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RESEARCH

Tribological Properties of Zn-Al 27 Bearing Alloy Under Boundary Lubrication*

The paper presents results of on investigation of friction and wear behavior of Zn-Al 27 alloy under boundary lubrication using the pin-on-disk testing rig. The results obtained lead to the conclusion that ZnAl 27 alloy satisfies the bearing material requirements. The results also show that the mechanical and tribological properties of the tested material are comparable with those of traditional alloys, such as some kinds of bronze

***Keywords**: Bearing material, Tribological properties, Boundary lubrication*

1. INTRODUCTION

A large number of metallic materials are used as sliding bearing materials because no single material is capable of satisfying all various requirements. This is, also, the reason why new materials are continually being developed. Among these, the application of Zn–based alloys has been on the increase during the last decade. New types of Zn-based alloys have been developed to satisfy the requirements of bearing materials, especially such as operating under low sliding speed and relatively high specific load /1, 2/.

The rapid increase in the commercial use of Zinc-Aluminium alloys as bearing material is the result of extensive investigations and studies undertaken in the last twenty years /3, 4 /. Two materials usually recommended for sliding bearings are ZnAl12 and ZnAl27, which contain 12 and 27 % Aluminium respectively. These materials were included into the EN 1774/98 and ASTM B 669-89 standards.

Zinc-based alloys containing Al and Cu have superior mechanical properties, good wear resistance, good embeddability, good running-in characteristics, low density and good castability /5/. The increasing interest in ZnAl alloys during the last decade, especially with 27 % Al, as a wear resistant material, has made it necessary to establish their tribological characteristics. In this paper, the tribological properties of the domestic ZnAl 27 alloy are therefore presented in order to illustrate the behaviour of this relatively new type of bearing material under critical running conditions. Also, the results of friction and wear are compared with those of traditional bearing alloy Cu Pb15Sn8 according to the ISO 4382/1 standard.

The tribological characteristics were tested under the condition of boundary lubrication using a pin-on-disk device. The procedure was carried out and results where presented in accordance with the standard ISO 7148/1.

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2. TEST MATERIALS

2.1 Bearing material

Experimental investigation was carried out with ZnAl 27 permanent die casting alloy of the following chemical composition and mechanical properties (Tab.1 and Tab.2):

Table 1. Chemical composition

Alloy Designation	Al	Composition Cu	% (m/m) Mg	Zn
ZnAl 27	26,2	2,3	0,029	Balance

Table 2. Mechanical and physical properties

Characteristics	Alloy ZnAl 27
1. Brinell hardness	124
2. 0,2 % Proof stress, N / mm^2	353
3. Tensile strength, N / mm^2	446
4. Elongation A, %	5,2
5. Elastic modulus E, KN / mm^2	83
6. Density ρ, kg / dm^3	4,83

* *The paper was published at The First Mediterranean Conference on Tribology* in Israel.

Chemical composition and mechanical properties of bronze CuPb15Sn8 satisfied requirements of the ISO 4382/1 standard.

2.2 Material of mating component

In all tests a steel disk was used as a mating couple. The steel disks were heat treated, so that surface hardness of 38 – 40 HRc was obtained. After the grinding of the working surface, roughness from 0,3 to 0,4 μm was achieved.

2.3 Lubricant

As lubricant hydraulic oil ISO-L-HM 68 was used.

3. TEST EQUIPMENT AND PROCEDURE

Experiments were performed using a pin-on-disk device. A stationary pin made from bearing materials, of 2,5 mm in diameter with a flat end, was in contact with the horizontally rotating disk.

The pin surface exposed to wear was polished by means of 600-grade emery paper, so the roughness Ra from 0,3 to 0,4 μm was obtained. Prior to testing, the pins and disks were cleaned with alcohol and acetone, then stored in desiccators until needed.

Lubrication was provided by a circulation system with ample oil supply to the friction couple.

The investigation was performed under the following conditions: sliding speed of 0,15 m /s, specific load of 3 and 5 MPa and oil temperature of 50 ^{0}C.

By preliminary tests it was established that the sliding distance was 3000 m, the steady-state friction and wear serving as criterion. These conditions give "pv" values of 450 and 750 kW / m^2, which are the typical values of sliding bearing under the condition of boundary lubrication.

During the testing the mass losses of pin were measured with 10^{-5} g accuracy. A load-cell, acquisition system and a PC continually recorded friction. A PC also monitored oil temperature.

4. RESULTS AND DISCUSSION

The mass losses for the ZnAl 27 alloy at various loads are shown in Figure 1. The results obtained demonstrate that the running-in period and the period of steady-state wear are clearly distinguished. With the majority of experimental specimens the running-in period was completed within the range between 500 and 700 m. The wear increased with the increase in load.

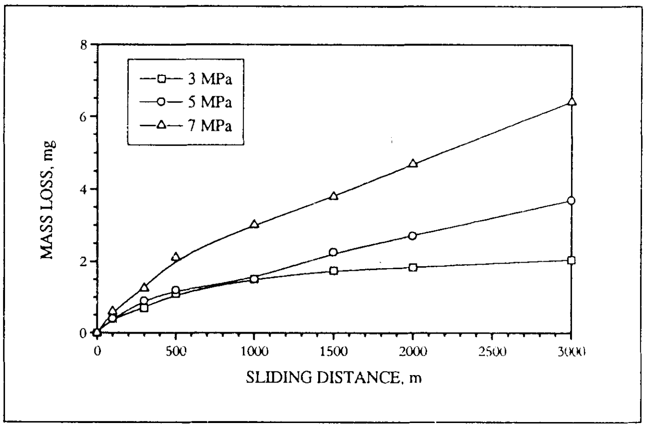

Figure 1. Mass losses of ZnAl 27 vs sliding distance at different loads

Typical graphic of friction, which was recorded during experiment, is shown in the Figure 2.

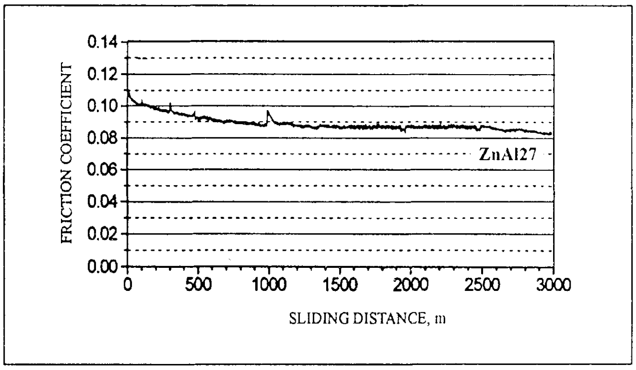

Figure 2. Coefficient of friction vs sliding distance

Calculated linear and volumetric wear intensity of pins at different specific load during the steady-state period are shown in Figure 3 and Figure 4, while the cumulative wear is given in Figure 5 in comparison with wear values of CuPb15Sn8 bronze obtained under the same testing condition.

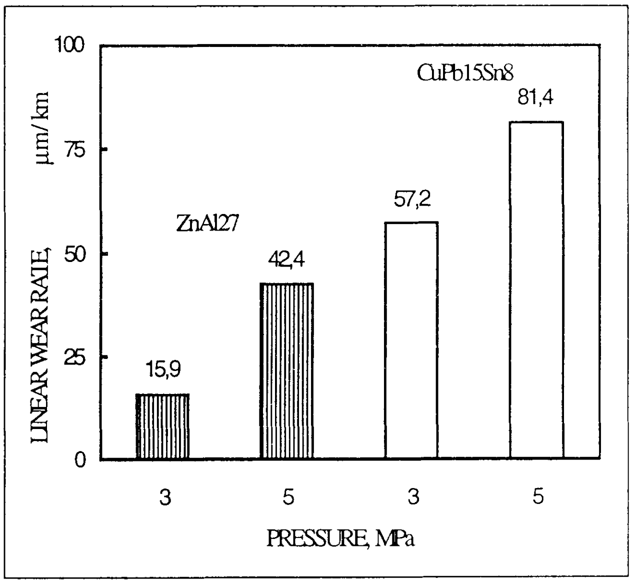

Figure 3. Linear wear intensity of pins in the period of steady state

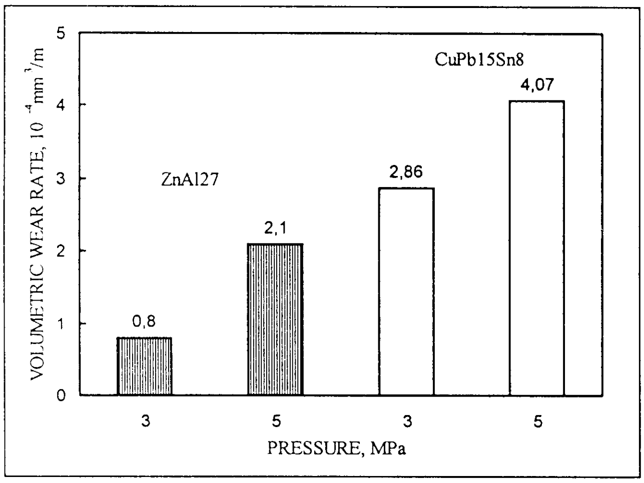

Figure 4. Volumetric wear intensity of the pin in the period of steady state

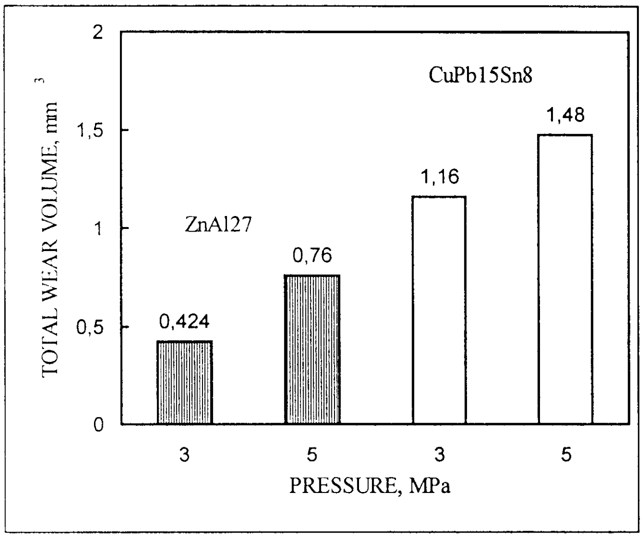

Figure 5. Total wear of pins

The wear factors in mm^3/Nm and coefficient of friction in the period of steady-state are show in Table 3.

Table 3. Wear factor and friction coefficient for steady-state condition

Material	Wear factor, $mm^3/Nm \times 10^{-6}$	Coefficient of friction
ZnAl 27	8,4	0,09
CuPb15Sn8	16,0	0,11

The lower wear intensity of Zn-alloy with 27 % Al is attributed to its better mechanical properties, multiphase structure and the formation of aluminium and zinc oxide. Aluminium give good wear resistance, whereas zinc-oxide being much softer, acts as a lubricant.

By microscopic examination of the wear track on the disc, it was established that the pin material had been transferred and smeared onto its surface. This material, however, was easily removable. No significant scratches were present.

5. APPLICATION

The performance of the ZnAl alloy mentioned above has been verified by field application - for bearings applied in shipping, for locomotive axle bearing and air compressors.

The main application in shipping is to be found as propeller shaft and stern bearings. After the initial 8 to 12 months of operation the bearings showed no significant wear and work trouble - free (Fig.5).

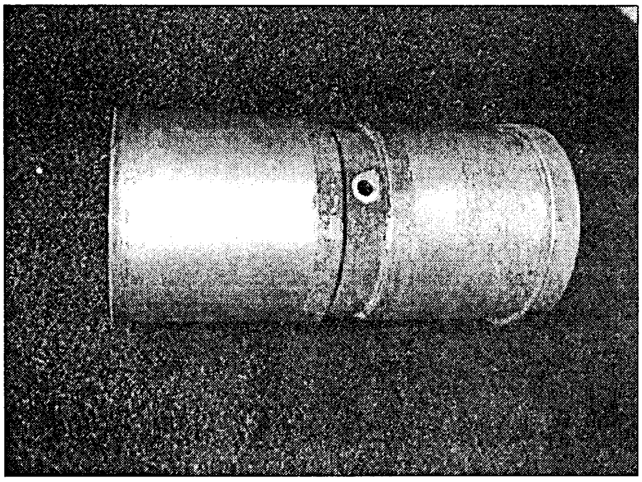

Figure 5. Propeller shaft bearing

Switching locomotive axle bearing made from ZnAl27 alloy had been in operation for more than three years without failure (Fig. 6).

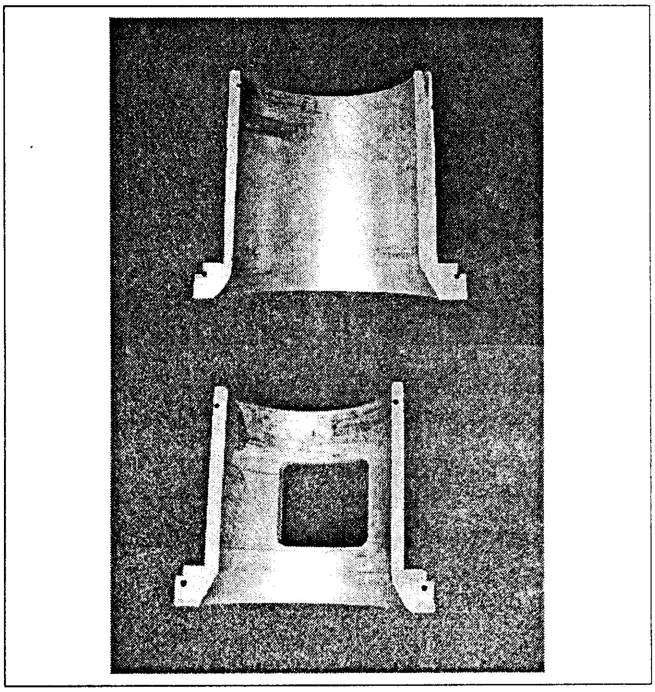

Figure 6. A ZnAl27 locomotive axle bearing

A multi-stage reciprocating air compressor operating continually in Oil Refinery has bearing made of ZnAl27 alloy (Fig. 7). No trouble has been reported with these bearings.

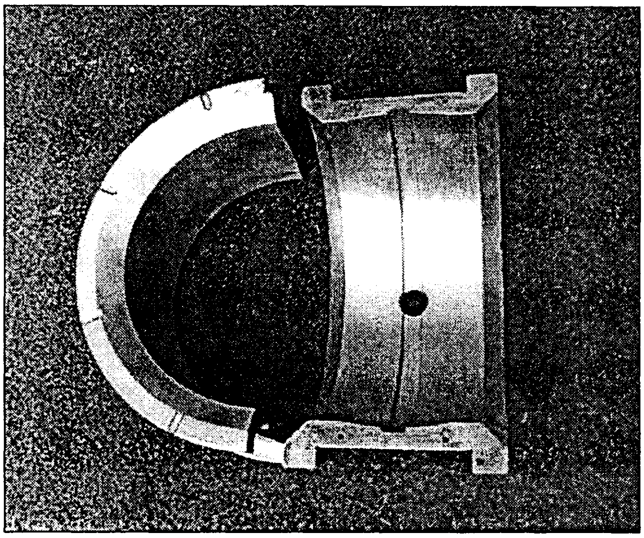

Figure 7. Compressor shaft bearing made of ZnAl alloy

5. CONCLUSIONS

Zinc-based alloys as antifriction bearing materials have found wide-spread use in different machines, particularly under the condition of boundary lubrication, because of their favourable mechanical and tribological properties.

Laboratory investigation demonstrates that Zinc-Aluminium alloy with 27 % Al wholly conforms to the laws of wear of metallic materials. The running-in period and the period of steady-state wear were clearly distinguished. The running-in period under the given condition of boundary lubrication ranged from 500 to 700 m.

Tribological characteristics of the tested Zn-based material are comparable with those of traditional bearing alloys, such as CuPb15Sn8 bronze.

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