

Research Article

Enhancement of Wear Performance of Commercial Lubricant using Zinc (Zn) Nano-Particles as Anti-Wear Additive under Mixed Lubrication Conditions

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Accepted 08 April 2015, Available online 14 April 2015, Vol.5, No.2 (April 2015)

Abstract

In the present work, experimental investigation has been carried out to identify the effectiveness of employing Zinc (Zn) nano-particles in varying quantities (0.5, 1.0 and 1.5% by weight) as anti-wear additive in a 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: Zinc nano-particles, anti-wear additive, Wear, Mixed lubrication, Lubricant additive.

1. Introduction

The severity of the operating conditions (heavy load and slow speed) prevent the hydrodynamic conditions and causes mechanical contact between the tribo pairs resulting in wear (Muzakir *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 (S.M. Muzakir *et al.* 2014; Samanta & Hirani 2008; Samanta, P Hirani 2007; H. Hirani *et al.* 2001; Lijesh & Hirani 2015a; Shankar *et al.* 2006; Chittlangia *et al.* 2014; Lijesh & Hirani 2015b; Lijesh & Hirani 2015c; Lijesh & Hirani 2014; Hirani & Samanta 2007; Samanta & Hirani 2006; Hirani 2005; Hirani *et al.* 2000b; Hirani & Verma 2009; Hirani & Suh 2005; Hirani 2004; Talluri & Hirani 2003; H Hirani *et al.* 2001; Hirani *et al.* 2000a; Hirani *et al.* 1999b; Hirani *et al.* 1999a; Hirani *et al.* 1998; Muzakir *et al.* 2015). Several anti-wear lubricant additives like Tungsten Disulphide (WS₂), Molybdenum Disulphide, Carbon Nano-tubes, etc are effective under mixed lubrication conditions. The Zinc (Zn) nano-particle is also being used as anti-wear lubricant additive (Muzakir *et al.* 2013). The Zinc forms an anti-wear tribo-film on the surface and prevents wear of the surface. The tribo-film is extremely thin with its thickness varying from few nanometers to several hundred nanometers being dependent mainly on the quantity of Zinc and operating temperature (Nicholls *et al.* 2005).

In the present work, experimental investigations have been carried out to determine the effect of adding

Zinc (Zn) nano-particles 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. The photograph and schematic diagram of the test setup is shown in Fig. 1 and 2.

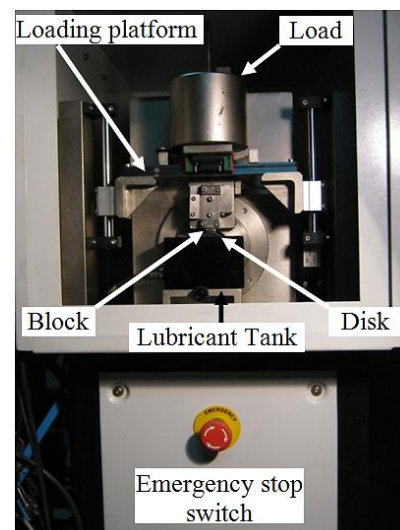


Fig.1 Photograph of block and disk test setup (S. M. Muzakir *et al.* 2014)

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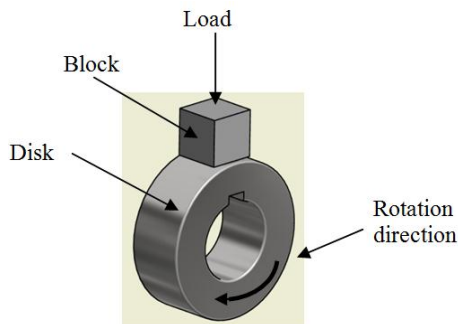


Fig.2 Schematic diagram of block and disk test setup

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 (70°C in the present tests) 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 Zinc (Zn) nano-particles in a commercial lubricant with Ammonium Citrate 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.

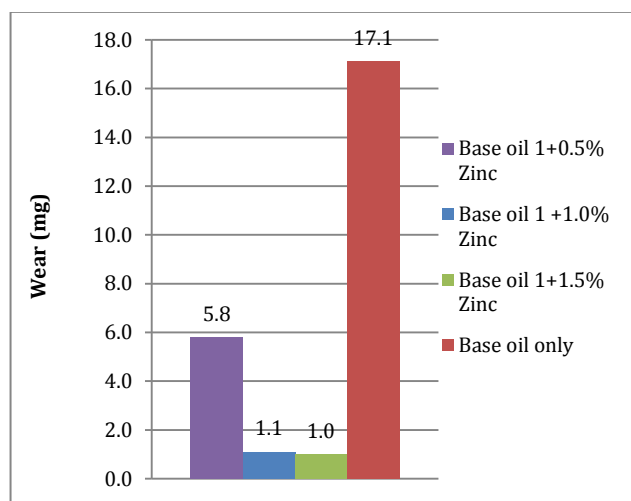


Fig.2 Results of wear test

It is observed from the Fig. 3 that there is a minimum of 66.08% decrease in the wear of the block when 0.5% quantity (by weight) of Zinc (Zn) nano-particles is used as solid lubricant additive which is considered to be substantial. The Zinc (Zn) nano-particles are able to provide an anti-wear tribo-film that prevents the wear of the sliding surfaces. The wear reduces with the

increase in the Zinc (Zn) nano-particles quantity. The minimum wear is observed at the 1.5% (weight percentage) of Zinc (Zn) nano-particles where the reduction in wear is 94.15%. A similar reduction of 93.57% in wear is obtained with the use of 1.0% Zinc (Zn) nano-particles quantity. It is observed that no significant reduction in wear (only 9.09%) is obtained when the Zn quantity is increased from 1.0% to 1.5%. Therefore there is no significant advantage in increasing the Zinc (Zn) nano-particles quantity from 1.0% to 1.5%. Since a limit to the maximum quantity of Zinc (Zn) nano-particles is imposed due to environmental considerations, therefore using a higher quantity is also to be avoided.

Conclusions

- 1) The wear of the sliding surfaces subjected to heavy load and slow speeds is reduced by using Zinc (Zn) nano-particles as anti-wear additive in lubricant.
- 2) A minimum wear to the tune of 94.15% is observed for 1.5% of Zinc (Zn) nano-particles quantity. A similar reduction of 93.57% in wear is obtained with the use of 1.0% Zinc (Zn) nano-particles quantity.
- 3) No significant reduction in wear (only 9.09%) is obtained when the Zn quantity is increased from 1.0% to 1.5%. Therefore there is no significant advantage in increasing the Zinc (Zn) nano-particles quantity from 1.0% to 1.5%.
- 4) Further theoretical and experimental studies are required to establish the optimum Zinc (Zn) nano-particles quantity under varying surface and operating conditions.

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