KASHIMA BEARINGS INC.

WHITE PAPER

ULTRA-HIGH-MOLECULAR-WEIGHT-POLYETHYLENE

UHMWPE-BEARING

„Relationship between Life, Load and Rotation Speed of UHMWPE Bearing under Dry Rolling Contact Fatigue“

Forschung, Entwicklung und Produktion

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Anwendungsbeispiele:

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- ***Medizingeräte***
- ***UV Bestrahlungsgeräte***
- *Färbeanlagen*
- *Reinigungsgeräte*
- *Isolierung (Messgeräte, Instrumente und Detektoren)*
- *Herstellung von Silizium-Mikroplättchen*
- *Filmreinigung und Oberflächenbehandlung*
- *Galvanotechnische Anlagen*
- *Springbrunnen und Wasserlandschaft*
- *Reinigungsstraßen für Glassubstrate*

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Keywords: Rolling contact fatigue, UHMWPE, Polymer bearing, Tribology, Wear, Dry contact

Abstract. The polymer bearings have been widely used in recent years. In this study, ultra-high-molecular-weight-polyethylene (UHMWPE) is investigated. In order to investigate the relation between the lives, loads and rotation speeds, rolling contact fatigue tests were conducted. It was found that rotation speed related to the bearing life and wear loss.

Introduction

Ball bearings need various properties; high strength, wear resistance, corrosion resistance, long life, etc. While metal bearings have been used, they are not able to satisfy all the requirements of industrial environment. Polymer bearings have many advantages (lightweight, self-lubrication, electrical insulation) and are used in special conditions (dry, water, chemical, electrical and vacuum environments).

Ultra-high-molecular-weight-polyethylene (UHMWPE) is used in special conditions due to its lightweight and excellent formability. UHMWPE is more molecular than normal polyethylene and has good impact resistance in a wide temperature range. Self-lubrication of UHMWPE increases high-wear resistance and sliding properties. In the present work, relation between the lives, wear loss, thrust load and rotation speed is investigated. Thrust type rolling contact fatigue tests were carried out and wear was observed.

Experimental procedure

Specimens. The geometry of the bearing specimens was designed based on the JIS B 1513 #51305 standard. The outer diameter, the inner diameter and the pitch circle diameter were 52 mm, 25 mm and 38.5 mm respectively. Figs. 1 (a) and (b) are photograph of UHMWPE race and UHMWPE retainer with soda glass balls. Nine soda glass balls within UHMWPE retainer were used. The ball diameter was 9.525 mm (3/8”). Table 1 shows the physical and mechanical properties of the materials.

Rolling contact fatigue tests. The RCF tests were conducted using a thrust type machine shown in Fig. 2 (a). This thrust type RCF testing machine was developed and produced by Kashima bearings corporation and Yosinori Industry, Ltd. All tests were performed under dry conditions as shown in Fig. 2 (b), and the total number of cycles was 2.88×10^5. However, the RCF tests were stopped when the thermal deformation or flaking failure occurred. The rotation speeds of the machine were 180 rpm, 200 rpm, 240 rpm, 300 rpm, 360 rpm, 450 rpm, 600 rpm, 750 rpm and 900 rpm. The loads were 1000 N, 900 N, 750 N, 600 N, 500 N, 400 N, 300 N, 240 N and 200 N. Under all of these conditions, the value of {rotation speed × load} is 1.8×10^5. Based on these tests, further experiments were carried out.

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After tested specimens were washed, wear loss was calculated by comparing the weights before and after testing using an electronic balance BM-252 (A&D Company).

(a) (b)

Fig. 1 Bearing samples: (a) UHMWPE race and (b) UHMWPE retainer with soda glass balls.

(a) (b)

Fig. 2 RCF test machine: (a) photograph of the device and (b) sample holder detail.

Table 1 Mechanical properties of the specimens (UHMWPE).

Melting point [ºC]	Rockwell hardness [HRR]	Specific density [g/cm^3]	Tensile strength [MPa]	Bending strength [MPa]	Bending elastic modulus [MPa]
136	107	0.94	44	66	2450

Experimental results and discussions

RCF lives. In these thrust type RCF tests, the number of cycles was set at 2.88×10^5. The value of {rotation speed × load} was constant at all tests. Under some conditions, the tests were interrupted because the thermal deformation occurred on bearing surfaces. Fig. 3 shows the life limitation of the bearings under RCF tests. From these results, it was found that RCF causes thermal deformation over a speed of 500 rpm. Bearing life depends on the rolling speed rather than the load. Fig. 4 shows the results of the RCF tests at a load of 600 N and also at a speed of 450 rpm. Failure occurred when the load and rotation speed are 600 N and 450 rpm. It is concluded that the speed limitation at 600 N is 450 rpm and load limitation at 450 rpm is 600 N. This results indicate that the line of {rotation speed × load} = 1.8×10^5 represents bearing work limitation. Fig. 5 shows the results of further tests at a rotation speed of 600 rpm. RCF caused thermal deformation over when a load is over 300 N.

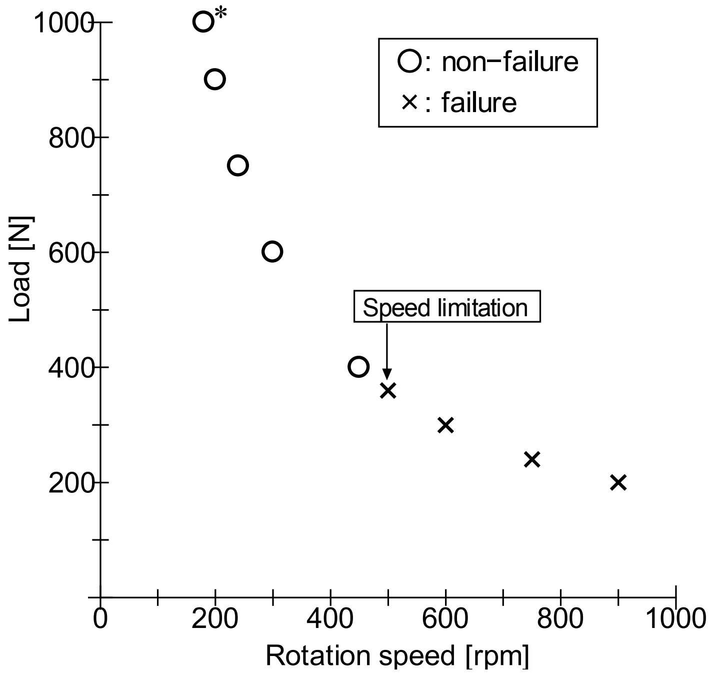

Fig. 3 Results of UHMWPE RCF tests.
Number of cycles = 2.88×10^5. All the value of {rotation speed × load} = 1.8×10^5.
Thermal deformation and failure occurred when a rotation speed is over 500 rpm.
*Smearings were observed.

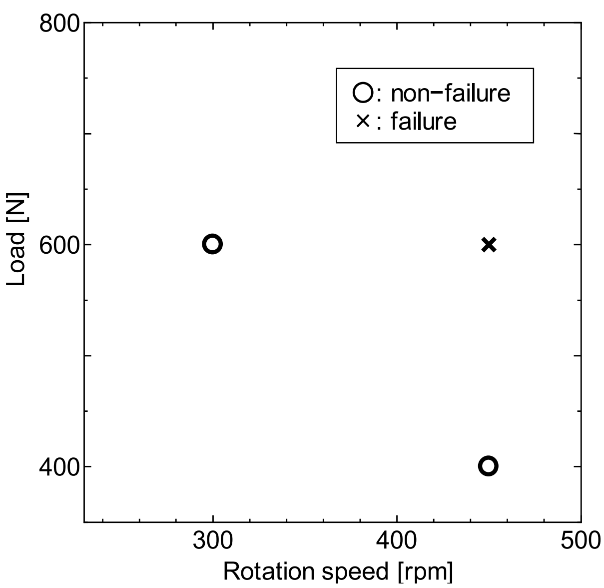

Fig. 4 Results of RCF test at 600 N and 450 rpm. Failure occurred at 600 N - 450 rpm.

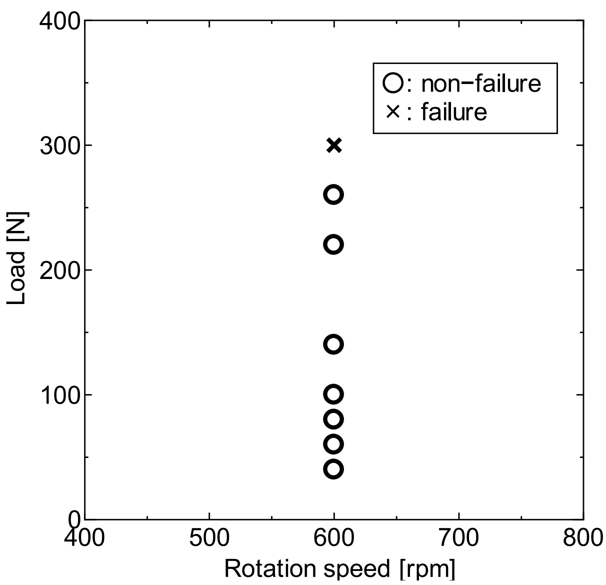

Fig.5 RCF tests at a rotation speed of 600 rpm. Thermal deformation occurred over 300 N.

Wear loss. Figure 6 shows the relation between wear loss and load. The wear loss is less than 3.0 mg. From this result, it was found that wear loss does not affect bearing failure.

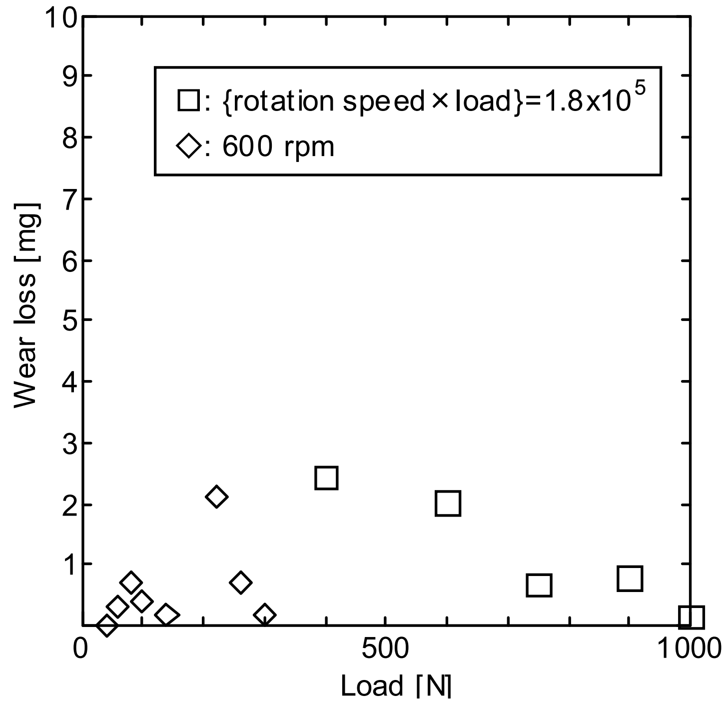

Fig. 6 Wear loss on non-failure bottom races.

Conclusions

The RCF tests were conducted using thrust type UHMWPE bearings and the number of cycles was set at 2.88×10^5. In all of test conditions, the value of {rotation speed × load} was 1.8×10^5. From RCF test results, it was found that RCF causes thermal deformation over a speed of 500 rpm and does not cause failure. These results mean UHMWPE bearing life depends on the rotation speed rather than the load. At further tests, failure occurred when the load and rotation speed are 600 N and 450 rpm. These results indicate that the line of {rotation speed × load} = 1.8×10^5 represents bearing work limitation. It is confirmed that bearings caused thermal deformation over a load of 300 N when the rotation speed is 600 N. It was found that wear loss does not affect bearing failure.

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