

Research Article

Experimental Investigations on Effect of Tungsten Disulphide (WS_2) on Wear Performance of Commercial Lubricant under Mixed Lubrication Conditions

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Abstract

In the present work, experimental investigation has been carried out to identify the effectiveness of employing Tungsten Disulphide (WS_2) in varying quantities (0.5, 1.0 and 1.5% by weight) in commercial lubricant on the wear of the sliding surfaces. The block on disk configuration-setup has been used to conduct experiments. The wear of the block is measured as its weight loss after the test. The results of the experiments have been reported.

Keywords: Mixed lubrication, Wear, Lubricant additive, Tungsten Disulphide.

1. Introduction

The extreme operating conditions of heavy load and slow speed prevent the hydrodynamic conditions and causes mechanical contact between the tribo pairs resulting in wear (S M Muzakkir *et al.* 2011). Much efforts have been made in the past to separate the tribo pairs operating in these conditions and many alternative technologies have been suggested to separate the contacting surfaces (H Hirani, Athre, and Biswas 1998, 1999a, 1999b, 2000a, 2000b, 2001; H Hirani and Samanta 2007; H. Hirani, Athre, and Biswas 2001; H. Hirani and Suh 2005; H Hirani 2004, 2005; Harish Hirani and Verma 2009; Lijesh and Hirani 2014, 2015a, 2015b, 2015c; S M Muzakkir, Hirani, and Thakre 2015; S M Muzakkir and Hirani 2015c; S. M. Muzakkir, Lijesh, and Hirani 2014; Samanta and Hirani 2006, 2008; Samanta, P Hirani 2007; Shankar, Sandeep, and Hirani 2006; Talluri and Hirani 2003). Several anti-wear lubricant additives like Zinc, Molybdenum Disulphide, Carbon Nano-tubes (Lijesh, Muzakkir, and Hirani 2015a, 2015b; S M Muzakkir and Hirani 2014, 2015a, 2015b; S M Muzakkir, Lijesh, and Hirani 2014, 2015; S. M. Muzakkir, Hirani, and Thakre 2013), etc are effective under mixed lubrication conditions. The Tungsten Disulphide (WS_2) is also being used as anti-wear lubricant additive. Chen *et al.* (Chen and Mao 2010) reported the self repair principle of ultrafine-tungsten disulfide particles in green lubricating oil. Ultrafine-tungsten disulfide particulates could fill and level up the furrows on abrasive surfaces, repairing abrasive surface valleys. The ultrafine-tungsten disulfide particulates could form a WS_2 film with low

shear stress by adsorbing and depositing in the valleys of the surface, making the surface smoother and the FeS film formed in tribo-chemical reaction could protect the surface further.

The lubricating property of Tungsten Disulphide (WS_2) is attributed to its layered crystal structure providing easy sliding of its lamellae. In the present work, experimental investigations have been carried out to determine the effect of adding Tungsten Disulphide (WS_2) as anti-wear additive in a commercial lubricant on the wear of the sliding surfaces with varying quantities ranging from 0.5% to 1.5% by weight. The experiments were conducted on a block and disk test setup. The wear of the block is measured as its weight loss. The results of the experiments are reported.

2. Experimental details

In the present work, wear tests were carried out on a block and disk test setup.

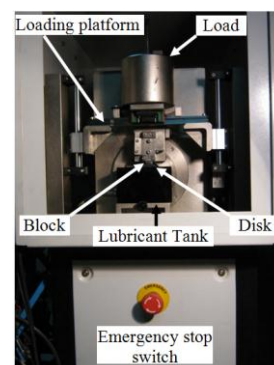


Figure 1 Photograph of block and disk test setup (S. M. Muzakkir *et al.* 2014)

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The photograph and schematic diagram of the test setup is shown in Fig. 1 and 2.

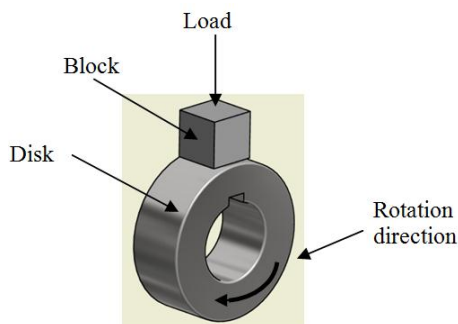


Figure 2 Schematic diagram of block and disk test setup

The lubricity tester employs a block (made of phosphorus bronze material) that slides on a hardened steel disk (diameter = 40 mm, width = 15mm), which in turn 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 70 N, the disk was rotated at a speed of 25 rpm corresponding to a sliding speed of $5.23 \times 10^{-2} \text{m/sec}$. The lubricant samples were prepared by dispersing the Tungsten Disulphide (WS_2) particles in a commercial lubricant with CTAB (Cetyl trimethylammonium bromide, $\text{CH}_3(\text{CH}_2)_{15}\text{N}^+(\text{CH}_3)_3\text{Br}$) as a surfactant by ultrasonic homogenization for duration of one hour.

3. Results and discussion

The experimental wear values were obtained after conducting wear tests and are given in figure 3.

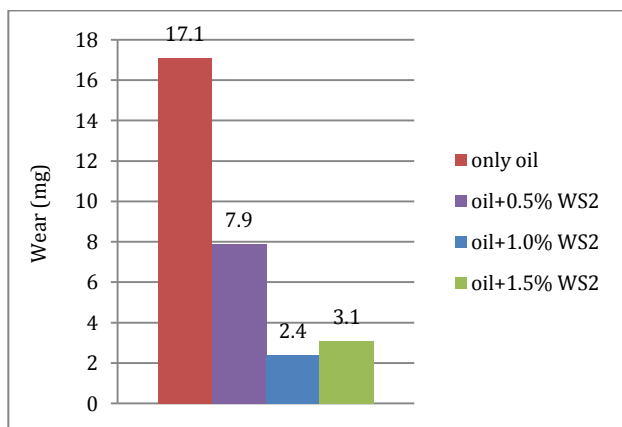


Figure 3 Results of wear test

It is observed from the Fig. 3 that there is substantial decrease in the wear of the block when Tungsten Disulphide (WS_2) is used as solid lubricant additive.

The minimum wear is observed at the 1.0% (weight percentage) of Tungsten Disulphide (WS_2). However a higher wear was observed when the WS_2 quantity is 1.5% as compared to 1.0% quantity of Tungsten Disulphide (WS_2). These observations indicate that only a certain percentage of Tungsten Disulphide (WS_2) provides the minimum wear rate. The estimation of the desired percent of Tungsten Disulphide (WS_2) for various operating conditions requires exhaustive experimental investigations. There is a need to perform molecular dynamic simulation of lubricating oil containing the Tungsten Disulphide (WS_2) to determine the optimum quantity of the Tungsten Disulphide (WS_2) in the lubricant. Since the Tungsten Disulphide (WS_2) fills the valleys of the surface and forms protective and sacrificial layer on the surface, therefore the surface topography affects must be incorporated in simulation study. The optimum quantity of Tungsten Disulphide (WS_2) as anti-wear additive is thus dependent upon the nature of contacting surfaces and the operating conditions, and there is a need to develop complex computer dynamic simulation algorithm.

Conclusions

- The wear of the sliding surfaces subjected to heavy load and slow speeds is reduced by using Tungsten Disulphide (WS_2) particles as anti-wear additive in lubricant.
- The minimum wear is observed for certain percentage of Tungsten Disulphide (WS_2) quantity. In the present study 1.0% (by weight) provides the minimum wear rate.
- Further theoretical and experimental studies are required to establish the optimum Tungsten Disulphide (WS_2) quantity under varying surface and operating conditions.

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