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# Wear of polymer composite solid lubricants for cryogenic ball bearing cages

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**ABSTRACT** – The self-lubricating effect of polymer composite cage fabricated by pure PTFE (Teflon), composites PTFE + $MoS_2$ + glass fibers, PTFE + bronze particles were verified by friction coefficient and wear rate. Cage center-of-mass orbits for cryogenic ball bearing with different solid lubricant are demonstrated. In the case of $MoS_2$ containing composite cage, circular orbit is observed. Among the tested materials, the composites PTFE with additive $MoS_2$ have shown good friction coefficient.

## 1. INTRODUCTION

It was experimentally elucidate the mechanism of friction wear surface for the sliding and rolling contact movement in the cryogenic atmosphere, such as low temperature for the equipment and space for the machine element. To evaluate the properties of the solid lubricating cage, we should minimize the frictional wear of the contact surface at a low temperature condition [1]. Investigations of wear resistance of polymers with additives, using the cryogenic pin-on-disk apparatus has been carried out. Normal load, rotating speed and liquid nitrogen flow rate were considered variables in the cryogenic wear tests. The friction and the wear mechanisms are briefly reviewed. Various polymeric materials containing solid lubricants were investigated.

## 2. EXPERIMENTAL

The self-lubricating effect of polymer composite cage fabricated by pure PTFE (Teflon), composites PTFE + $MoS_2$ + glass fibers, PTFE + bronze particles were verified by friction coefficient and wear rate. Disc of PTFE composite with $MoS_2$ and bronze were tested against metal round pin with axial and radial load of 3kN and liquid nitrogen flow of 80g/second. Liquid nitrogen was flowed through the gap between balls and the cage clearance. Rotating speeds were changed up to 10,000rpm. In all tests, debris and flakes of worn materials were verified to define the wear mechanism [2]. Wear resistance of polymers and composites is its strong dependence on the environmental relative humidity and normal load [3]. In this experiment, the ball bearing cage composition change in the cryogenic atmosphere were also investigated to analyze the effect of bearing friction and wear. Weight loss and the cage centroid movement were measured to analyse the cage stability.

## 3. RESULTS AND DISCUSSION

Solid lubricant $MoS_2$ and bronze particles mixed with polymer precursor powder are shown in Figure 1. Fabricated cage and assembled ball bearing (Figure 2) is tested in cryogenic atmosphere. As shown in Figure 3, polymer composite cage with $MoS_2$ solid lubricant shows stable torque variation due to the rigid cage pocket shape. Lower torque and higher cage stability in PTFE-Bronze composite cage than PTFE-glass fiber-$MoS_2$ composite cage were shown. Figure 4 shows that the wear loss and mass transport from cage to race way are changed by the adhesion of the lubricant. High weight change and no mass transfer of PTFE/bronze were observed. Good mass transfer of PTFE affect the solid lubricant roles in the ball bearing rotation. $MoS_2$ and PTFE materials easily adhere to the raceway surface. Cage center-of-mass orbits for cryogenic ball bearing with different solid lubricant are demonstrated as shown in Figure 5. Unstable cage centroid movement in PTFE cage even though good mass transfer is due to the cage instability caused by the irregular wear. Relatively stable cage centroid movement in PTFE/glass fiber/$MoS_2$ due to the improvement of cage strength by fibers.

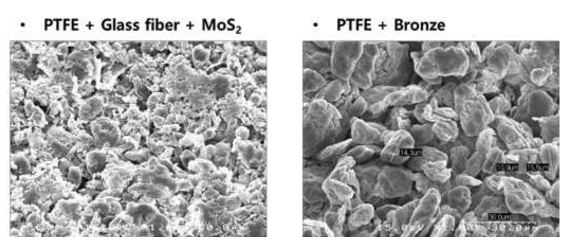


Figure 1 Microstructures of composite powders.


Figure 2 Composite cages and assembled ball bearing.

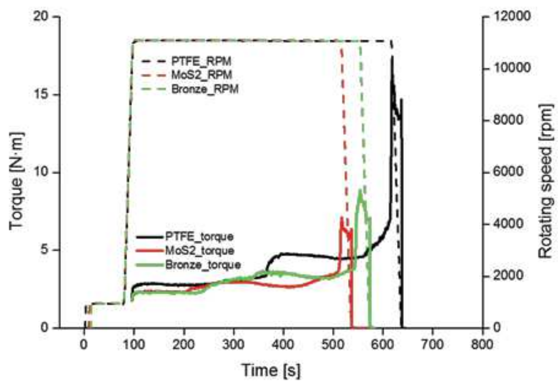


Figure 3 Torque changes with various composite solid lubricants.

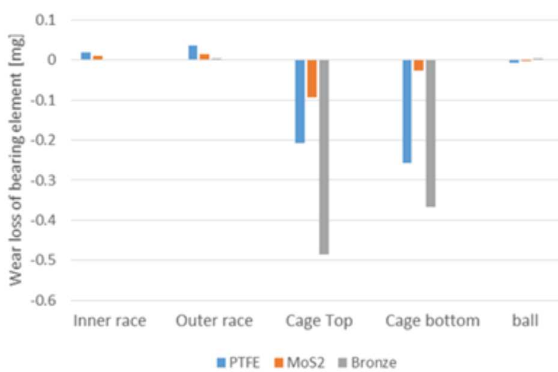


Figure 4 Wear loss of various composite.

## 4. SUMMARY

In the case of $MoS_2$ containing composite cage, circular orbit is observed. Among the tested materials, the composites PTFE with additive $MoS_2$ have shown good friction coefficient.

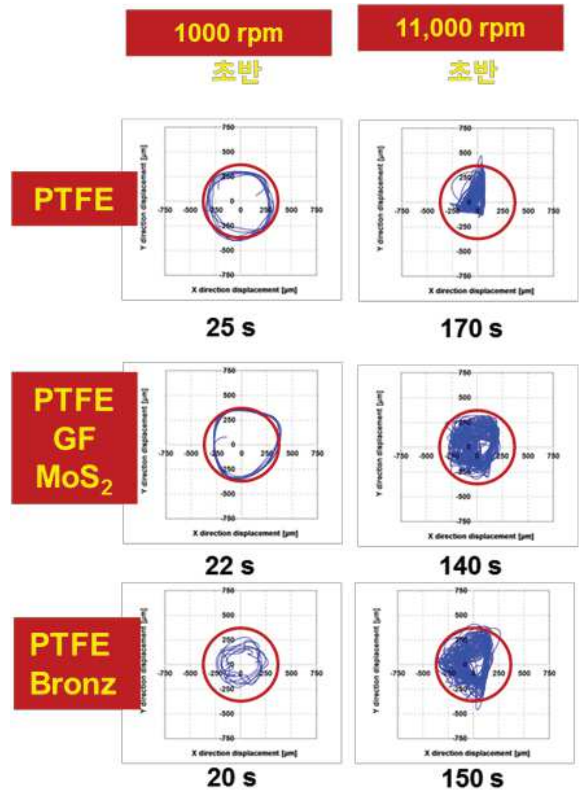


Figure 5 Cage center-of-mass orbits for cryogenic ball bearing with different solid lubricant.

## REFERENCES

[1] Kawakame, M., & Bressan, J. D. (2006). Study of wear in self-lubricating composites for application in seals of electric motors. *Journal of materials processing technology*, *179*(1-3), 74-80.

[2] Marquart, M., Wahl, M., Emrich, S., Zhang, G., Sauer, B., Kopnarski, M., & Wetzel, B. (2013). Enhancing the lifetime of MoS2-lubricated ball bearings. *Wear*, *303*(1-2), 169-177.

[3] Ghaisas, N., Wassgren, C. R., & Sadeghi, F. (2004). Cage instabilities in cylindrical roller bearings. *Journal of tribology*, *126*(4), 681-689.