Development of Helical Groove Bush for Construction Machines

Kazuo MARUYAMA(1), Osamu MAWATARI(2) , Hidekazu TOKUSHIMA(3)
Takeshi YANASE(4), and Kunio MAKI(5)

1)-5)520,Minoridai, Matudo-shi,Chiba,270-2295 JAPAN

Abstract

This study was conducted to improve the durability and decrease the friction of the sintered bushing used in the joints of construction equipment.1)
Research was carried out to examine the effects of the groove pattern on the inner surface. The following results were obtained: (1) The bushing (EK Bush) with grooves on the inner diameter showed increased durability as compared to a non-grooved bushing. (2) The helical-grooved bushing showed the least amount of wear; it was 1/10 of the wear of the non-grooved bushing. (3) If the distance between grooves was decreased, then the coefficient of friction also decreased.

Keywords: oil-impregnated sintered bushing, helical groove, coefficient of friction, wear resistance

1. Introduction

The oil impregnated sintered bushing (EK-Bush) is used as a component for the joints of construction equipment. The EK-Bush has shown increased durability when compared to conventional steel bushings; this is mainly due to the self-lubricating properties of the sintered material. The market's request for this type of component is to reduce noise by decreasing friction and to improve durability, while reducing the price.

This report introduces an advanced "EK-Bush" which has many narrow helical grooves; these grooves improve the durability and decrease friction.

2. Experimental Method

2.1 Specimen

The Investigation was carried out using the material shown in Fig. **1**. The chemical composition of the material was **Fe-18Cu-C-10% hard particle (mass%)**.
This material was impregnated with wax to fill in the Porosity, the wax content was 20% by volume.

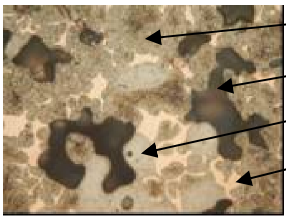

Fig. 1. Microstructure of EK material

2.2 Experimental method

Evaluations were made using an oscillating bearing tester and actual EK-Bushings. Shafts were produced from S45C (JIS) with induction quenching and tempering. Lithium grease with dust (JIS (Z 8901)) was used as the lubricant in the clearance of the bushing and shaft.

For the investigation of the effectiveness of the groove, testing was conducted under a sliding speed of 0.5 m/min, with a surface load of 50 MPa, and an oscillating angle of 45 degrees. For this test it was assumed that bushing siezure would occur for a coefficient of friction over 0.35.

To investigate the affect of the groove shape, the same test was conducted, but the load was changed to 100 MPa.

3. Experimental results and consideration

3.1 Investigation of the effects of the groove

With gerneral use metal to metal contact is the cause of busing failure, this contact is caused by a lack of lubricating grease. For the EK-Bush different types of grooves were evaluated to understand the affect on lubricity.

Fig. 2 shows the patterns of groove for EK-Bush evaluated in this study.

Fig. 3 shows the tendency of seizure and the coefficient of friction for several groove patterns.

The width of the grooves was 5.5 mm, and area ratio of the grooves was chosen to be a uniform 20%.

The no grooved specimen seized after testing for 45 hours. The coefficient of friction of the cross groove type slightly increased after 95 hours. The coefficient of friction of both the straight and the helical groove types were stable around 0.13 for 100 hours. The normal steel bush, for reference, seized at 0.5 hours in this evaluation.

Fig. 4 shows the wear rates of each typs of bushing.

The wear rate of the non-grooved bushing was 0.5 micrometers/hour. The wear rates of the grooved specimens ranged from 0.04 to 0.35 micrometers /hour.

The helical grooved specimen showed the best wear rate at 0.04 micrometers/hour.

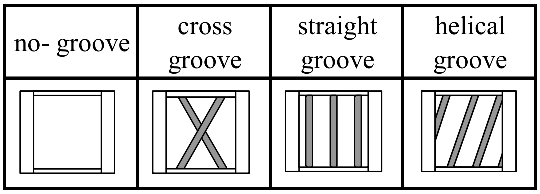

Fig. 2. Groove patterns of test specimens

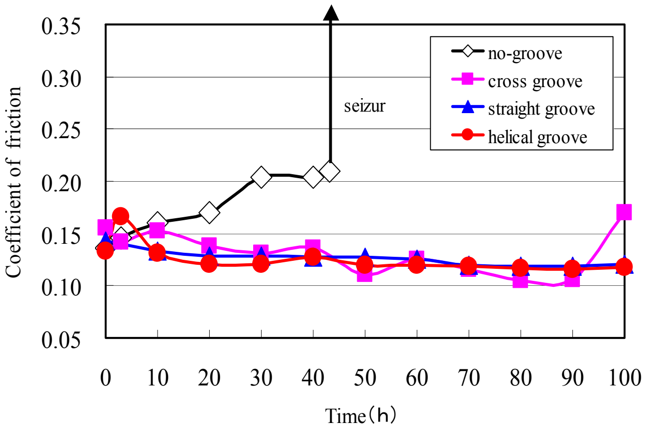

Fig. 3. Comparison of Friction coefficient of various grooves

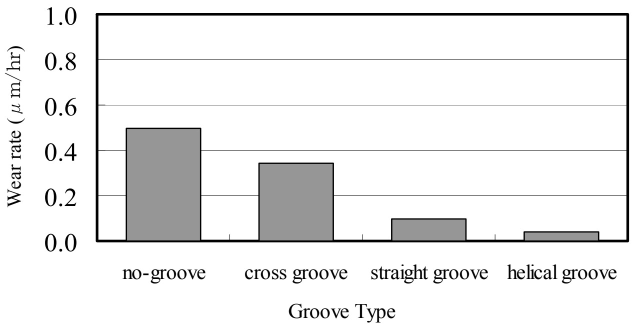

Fig. 4. Comparison of wear rate of various grooves

The decrease in the wear rate and the coefficient of friction is the result of the grooves holding more grease and allowing the dust or contamination to settle in the groove, so that it is not in the contact area of the busing and shaft.

The helical groove on the EK-Bush is judged to have the best performance for improving durability and decreasing friction.

3.2 The effect of the pitch of helical grooves

Fig. 5 shows the effect of the pitch (width of a land and a groove) of the helical groove.

The affect of the angle and pitch was considered for the groove specification.

The angle of the helical groove was 20 degrees, and the ratio of groove width to land width was chosen to be 1:4. This made the area ratio of the grooves a uniform 20%.

Fig. 5 shows the comparison of several chosen pitches.

This shows that a smaller pitch improves the performance for reducing friction. The coefficient of friction of the 3.5 mm pitch was 0.12.

This shows that by decreasing the land and thus increasing the number of grooves, the friction is reduced. This is primarily caused by the increase in the amount of lubricant that can be supplied from the grooves and by the reduction in contact area.

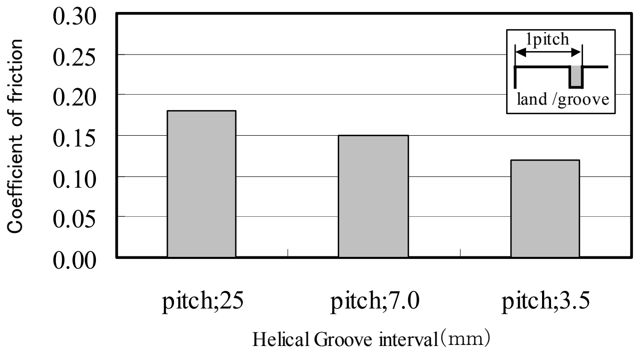

Fig. 5. Effect of helical groove pitch for Coefficient of friction

4. Conclusions

1) Adding various grooves on the inner surface of EK-Bush, showed an increase in durability over a non-grooved bushing. The coefficient of friction was stable and ranged from 0.12 to 0.18. No seizing occurred under severe conditions, using lubricant with dust. This result means that noises would be reduced under normal machine operation.
2) The wear rate was reduced by 1/10 using the helical grooved EK-Bush.
3) Groove pitch has a large affect on the friction between the bushing and the shaft. By narrowing the pitch from 25 mm to 3.5 mm, the coefficient of friction was reduced by 35%.

The difference in cost for adding helical grooves to the current EK-Bush is not large, since there are no additional processing cost associated. The helical grooves can be compacted into the component using special tooling.

5. Example of Application

The development of helical groove for EK-Bushes is adopted for the bushing used in joints of construction equipment. Additional applications could be considered for use in industrial machines, industrial robots, etc.

6. Reference

1) T.Yanase.et.al. "Sliding Property of Fe-Cu C Sintered Materials Height Contact Stress and at Low Sliding Velocity" Hitachi Powdered Metals technical report, No.1 (2002) PP.19-23.