is gratefully acknowledged.

REFERENCES

[1] A. Marinkovic, M. Stankovic: Advantages and Applications of Self-Lubricating Plastic Bearings, in: Proceedings of the 13th International Conference on Tribology – SERBIATRIB '13, 15-17.05.2013., Kragujevac, Serbia, pp. 247-250.

[2] M. Stankovic, A. Marinkovic: Tribological Properties of Selflubricating Sliding Bearings Made of PTFE and POM-Based Composite Materials, in: Proceedings of the 14th International Conference on Tribology – SERBIATRIB '15, 13-15.05.2015., Beograd, Serbia, pp.314-318.

[3] SKF bushings catalogue, Publication 4741 E

[4] B. Sadık Ünlü, E. Atik, S. Köksal: Tribological properties of polymer-based journal bearings, Materials and Design, Vol. 30, No. 7, pp. 2618–2622, 2009.

[5] M. T. Demirci, H. Düzcükoglu: Wear behaviors of Polytetrafluoroethylene and glass fiber reinforced Polyamide 66 journal bearings, Materials and Design, Vol. 57, pp. 560–567, 2014.

[6] V. Krsmanović, R. Mitrović: Klizni i kotrljajni ležaji, ISBN: 978-86-17-19284-4, 2015

[7] B. Sadık Ünlü, E. Atik, S. Köksal: Determination of Friction Coefficient in Journal Bearings, Materials and Design Vol. 28, No. 3, pp. 973–977, 2007.