International Journal of Scientific Engineering and Technology (ISSN : 2277-1581)
Volume No.4 Issue No.3, pp: 162-164 01 March. 2015

Effect of Molybdenum Disulfide Particle Sizes on Wear Performance of Commercial Lubricant

S. M. Muzakkir and Harish Hirani
Department of Mechanical Engineering, Indian Institute of Technology Delhi, India
Corresponding Author Email: mez108659@mech.iitd.ac.in

Abstract*: Experimental investigations have been conducted for determination of effectiveness of employing a combination of three particle sizes (40 nm size, 1.75 µm size and 53 µm size) of Molybdenum Disulphide as anti-wear additive in a commercial lubricant. The conformal block and disk configuration has been used to conduct experiments for determination of wear of the sliding surfaces. The performance of the proposed combined particle sizes anti-wear additive is compared with single particle size anti-wear additives to establish its robustness under varying surface conditions.

Keywords— Wear, Anti-wear lubricant additive, Nano-particles, Molybdenum Disulphide

I. Introduction

There are several industrial applications wherein the journal bearing operates in mixed lubrication conditions [1]. These conditions of mixed lubrication arise due to severe load and slow operating speeds. The asperities of sliding surfaces contact each other under these conditions and causes wear. The gradual wear that occurs in each cycle may eventually lead to bearing failures. The goal of a designer is either to completely eliminate the wear or to achieve control on wear to obtain a satisfactory operating life of the bearing. In order to completely eliminate wear, the concept of levitating the journal from the bearing was studied [2]. The concept of hybridization of passive magnetic levitation and hydrodynamic lubrication was investigated experimentally but was not found to be suitable for heavily loaded and low sliding velocity operating conditions [3]. The active magnetic bearing technology was however much costlier to implement [4] and so also other hybrid technologies that were not suitable for heavy loaded journal bearings [5]. Based on this understanding, the control on wear may be obtained by using suitable lubricant additives that minimizes wear in mixed lubrication conditions [6]. The Molybdenum Disulphide (MoS_2) has also been used extensively as an anti-wear additive in lubricants for controlling wear under such extreme operating conditions [7]. The superior lubricating property of molybdenum disulphide (MoS_2) is attributed to its layered crystal structure providing easy sliding of its lamellae [8]. The amount of wear reduction is dependent on the particle size of molybdenum disulphide (MoS_2) in relation to the nature of the sliding surfaces. Even though the surface roughness is a major influencing factor under mixed lubrication conditions however the geometric variations caused due to manufacturing variability dwarfs their effects and the role of the lubricant with suitable anti-wear additive assumes importance in such conditions [9]. Many studies have been conducted in past [7] to investigate the effect of particle size of (MoS_2) and it was shown that nano-sized particles were more effective in reducing wear and friction as compared to micro-sized particles [10].

However, the effectiveness of the particle size of molybdenum disulphide in reducing wear is dependent on the surface roughness value of the sliding surfaces [11], and therefore the selection of the particle size is dictated by the surface roughness of the sliding surfaces. Since the wear occurs gradually, it modifies the surface roughness of the sliding surfaces in each cycle. A particle size selected for a particular initial surface roughness value will thus no longer remain effective with the change in the surface roughness value of the sliding surfaces over a period of time. In order to achieve effectiveness of the lubricant additive under varying surface roughness conditions spanning over the useful operating life, an anti-wear additive comprising of three different particle sizes (Nano-particles: 40 nm size, Technical superfine grade particles: 1.75 µm size and Technical grade particles: 53 µm size) of molybdenum disulphide (MoS_2) is proposed. The effectiveness of the proposed composite anti-wear additive is experimentally determined. The experiments were conducted on a conformal block of phosphorus bronze material sliding against a steel disk. The conformal block and disk test set up is used to simulate the contact conditions of a journal with bearing. The wear of the conformal block is measured as its weight loss after the test. In order to achieve a distinct performance, the wear during the initial running-in period was segregated from the steady state wear. Based on the earlier experimental investigations [9], a sliding distance of 750m (corresponding to a test duration of 2 hours) is taken as the minimum sliding distance for the completion of the running-in process [9]. The results of the experiments are reported.

II. Experimental Details

In the present work, wear tests were carried out on a conformal block and disk test set up. The photograph and schematic diagram of the test set-up is shown in figure 1 and 2.

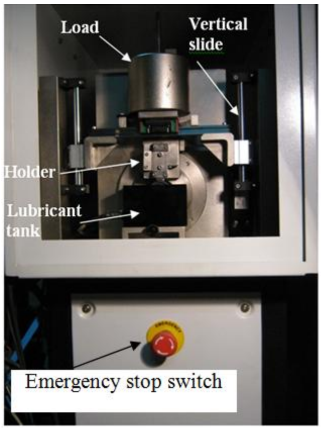

Figure 1Photograph of Conformal Block 7 Disk test set up [9]

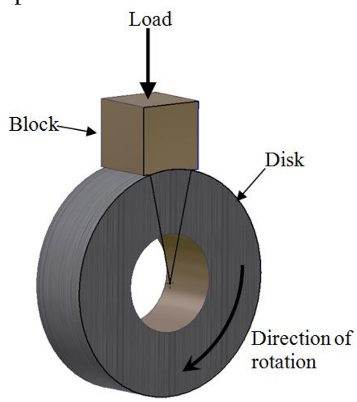

Figure 2 Schematic diagram [9]

The conformal block and disk test set up employs a conformal block (made of phosphorus bronze material) that slides on hardened steel disk (diameter = 40 mm, width = 15mm), which is driven by induction motor. Half of the steel disk is immersed in the lubricant tank. The lubricant inside the tank is maintained at the desired temperature by the help of heaters and thermal cut-off switch. The static load is applied on the platform on which the block is fixed. The tests were conducted at a load of 50N for a disk of 40 mm diameter. For running-in tests, the disk was rotated at 50 rpm at a load of 50N for duration of 2 hours. For normal wear tests the disk was rotated at 25 rpm corresponding to a sliding speed of 5.23×10^{-2} m/sec at a load of 50N for duration of 6 hours. The lubricant samples were prepared by dispersing the molybdenum disulphide (MoS_2) particles in a commercial lubricant with lithium stearate as a surfactant by ultrasonic homogenization for duration of one hour.

III. Results and Discussion

The running-in experiments were conducted to achieve conformity of the sliding surfaces preceding the normal wear experiments to achieve steady state wear conditions. The results of the normal and running-in wear tests with lubricant containing anti-wear additives with single size MoS_2 particles and combined MoS_2 particles are shown in figure 3 and figure 4 respectively.

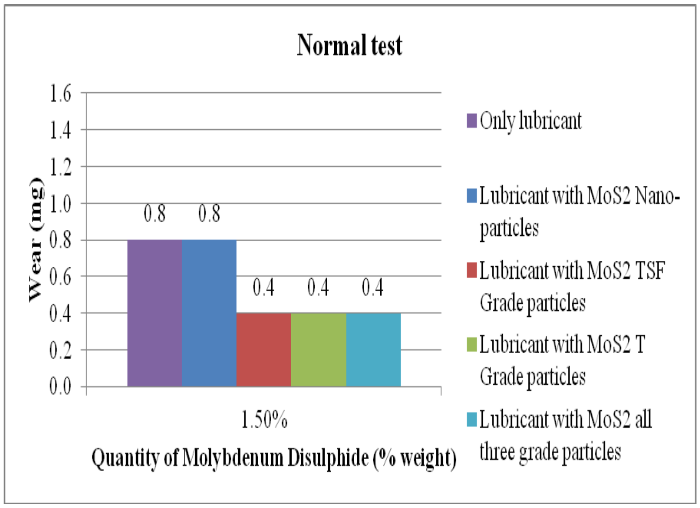

Figure 3 Wear results of normal tests

It is observed from the normal wear test results that the wear during the normal test is reduced with the use of MoS_2 particles as lubricant additive as compared to the lubricant without any MoS_2 particles. Similar wear is observed with the other particle sizes of MoS_2 except that of MoS_2 nano-particles.

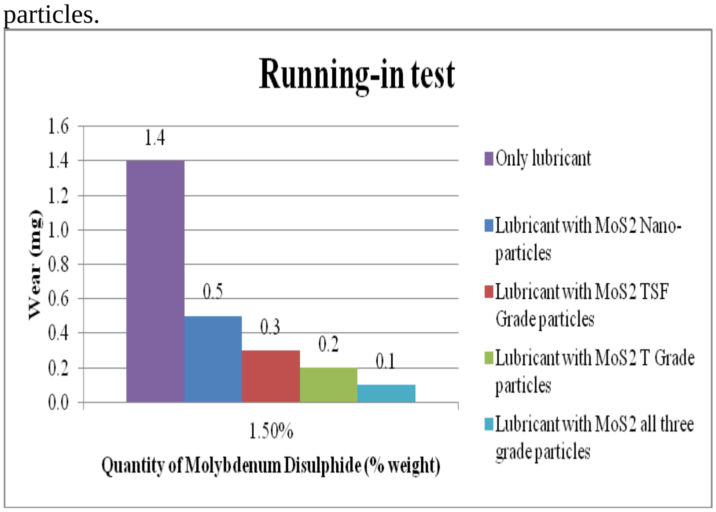

Figure 4 Wear results of running-in tests

It is observed from the running-in wear test results that the wear during the running-in is substantially reduced with the use of lubricant additive consisting of all three grades of MoS_2 particles as compared to the lubricant additive with any one type of MoS_2 particle. Similar reduction in wear is observed with the other particle sizes of MoS_2. The use of combined MoS_2 particles is able to minimize the wear by filling up the valleys of the surfaces under different surface roughness values. This is the main advantage of using all three grades of MoS_2 particles that the different size of particles fills the valleys of different sizes (depths) corresponding to different surface roughness and thus provides easily sliding of lamellae of MoS_2. The SEM image of molybdenum disulphide (MoS_2) particles is shown in figure 5.

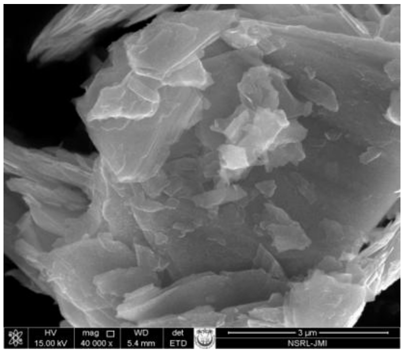

Figure 4 SEM image of MoS_2 particle

It is observed from the SEM images that the molybdenum disulphide (MoS_2) particles are in a predominantly slices form with a distinct layered structure which is responsible for easy sliding of its lamellae that contributes in wear and friction reduction. The surface roughness (root mean square roughness, R_q) of the conformal blocks used in conducting experiments is in the range of 0.3116 to 0.5654 µm.

The figure 5 depicts the total wear of the conformal block for the different lubricant additives.

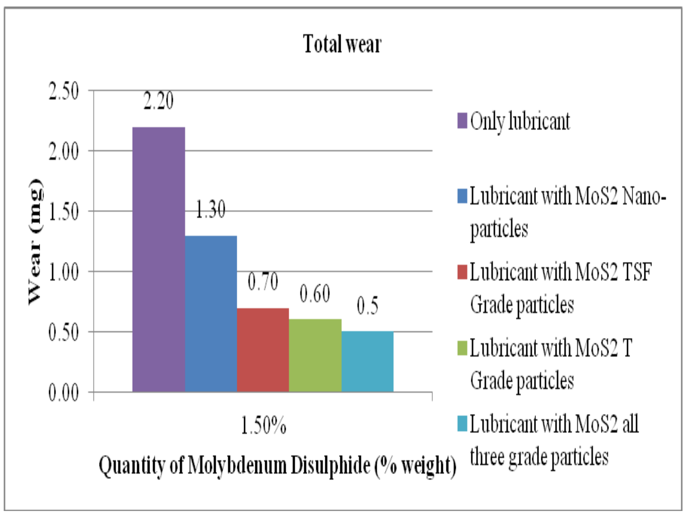

Figure 5 Total wear results

It is observed from figure 5 that the maximum reduction in wear is obtained by using the lubricant additive consisting of all three grades of MoS_2 particles as compared to the lubricant additive with any one type of MoS_2 particle. This is particularly evident from the wear during the running-in wear tests.

IV. Conclusion

- The wear of the sliding surfaces subjected to heavy load and slow speed is reduced by using molybdenum disulphide (MoS_2) particles as additive in lubricant.
- The maximum reduction in wear is obtained by using the lubricant additive consisting of all three grades of MoS_2 particles as compared to the lubricant additive with any one type of MoS_2 particle.

The lubricant additive consisting of only technical grade MoS_2 particles was able to provide good reduction in wear of the sliding surfaces under mixed lubrication conditions.

The minimum reduction in wear was observed with lubricant additive consisting of only MoS_2 nano-particles. This may be attributed to the possible agglomeration of nano-particles.

The anti-wear lubricant additive consisting of all three grades of MoS_2 particles is able to minimize wear under varying surface roughness conditions spanning over the useful operating life.

References

[i] *S. M. Muzakkir, H. Hirani, G. D. Thakre, and M. R. Tyagi, "Tribological failure analysis of journal bearings used in sugar mills," Eng. Fail. Anal., vol. 18, no. 8, pp. 2093–2103, 2011.*

[ii] *H. Hirani and P. Samanta, "Hybrid (hydrodynamic + permanent magnetic) journal bearings," Proc. Inst. Mech. Eng. Part J J. Eng. Tribol., vol. 221, no. 8, pp. 881–891, Jan. 2007.*

[iii] *S. M. Muzakkir, K. P. Lijesh, and H. Hirani, "Tribological failure analysis of a heavily-loaded slow speed hybrid journal bearing," Eng. Fail. Anal., vol. 40, pp. 97–113, May 2014.*

[iv] *S. Shankar, Sandeep, and H. Hirani, "Active Magnetic Bearing: A Theoretical and Experimental Study," Indian J. Tribol., vol. 1, no. July-December, pp. 15–25, 2006.*

[v] *P. Samanta and H. Hirani, "Magnetic Bearing Configurations: Theoretical and Experimental Studies," IEEE Trans. Magn., vol. 44, no. 2, pp. 292–300, Feb. 2008.*

[vi] *S. M. Muzakkir, H. Hirani, and G. D. Thakre, "Lubricant for Heavily Loaded Slow-Speed Journal Bearing," Tribol. Trans., vol. 56, no. 6, pp. 1060–1068, Nov. 2013.*

[vii] *S. M. Muzakkir and H. Hirani, "Experimental Investigation on Effect of Particle Sizes of Molybdenum Disulphide on Wear Under Heavy Load and Slow Speed Conditions," Int. J. Mod. Eng. Res., vol. 4, no. 12, pp. 46–49, 2014.*

[viii] *Lansdown, Molybdenum disulphide lubrication. Elsevier, 1999.*

[ix] *S. M. Muzakkir, K. P. Lijesh, H. Hirani, and G. D. Thakre, "Effect of cylindricity on the tribological performance of the heavily loaded slow speed journal bearing," J. Eng. Tribol., vol. 229, no. 2, pp. 178–195, 2014.*

[x] *K. H. Hu, X. G. Hu, Y. F. Xu, F. Huang, and J. S. Liu, "The Effect of Morphology on the Tribological Properties of MoS2 in Liquid Paraffin," Tribol. Lett., vol. 40, no. 1, pp. 155–165, Jul. 2010.*

[xi] *X. Hu, Y. Wu, G. Yuan, P. Huang, and H. Jing, "Tribological Properties of Nano-sized Molybdenum Disulphide Particles," in World Tribology Congress, 2005, pp. 3–4.*