COMPARING THE FRICTION PROPERTIES OF POLYMER SLIDING BEARINGS

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Abstract
The Institute of Machine Design at the Budapest University of Technology and Economics has been investigating the tribological properties of polymers for decades. Recently polyamides, polyamide composites and "high performance polymers" have been investigated. There was found extremely high coefficients of friction in some cases by tests using polymer block – steel cylinder pairs. It seems line contacts are disadvantageous in the point of view of friction of polymers.
Polymer sliding bearings paired with steel shafts result better friction properties. During these tests pure polyamides and polyamides containing lubricants and also other polymers as polyacetal homo- and copolymers, polyethylene-terephtalat were investigated. The aims of the investigations were to determine the maximal load carrying capacity of polymer bearings in dry and lubricated conditions. These results are summarized in this article.

Keywords
Polymer, sliding bearing, tribology, friction, maximum load carrying capacity

1. INTRODUCTION

The Institute of Machine Design at the Budapest University of Technology and Economics has been investigating the tribological properties of polymers for decades. Recently polyamides, polyamide composites and so-called high performance polymers such as poly(ether-ether-ketone) have been investigated [1-3]. Coefficient of friction of polymer block/steel cylinder sliding pairs (load: 100 N, width of polymer specimen: 10 mm, sliding speed: 0,3 m/s) investigated on tribometer Amsler achieved extremely high values in many cases. For example the coefficient of friction of specimens made of polyamide 6 exceeded the values of 1.0 [1-3].

These results have shown that line contact is disadvantageous for sliding polymers because of the fast increasing temperature on the rubbing surfaces causing damage of plastic specimens. At the same time polymer sliding bearings paired with steel shafts has resulted in better friction properties, as it were proved by our investigations results of which are presented in the following. The aims of these investigations were to determine the maximal load carrying capacity of polymer bearings made of pure polyamides, polyamides containing lubricants and also other polymers such as polyacetal homo- and copolymers, polyethylene-terephtalat in dry and lubricated conditions.

2. TEST METHOD

The investigation was made on Amsler tribometer. The test rig with polymer sliding bearing and carrying apparatus are shown in Fig. 1.

The diameter of steel shaft is 32 mm, the width of sliding bearing is 15 mm, the relative bearing clearance is 1.8%. The speed of revolutions was 3.18 rps, which means 0.3 m/s sliding speed. The bearing clearance was determined during preliminary tests. Narrower bearing clearance leads to lower load carrying capacity of sliding bearings, because the bearing seized owing to the high thermal expansion of polymer bushings. The material of shaft is mild carbon steel (C 45), its rubbing surfaces were ground to the surface roughness of R_a = 0.3 – 0.35 μm (CLA). Before investigations the sliding surfaces were cleaned by alcohol.

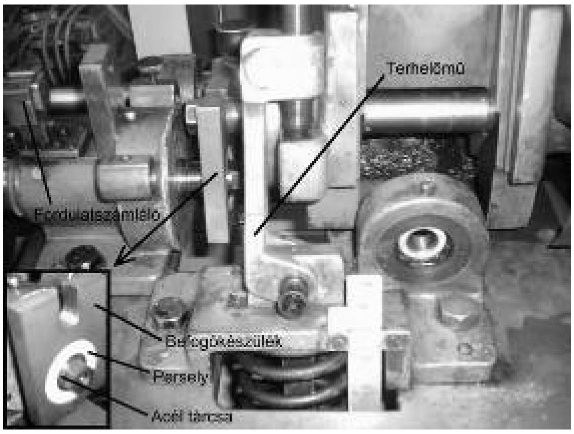

Fig.1. The tester machine

Fig.2. POM-H bearing with damaged running surface

During the investigation the load was increased step by step. The first load level was 300 N and then the load was increased by 100 N steps. The running was continued at every load level until the temperature stabilized (about 2 hours). Then the load was increased by the next 100 N step. The investigation went on until the damage of running surfaces of polymer bushings appeared. The damage was signalled by the rapid increase of friction moment and/or temperature.

During the first part of investigation the sliding bearing ran without lubrication, then (before damage of bushing) a small amount of pure mineral oil (without any additives) was added into the bearing clearance and the investigation was continued. The oil has a viscosity grade of ISO VG 10. The tribometer measured and registered the friction moment. The temperature was determined by a handy laser thermometer.

The changing of friction moment, which was registered during investigation of a bearing made of polyamide 6.6, can be seen in Fig.3. On the right side of figure it can be noticed that the moment of friction decreased remarkably when the oil was added. Moving from right to left in the figure we can see that the gradual increasing of load was followed by the gradual increasing of friction moment. The last load level where the temperature and the friction moment were still constant was called the load carrying capacity of sliding bearing. At too high load the surface of polymer bearing melted in spite of the low coefficient of friction. This can be seen in the picture of a POM-H bearing (Fig.2).

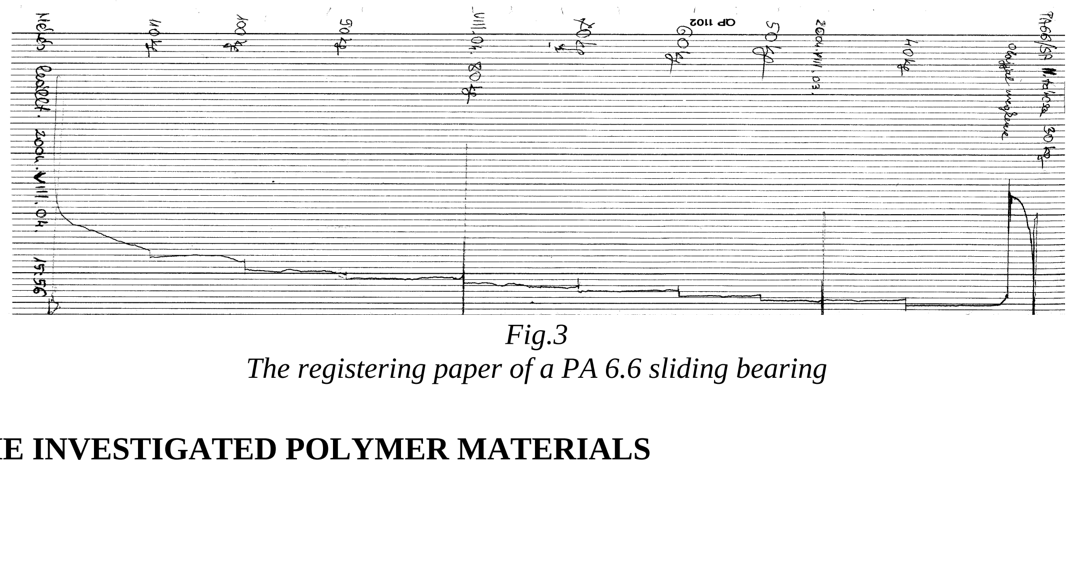

Fig.3

The registering paper of a PA 6.6 sliding bearing

3. THE INVESTIGATED POLYMER MATERIALS

The bushings of sliding bearing were made of the following commercially pure or filled polymers [4]:

- Teramid PA 6G/Na: pure cast polyamide (PA) 6 (made with Na catalyst)
- Teramid PA 6G/Mg: pure cast polyamide 6 (experimental material, made with Mg catalyst)
- Ertalon 66 SA: pure polyamide 6.6
- Ertalon LFX: cast polyamide 6 containing silicone oil
- Nylatron GSM: cast polyamide 6 containing MoS_2
- Nylatron NSM: cast polyamide 6 containing solid lubricant
- Ertacetal C: pure polyacetal copolymer (POM-C)
- Ertacetal H: pure polyacetal homopolymer (POM-H)
- Ertalyte 16: pure poly(ethylene-terephtalat), PET

4. TEST RESULTS

Fig.4 compares the coefficient of friction and temperature of pure polyamide sliding bearings at load of 300 N without external lubrication at the beginning and at the end of tests. The load carrying capacity of these bearings lubricated with pure mineral oil can be seen on Fig.5. This figure also shows the temperature and the coefficient of friction at this load level.

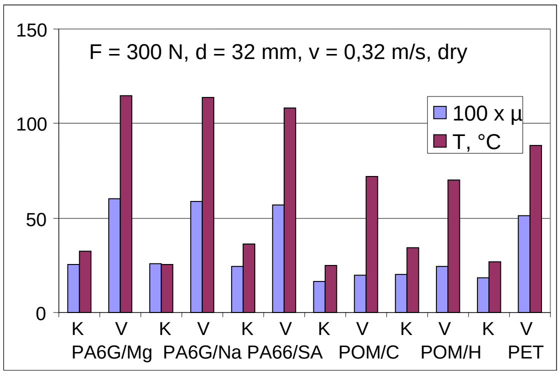

Fig.4 Coefficient of friction and temperature of pure polymers without external lubrication at the beginning (K) and at the end (V) of measuring by load of 300 N

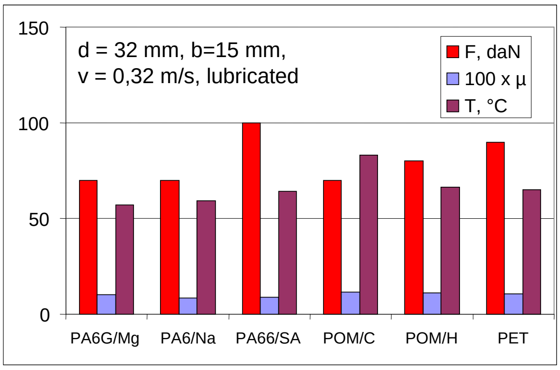

Fig.5 Maximum load carrying capacity of pure polymers with external lubrication; the coefficient of friction and temperature by this load

Fig.5 shows that the oil lubrication (which was used only once after the increasing of coefficient of friction or temperature signed the beginning of damages of bushing) decreased efficiently the coefficient of friction at all investigated polymers. The coefficient of friction did not exceeded the value of 0.12 even by maximum load carrying capacity with its high temperature. It is interesting that the maximum load carrying capacity of each polyamid is remarkably different despite the fact that there was not big differences between their friction properties in dry running conditions. The coefficient of friction of pure polyamides was almost the same.

The load carrying capacity of POM and PET sliding bearings is higher than of polyamide 6, but it does not reach the load carrying capacity of polyamide 6.6. In some cases it occurred that the running surface of polymer melted (see in Fig.2) and a thin polymer layer developed on the metal surface. According to expectations the load carrying capacity of POM-C is lower than POM-H due to its more advantageous friction properties (its coefficient of friction is lower with about 20%).

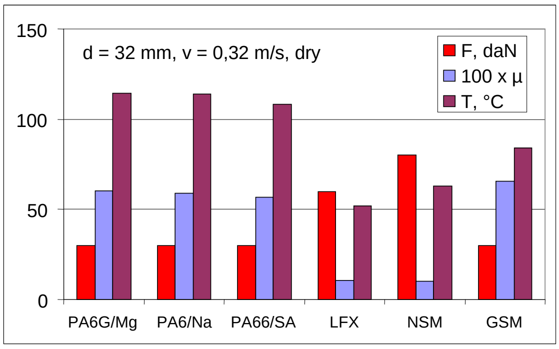

Fig.6 Maximum load carrying capacity of pure and filled polyamides without external lubrication; the coefficient of friction and temperature by this load

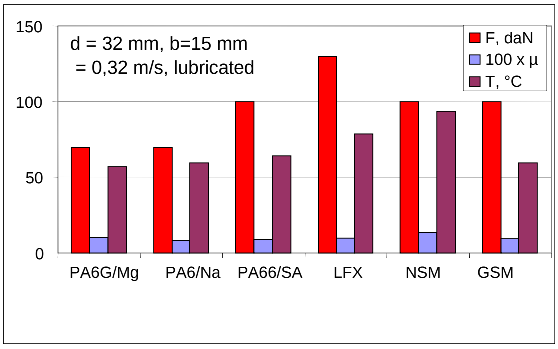

Fig.7 Maximum load carrying capacity of pure and filled polyamides with external lubrication; the coefficient of friction and temperature by this load

Fig.6 and 7 show the coefficient of friction, the temperature and the load carrying capacity of pure and internal lubricated (filled) polyamides without and with external lubrication. As it can be expected the filled polymers reached better results in both cases except one material. Polyamide containing MoS_2 (material signed with 'GSM') has not got higher load carrying capacity than the pure polyamide 6 material, and its coefficient of friction also was higher. The oil lubrication more increased the load carrying capacity of GSM than ones of the pure polyamides. It became more advantageous in these test conditions, but it could not exceed the load carrying capacity of PA 6.6. During dry running conditions the load carrying capacity of polyamide composite called 'NSM' was the highest while using lubrication the 'LFX' material was proved as the most advantageous.

5. SUMMARY

The test results show that the tribological properties of polymers remarkably depend on the conditions of investigation. The coefficient of friction of sliding bearings without external lubrication is much lower than the coefficient of friction of polymer block/steel cylinder. The lubricants added to polyamides during manufacturing have an advantageous effect on the properties polymer bearings (except polyamid composite called 'GSM'). The oil lubrication used only once increases remarkably the load carrying capacity of polyamide 6 while the coefficient of friction is decreased.

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