Experimental Investigation on Effect of Grinding Direction on Wear Under Heavy Load and Slow Speed Conditions with Molybdenum Disulphide (MoS_2) as Additive in Commercial Lubricant

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Abstract— In the present work, experimental investigation has been carried out to identify the effect of grinding direction on the wear of the sliding surfaces subjected to heavy load and low sliding velocity with molybdenum disulphide MoS_2 as additive in commercial lubricant. The conformal block and disk test setup has been used to conduct experiments on conformal blocks with two grinding directions: one along the direction of sliding and other across the direction of sliding. The wear of the block is measured as its weight loss after the test. The results of the experiments are reported.

Keywords—Wear, grinding direction, lubricant additive, molybdenum disulphide

I. Introduction

The sliding surfaces contact each other under the operating conditions of heavy load and slow speed and the mixed lubrication regime is operative. Journal bearings of sugar mill [1] etc operates in mixed lubrication regime. The nature of the contacting surfaces dominantly affects the friction and wear behavior of the contacting tribo-pair under these conditions. The amount of wear of the sliding surfaces is dependent on the surface roughness and the grinding direction. This aspect has been the focus of many studies in past. Staph et al. [2] have experimentally indicated that both the surface roughness and surface texture affects the frictional behavior of the contacting surfaces. Maatta et al. [3] in a study on stainless steel strips have shown that friction is affected by surface topography. Experimental study by Marcus et al. [4] showed that the wear is dependent on surface roughness and grinding direction of the sliding surfaces. Lakshmipathy and Sagar [5] studied the effect of directionality of die grinding marks on friction and found that friction factor was less with criss-cross ground pattern. In another study by Blau et al. [6] the wear rate was shown to be dependent on the direction of grinding. Franklin and Kracker [7] have also shown that the wear rate is dependent on the orientation of the grounded surfaces.

However, Rasp and Wichern [8] in an experimental study found that surface roughness and lubrication regime have greater influence on friction than directionality. Hu and Dean [9] showed that reduction in friction occurs due to lubricant retention in smooth surfaces. Nosar et al. [9] in an experimental study showed that severe wear occurs when sliding takes places perpendicular to the grinding direction. In another study, Muzakkir and Hirani [10] showed that molybdenum disulphide particles when used as lubricant additive substantially reduces the wear of the sliding surfaces. Muzakkir et al [11] have also experimentally showed that zinc particles used as additives in lubricant minimizes the wear. Very few studies have dealt with the effect of using molybdenum disulphide (MoS_2) as solid lubricant additive on the wear corresponding to the grinding direction under mixed lubrication regime.

Since most of the bearing inner surfaces are produced by grinding process to obtain a better surface finish, a consideration with respect to the direction of grinding is essential for reducing the wear. However many other relevant factors needs consideration for a comprehensive design of a journal bearing [12] in addition to the grinding direction. The effect of manufacturing variability also affects the magnitude of wear [13]. The complete process of optimum design of the journal bearing may also be carried out by employing the multi-objective criterion [14].

In the present experimental investigations, comparative study have been carried out to study the effect of using molybdenum disulphide (MoS_2) particles (technical superfine grade: 1.75 μm size) particles in a commercial lubricant on the wear of conformal block with two grinding orientations. The wear tests were conducted on conformal blocks that were fabricated with final grinding obtained in two mutually perpendicular directions, one along the direction of sliding (represented by 0° orientation) and other across the direction of sliding (represented by 90° orientation). 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 setup. The photograph and schematic diagram of the test setup is shown in figure 1(a) and 1(b).

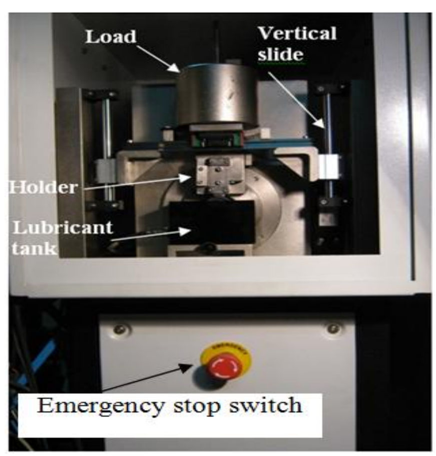

Figure 1(a) Photograph of conformal block and disk test setup [13]

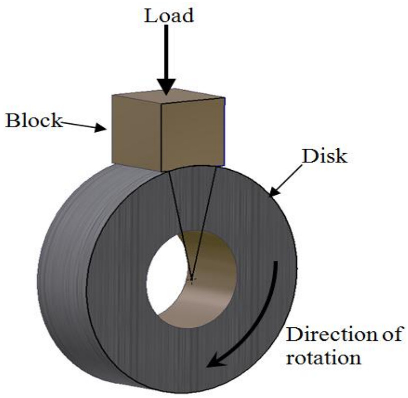

Figure 1(b) Schematic diagram [13]

The test setup comprises of a conformal block (made of phosphorus bronze material) on hardened steel disk (diameter = 40 mm, width = 15mm), which is driven by induction motor. The conformal blocks were fabricated with final grinding obtained in two mutually perpendicular directions, one along the direction of sliding (represented by 0° orientation) and other across the direction of sliding (represented by 90° orientation).

The tests were conducted at a load of 50N generating a pressure of $4.6\times10^5 N/m^2$ corresponding to the contact area of $1.085\times10^{-4} m^2$ of conformal block for a disk of 40 mm diameter. The disk was rotated at a speed of 25 rpm corresponding to a sliding speed of 5.23×10^{-2}m/sec. 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. The test setup comprises of a conformal block (made of phosphorus bronze material) on hardened steel disk (diameter = 40 mm, width = 15mm), which is driven by induction motor. 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. About half of the steel disk is immersed in the lubricant tank.

III. Results and Discussion

The normal wear tests of 6 hours duration were conducted after completing the running-in of the conformal blocks for 2 hours corresponding to a sliding distance of 750m. The results of the running-in and normal tests are shown in figure 3 and 4.

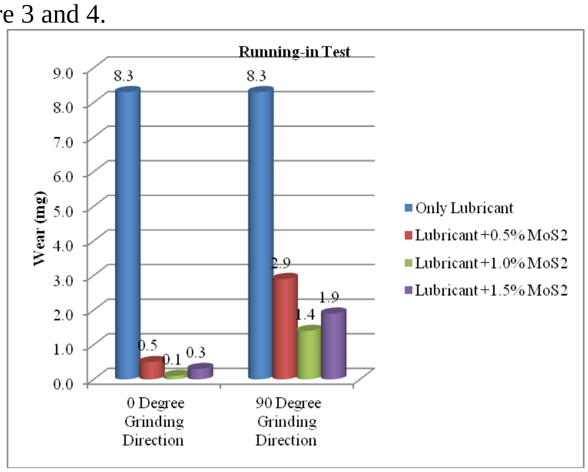

Figure 3 Initial running-in wear

It is observed from figure 3 that the initial wear when the grinding direction is 90° is much higher as compared to the wear when the grinding direction is 0°. The minimum wear was obtained for 1.0% quantity of MoS_2 particles.

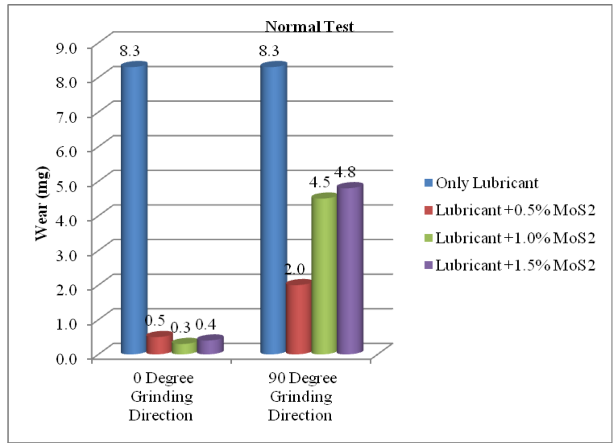

Figure 4 Wear during normal test

It is observed from figure 4 that a similar trend is observed in respect of the normal wear wherein significantly higher wear is obtained when the grinding direction is 90° as compared to when the grinding direction is 0°. The lubricant containing MoS2 particles as solid additives is able to cause significantly less wear as compared to only lubricant. The experimental observations indicate a significantly higher wear for a conformal block having 90° grinding direction.

The lubricant flow is much easier when the grinding direction is 0° due to the grinding marks grinding direction is 0°. The lubricant containing MoS_2 particles as solid additives is able to cause significantly less wear as compared to only lubricant. The experimental observations indicate a significantly It is observed from figure 4 that a similar trend is observed in respect of the normal wear wherein significantly higher wear is obtained when the grinding direction is 90° as compared to when the acting as micro channels facilitating the lubricant flow and causing reduction in wear. These micro channels also prevent wear debris accumulation and thus causing reduction in wear. The photograph of the conformal block with 90° grinding direction and 90° grinding direction are shown in figure 5 and 6 respectively.

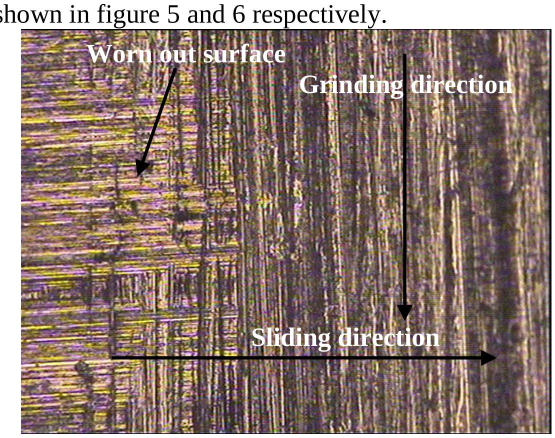

Figure 5 Photograph of the conformal block with 90° grinding direction

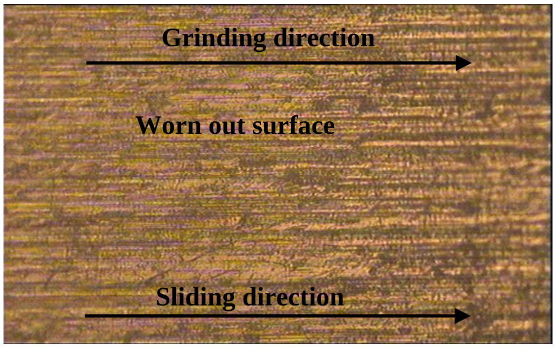

Figure 6 Photograph of the conformal block with 0° grinding direction

IV. Conclusion

- The minimum wear is obtained when the grinding direction is aligned with the sliding direction, possibly due to unrestricted lubricant flow through the micro channels.
- The maximum wear is obtained when the grinding direction is transverse to the sliding direction.
- The use of lubricant containing 1.0% Molybdenum Disulphide (MoS_2) particles as solid additives is able to cause significantly less wear as compared to lubricant without Molybdenum Disulphide (MoS_2) particles.
- The grinding direction must always be aligned with the sliding direction in order to achieve minimum wear.

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