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Experimental Investigation of Tribological Behaviour of Nano-Oil

#1 Amarsinh S. Shinde, #2 Prof. S. C. Shilwant

[1] amar.shinde8686@gmail.com
[2] scshilwant.sae@sinhgad.edu.com

#12 Department of Mechanical Engineering, SPPU, Pune
Sinhgad Academy of Engineering, Kondhwa, Pune, India-411048

ABSTRACT

Nanoparticles are particles between 1 and 100 nanometers in size. In nanotechnology, a particle is defined as a small object that behaves as a whole unit with respect to its transport and properties. Particles are further classified according to diameter. Nanoparticles can be used as an additive in the engine oil to improve its Lubrication properties to reduce wear and friction of the engine. The properties of lubricants are mainly the result of adding a material for improving or producing the required properties. Today, different materials with various nanostructures are used as new additives which, because of their unique properties, are used for improving the lubricant's properties. In this research copper oxide (CuO) nanoparticales are added to the engine oil and tribology properties are investigated. The wear and friction experiment was carried on Pin on Disc Tribometer and the tests were performed with varying load (30, 50, 65 N), speed (1000, 1200, 1500 rpm) and varying concentration (0.2, 0.5, 1.0 wt. %) of nanoparticles in engine oil. The obtained results show that CuO nanoparticles (1.0 %) added in engine oil exhibits good friction reduction and anti-wear properties and also decreased the coefficient of friction by 17% and 44% as compared with standard engine oil without CuO nanoparticles.

Keywords— CuO nanoparticles, tribological properties, engine oil, pin on disc tribometer.

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I. INTRODUCTION

Nanotechnology is regarded as the most revolutionary technology of the 21st century. It can be used in many fields and ushers material science into a new area. In recent years numerous investigations have been carried out on the tribological properties of lubricants with different nanoparticles added in it. A large number of papers have reported that the addition of nanoparticles to lubricant is effective in reducing wear and friction [1-10]. Among those that were added into oils, CuO nanoparticles have received much attention and exhibited excellent applications for their good friction reduction and wear resistance properties [1-5]. The reduction of wear depends on interfacial conditions such as normal load, geometry, relative surface motion, sliding speed, surface roughness, lubrication, and vibration. In addition, anti- wear properties, load-carrying capacities, and friction reduction are mainly controlled by the chemical additives in lubricating fluid under boundary lubrication conditions. Since stabilization of nanoparticles has been resolved by the addition of a dispersing agent or the use of a surface modification preparation technique, inorganic

Nanoparticles	**Properties**
Copper oxide (CuO)	Morphology: nearly spherical, Purity: 99.95+%, APS: 25-55 nm, Bulk Density: 0.79 g/cm^3, True Density: 6.4 g/m^3

nanoparticles have received considerable attention in the lubrication field [7].

Nanoparticles have received considerable attention because of their special physical and chemical properties. The preparation of organic–inorganic complex nanoparticles is causing more interest in science and industry. Now, a number of these nanoparticles have been synthesized and many of them have been studied as lubrication oil additive [6]. However, few of them were used and studied as water base lubrication additives. In recent years, with the development of nanomaterials, many scientific researchers added nanoparticles into lubricating oils to improve extreme pressure, anti-wear and friction reducing properties, and the efficiency and service life of machinery were improved and prolonged. The application of advanced nanomaterials has played an active role in improving and reforming traditional lubrication technology [10].

Y.Y. Wu et al. examined the tribological properties of two lubricating oils, API-SF engine oil and Base oil, with CuO, TiO2, and Nano-Diamond nanoparticles used as additives. The experimental results show that nanoparticles, especially CuO, added to standard oils exhibit good friction-reduction and anti-wear properties. In addition, investigations were performed using TEM, OM, SEM, and EDX to interpret the possible mechanisms of anti-friction and anti-wear with nanoparticles [1].In particular, the tribological properties of metal oxides, rare earth compounds, metals, metal borates and metal sulfide used as lubricate additives have been investigated. The anti-wear mechanism of a metal oxide nanoparticulate additive was tribo-sintering of nanoparticles on the wear surfaces. That process reduced the metal-to- metal contact and created a load bearing film. Also the summarized mechanisms of the friction-reduction and anti- wear of nanoparticles in lubricants as the result of colloidal effect, rolling effect, protective film, and third body are studied. The results of these investigations show that nanoparticles deposit on the rubbing surface and improve the tribological properties of the base oil, displaying good friction and wear reduction characteristics [7].

In the present study we will synthesize stable CuO nanoparticles with an 'oleic acid' surface modifier which will give very good dispersibility in organic solvents. In order to estimate the ranges of applications of CuO nanoparticles, it is necessary to investigate its tribological behaviour under increasingly severe contact conditions.

II. EXPERIMENTAL

A. Material

We can use the SAE 20W40 engine oil as the base oil. The Pure lubricant engine oil contains some additives for frictionreduction and anti-wear, but the Base oil SAE 20W40 does not. Pure lubricants are manufacturers of industrial lubricant, automobile oil and greases. It is a British Standards certified company. The properties of base oil are:-Color : Brown & clear, Appearance: 1.5 ASTM, Density: 0.880gm/ml, Viscosity : Index 94 MIN.

Figure 1: Copper oxide (CuO) in form of nano powder

B. Preparation of Nano-oil

One of the most effective factors of the nanofluid properties is the rate of dispersion and stability of nanoparticles inside the base fluid. When dispersion of particles inside the base fluid is not good, it is possible that agglomeration and precipitation of nanoparticles occur; which may cause damage of the frictional surfaces. In the present research, to disperse nanoparticles inside the base oil, we used oleic acid as surface modifier and by preparing lubricant samples in concentrations of 0.2 wt%, 0.5 wt%, 0.75 wt% and 1wt% using an ultrasonic probe for 45 min. These concentration values were obtained from the results of bibliographic research, where concentration of nanoparticles is in the range 0.2-1 wt%. The materials used in the experiments and their properties are shown in Table 1

C. Anti-Wear Test Procedure

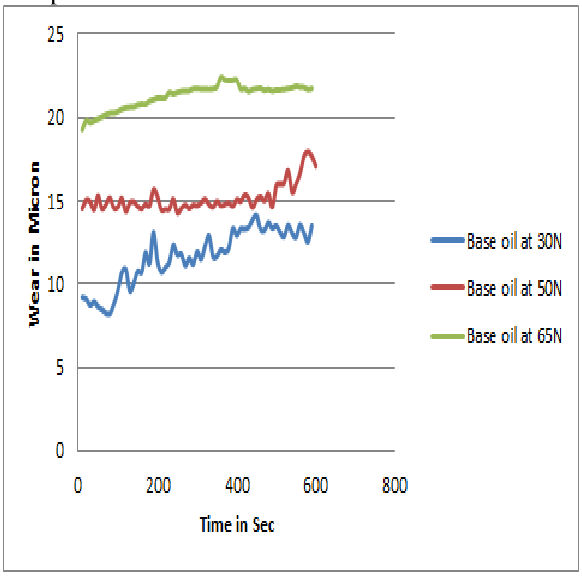
Test-section components are cleaned thoroughly. Tastings are conducted by using a Pin on Disc Tribotester.The friction andwear testing machine was set for pure sliding contact, with apin-on-disk configuration. The manufactured test pins run against a counter face of the manufactured disk. All weartests were carried out at loading condition 30N, 50N and 65N.The disk rotate at constant speed of 1000 rpm atroom temperature for 10 minute time. The coefficient of friction and wear rate are recorded by using strain gauge in tribotester.

Table 1: Properties of the materials

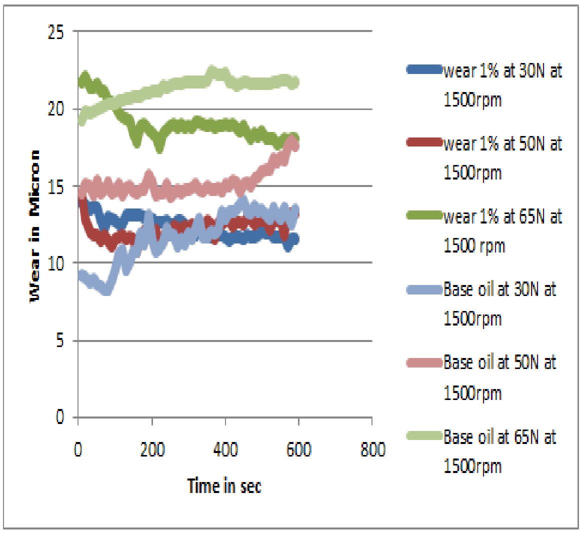
III.RESULTS AND DISCUSSION

A. Anti-wear Properties

The anti-wear properties are examined according to the results obtained from computerized data acquisition system in the form of graph. We get the wear in microns of base oil without nano particles as shown in the Graph 1 and which gives a similar pattern for different experimental values, and a maximum standard deviation 0.0391, 0.0634, 0.079 with respect to load conditions 30N, 50N and 65N at 1500 rpm. The anti-wear property is a function of additive concentration in base oil. Graph 2 shows the graph of wear verses time in which 1.0 wt. % concentration of base oil sample drastically improved the wear reduction at 50N and 65N loading conditions of 2µ and 4µ. But at 30N the wear rate slightly increased by 0.9 µ than that of the base oil. So as per the above discussion nanoparticle at 1.0 % can reduce wear compared with pure base oil. Since base oil does not contain any anti-wear additive, the tribochemical reaction film cannot be produced on rubbing surfaces. Therefore, lower wear might be attributed to rolling effect of the nanoparticles.



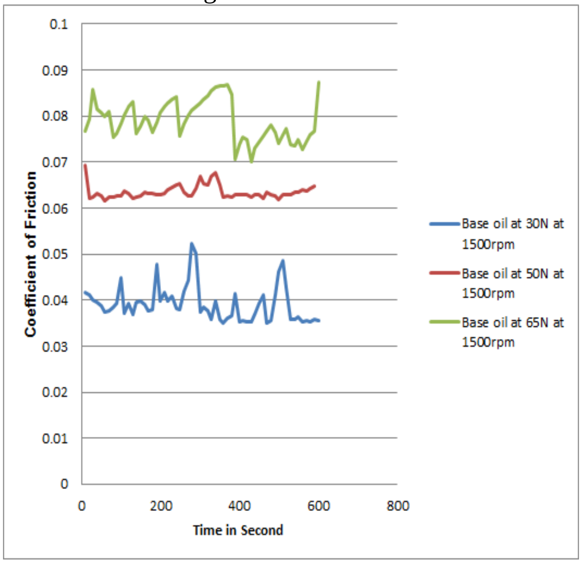
Graph 1: Wear in micron with base oil without nanoparticles



Graph 2: Wear of base oil with and without nanoparticles at 1.0 % concentration

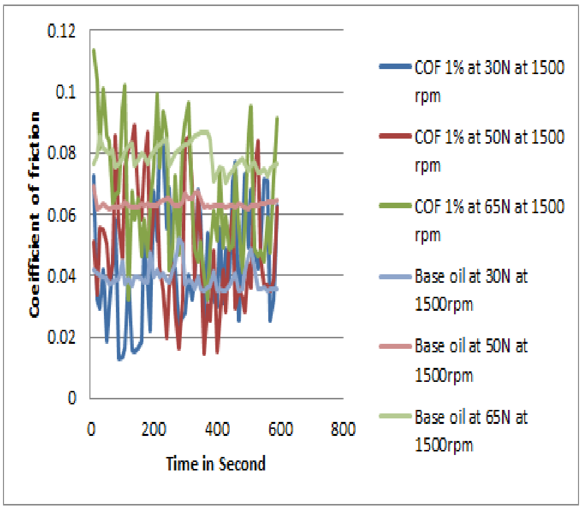
B. Friction-reduction properties

In order to confirm the repeatability of experimental data, the coefficient of friction are measured in triplicate using the pin on disk tribotester under 30N, 50N and 65N load conditions for 10 minute. The friction coefficients of base oil without nanoparticles are displayed in Graph 3, they show a similar trend for different experimental results, and a maximum standard deviation 0.0391, 0.0634, 0.079 with respect to 30N, 50N and 65N load conditions among all sets of test data.



Graph 3: coefficient of friction of base oil without nanoparticles

The addition of CuO nanoparticles reduced coefficient of friction with respect to pure base oil. The best results were found for the suspensions with a nanoparticle concentration of 1.0 %. Graph 4 shows the suspensions with 1.0 wt. % of base oil sample exhibited 17% and 44% of friction coefficient reduction with respect to the pure base oil at, 65N and 50N load condition respectively. But for 30N load it was observed slight increase in friction coefficient by 14% for 1.0 %wt. As can be seen the base oil containing nanoparticles yields better friction reduction behavior which helps the lubrication regime to change from boundary lubrication into mixed or hydrodynamic lubrication, as a result the lower coefficient of friction is observed.



Graph 4: coefficient of friction of base oil with and without nanoparticles at 1.0 % concentration

IV. CONCLUSION

1. Base oil with CuO nanoparticles improved tribological properties in terms of load carrying capacity, anti-wear and friction reduction than base oil without nanoparticles. The results showed that 1.0 wt% concentration was an optimum concentration.

2. For the friction reduction test, when CuO nanoparticles were added into base oil, the coefficient of friction reduced by 17 % and 44 % at 1.0 wt. % concentration as compared to base oil without nanoparticles.

3. The deposition of nanoparticles on the worn surface can decrease the shearing stress, and hence reduce friction and wear.

V. FUTURE SCOPE

1. We can study the wear and coefficient of friction characteristics using different nana particles concentration under different load and rpm.
2. With DOE using Taguchi Method we can study the relationship of the load, rpm and concentration of nano particles with the wear and coefficient of friction outputs for specific ranges.

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