

Tribological Properties and Stabilization of Engine Oil with Nano Particles-A Review

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ABSTRACT: Engine oil, a mile post invention is simply a oil which is used to lubricate the engine and other internal parts of engine of a motor such as a car or other road vehicles. The purpose motor oil is to reduce friction and wear on moving parts in its real time application thereby it cools the engine by carrying the heat away from moving parts. Though it was found to have all the above mentioned advantages, it leads to the formation of oil sludge which may lead to engine failure. To eradicate this defect, scientists came out with an idea of dispersing nanoparticles in the engine oil. This review mainly focuses on the tribological properties and stabilization of engine oil dispersed with nanoparticles.

KEYWORDS: Engine oil, Nano particles, Tribology, stabilization.

I. INTRODUCTION

The engine oil which is being traditionally used since the invention of machineries is mainly used for reducing the friction and wear on moving parts leads had the disadvantage of forming oil sludges. Thus there was a need to develop a new type of engine oil which can overcome this drawback even at the conditions of extreme pressure. Finally researchers were laid open with an idea of dispersing nanoparticles in the engine oil. When the engine oil with dispersed nanoparticles were subjected to service conditions, it was observed that they performed better in reducing the friction, wear and lubrication, etc. It was experimentally noticed that engine oil with dispersed CuO nanoparticles reduces coefficient of friction by 25% and wear by 53% than that of pure engine oil. This value is found to vary with thenature and size of nanoparticles. As a result, the implementation of this technique would increase the service life of machinery. Though this modified engine oil showed better tribological, there was a problem of coagulation or agglomeration of nano particles which were being dispersed in the base (engine oil). Thus there arouse a necessity to enhance the stabilization of nanoparticles in the engine oil. Thus the study of tribology and stabilization is a thrust area where ample research has to take place.

II. STABILIZATION

Characteristically engine oil has high heat capacity which leads to the formation of oil sludge. The experiments conducted by Thibault, Khan Mohammadi and Etemad revealed that heat capacity can be reduced by increasing the thermal conductivity which in turn can be achieved by improving the stability. Thermal conductivity can be measured by hot wire transient method using the following equation,

$$k = \frac{Q \ln(t_2/t_1)}{4\pi (T_2 - T_1)}$$

where t1 and t2 are time intervals from the beginning of heating process corresponding temperatures T1 and T2 at the centre of the wire. Q is the rate of heat generation of the line source. Scientists tried to overcome this by dispersing ultrafine particles into the base fluid (engine oil). The ultrafine particles which were being dispersed into the base can be metallic (Cu, Al, Ni) or non-metallic (CuO, Al2O3).when scientist Choi of Argonne laboratory prepared nanofluid for the first time in 1974, the nanoparticles which were being suspended in the base are found to

coagulate under elevated conditions of temperatures and pressure. This difficulty can be chocked out by enhancing the stability of nanofluids. Here nanofluids refer to a simple colloidal suspension of nano particles into the engine oil. The stability of nanofluids can be enhanced by altering the mechanism by which stabilisation takes place and by increasing the dispersion effect of nanoparticles in engine oil.

II.a. Stability Mechanisms

Thus by varying this base property, the thermal conductivity can be enhanced by which heat capacity can be reduced. There are two basic mechanisms by which stability can be enhanced. They are

- * Electrostatic stabilization
- * Steric stabilization

II.a.1. Electrostatic stabilization

Electrostatic stabilization is one of the basic mechanism by which stability of nanofluids (colloidal suspension of nanoparticles in engine oil) can be improved. The basic principle behind electrostatic stabilization is the repulsive electrostatic force which is usually being experienced by nanoparticles when they are surrounded by double layer of electric charges. Charges on the surface of nanoparticles decide their electrostatic stability. So they are often deciders of electrostatic stability. Electrostatic stabilization can be enhanced by having control on repulsive force between two equal sized spherical nanoparticles. This repulsive force can be modified by controlling the pH level of nanofluids. This method has very limited application in reality because of its chemical reactive behaviour.

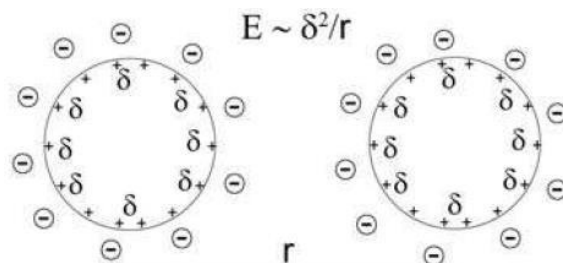


Fig.1. Electrostatic stabilization

II.a.2. Steric stabilization

Steric stabilization is mainly based on the steric repulsion between the molecules or ions absorbed on neighbouring particles. The size and chemical nature of molecules also determine the degree of stabilization. Steric stabilization is the mechanism of attaching the macromolecules such as polymers or surfactant to the surfaces or particles. The attachments of macromolecules serve as steric barrier to prevent particles coming close to one another. Longer the hydrocarbon chain, better is the steric stability.

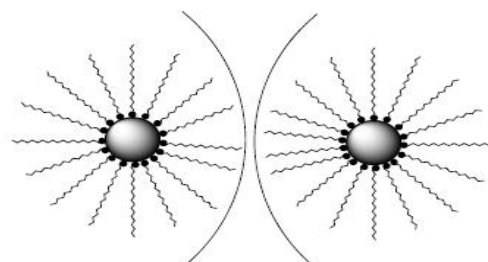


Fig. 2. Steric stabilization

III. TRIBOLOGICAL PROPERTIES

Tribology is the science of interacting surface in relative motion. It includes the study and applications of principles of friction, lubrication and wear. The reduction of wear depends on the conditions such as load, geometry, relative surface motion, sliding speed, surface roughness, lubrications and vibrations. There are several experiments for testing friction and wear in which one of the main testing method is pin-on-disc configuration. In this test, friction and wear can be calculated at various loading conditions such as 30N, 50N, 65N. The disc is to be rotated at constant speed at 100 rpm at room temperature for 10 minutes of time. The results obtained by the above mentioned technique is recorded by using strain gauge in tribotester. The wear surfaces on the pin can be visualised by using Scanning Electron Microscope, which is often referred to as SEM. From the experiments conducted by Ajinkya S. Pisal and D.S.Chawan, it was determined that graph of wear versus time in which 0.5 weight % concentration of nanoparticles in base oil drastically improved its wear reduction at 30N and 65N of coating conditions of three microns and 18 microns. But at a loading condition of 50N, the wear rate slightly increased by 0.8 microns than that of the base oil.

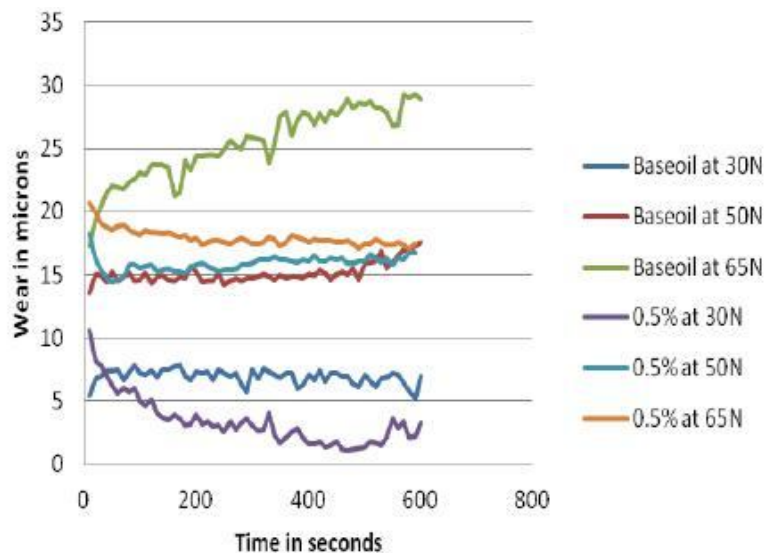


Fig. 3. Wear diameter in microns

The main reason for lower friction co-efficient of engine oil dispersed with CuO nanoparticles in comparison with pure engine oil is that viscosity of engine oil reduces as the temperature increases and thus the lubricative layer becomes thinner, and thus suspended nanoparticles make the mixture more viscous. Finally lubricative film between tribo-pairs with low nano hardness and elastic modulus on the surface has been formed. This contributes to the lower friction co-efficient of modified engine oil.

It is clearly visible from the data that the dispersion of 0.5% nanoparticles can reduce wear when compared with pure oil. Base oil does not contain any anti-wear property. The tribo chemical reaction film cannot be produced on the relative surfaces when they are subjected to rubbing. It can also be confirmed from the data obtained by the pin-on-disc configuration. The friction coefficient of base oil mixed with nanoparticles are slightly lower than the friction coefficient of base oil without nanoparticles. For example, the addition of CuO nanoparticles reduced the coefficient of friction with respect to pure base oil. The best results were found for the suspensions with a nanoparticle concentration of 0.5%. The suspension with 0.5 weight % base oil sample exhibited 24% and 53% of friction resistance coefficient reduction with respect to the base oil without containing nanoparticles at 50N and 65N load condition respectively. But for 30N load, there was a slight increase in friction coefficient by 1% for 0.5% weight.

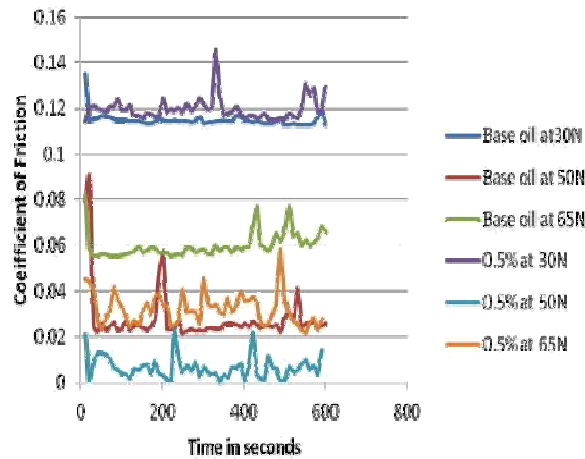


Fig. 4. Friction co-efficient reduces as a function of suspension of nanoparticles

The reason behind the anti-wearing property of modified engine oil is the lubricative film formed by the dispersed nanoparticles by which adhesion between two surfaces is prevented and also due to the rolling effect of spherical CuO nanoparticles between rubbing surfaces when the lubricative layer occurs. Thus it is clearly evident that base oil containing nanoparticles exhibit better friction reduction behaviour when compared to pure base oil. From the SEM diagrams below engine oil with nanoparticles showed better wear resistance than that of pure engine oil.

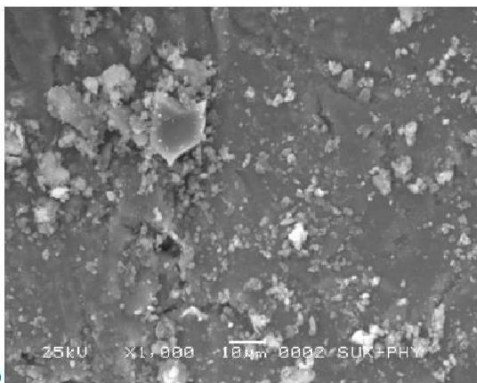


Fig. 5. SEM images of worn surfaces with base oil without nanoparticles



Fig.6. SEM images of worn surfaces with base oil with CuO nanoparticles

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IV. CONCLUSION

In this review, an attempt was made to cover all major concepts that can be adopted to enhance the stabilization of engine oil dispersed with nanoparticles. The tribological properties of engine oil with nanoparticles are explained with required examples in this review. The following conclusions were made on account of few available experimental results

- Wear resistance is found to be enhanced with the addition of nanoparticles in the base (engine oil)
- Friction reduction properties i.e., coefficient of friction of modified engine oil (engine oil with nanoparticles) is slightly lower than those of base oil without any external additives (nanoparticles)
- The stability of nanoparticles can be altered by the addition of acids preferably oleic acid which in turn controls the pH level
- Worn out surfaces can be healed by the deposition of nanoparticles, this in turn reduces the shearing stress, friction and wear.

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