Tribological behavior of Carbon Coated Nickel Nanoparticle, Silicon Oxide and their Combinations with Lubricating Oil

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Abstract—This study examined the tribological properties of SAE 40 oil with nickel carbon coated and silicon oxide nanoparticles and their combinations. The tribological properties were investigated on a four ball oil tester using accordance with the American Society for Testing and Materials (ASTM) standard 4172. Results show that on addition of nickel carbon coated and silicon oxide with SAE 40 oil the antiwear properties of lubricant were improved.

Key words: Antiwear, Lubricating Oil, Nanoparticles, Viscosity

I. INTRODUCTION

It is well known that the addition of an appropriate additive to an oil-based lubricant can effectively increase the mechanical efficiency, decrease the energy consumption, and reduce friction and wear of machinery equipment. Machine components and pairs depend on high quality of lubricant to enable with standing high temperatures and extreme pressure. With the rapid development of nanotechnology, nanolubricants with metallic additives have also been studied. Experimental results report that the use of metallic nanoparticles as additives to oils can improve the antiwear properties under extreme pressure conditions. The metallic nanoparticles can also act without any corrosive effect and can be used at high temperatures. Therefore, they have the potential to become a new generation of anti-wear and extreme pressure additives. [1]The tribological behavior of lubricants with the addition of copper nanoparticles has been studied by some authors. In all these cases, when copper coated nanoparticles were tested as oil additives, the results showed that the oils with the addition of these nanoparticles show an excellent antifriction and anti-wear performance and high load-carrying capacity. Recently used were surface-coated copper nanoparticles as oil additives. They showed that surface-coated nano-copper additives can significantly improve the wear resistance and load-carrying abilities of oil, as well as reduce the friction coefficient. They related the results to a soft copper protective film that is formed on the worn surface lubricated with oil containing nano copper additives, which separates the worn surfaces, avoids their direct contact and reduces friction and adhesive wear. On the other hand used graphene encapsulated copper nanoparticles as a lubricant additive. In this case, the additive also increased the load-carrying capacity of the base oil, decreased the friction.

II. LITERATURE SURVEY

H.L.Yu,Y.Xu studied the effect of surface coated ultrafine powders of serpentine added in lubricants on the tribological behaviors of a mated 1045 steel contact . With the addition of serpentine to oil, the wear resistance capability was improved and the friction coefficient was decreased. The addition of 1.5 wt% serpentine to oil is reduces friction and wear.[1] Rende Liu, Xicheng Wei studied the Surface modified mixed rare earth nanoparticles are prepared and their tribological performances as lubrication additives are evaluated using a four-ball friction and wear tester. The analytical results confirm that the average size of the particles is less than 30nm and they show excellent anti-wear, load carrying and good friction reducing capacities in base stock. [2] Xiaowen Qi , Ling Lu studied the Friction and wear experiments were carried out with nanoscale serpentine and magnesium hexasilicate powder as lubricating oil additives at 4000C.The tribological test results showed that the self-repairing protective layers formed on the contact surfaces, whether nanoscale serpentine or magnesium hex silicate powder was added into lubricating oil..[3]Ehsan-o-llah Ettefaghi investigated the effect of multi-walled carbon nanotubes in different concentrations on some of the properties of engine oils was studied. Viscosity, pour point, flash point and thermal conductivity as four quality parameters, which are effective in functionality of engine oil.. According to the obtained results, thermal conductivity and flash point of nanolubricants with 0.1 wt% improved with respect to the base oil. [4]S. Syahrullail tested properties of palm fatty acid distillate mixed in mineral oil.. The mixing percentage varies from 5% to 25% of the total mass. Testing was conducted using four-ball tribotester accordance with the (ASTM) standard 4172. The results show that by mixing a 20 % total mass of palm oil in the mineral oil, the coefficient of friction reached its lowest value. From these results, it can be concluded that the performance of the mineral oil could be improved by mixing it with vegetable oil.[5]Binu K.G.Influence studied the effect of TiO2 nanoparticle lubricant additive on the load carrying capacity of a journal bearing. The pressure distribution and load carrying capacity are theoretically evaluated using a modified Reynolds equation for various TiO2 nanoparticle concentrations and cumulative sizes. Results disclose an increase in load carrying capacity of journal bearing using TiO2 nanoparticle lubricant additive as compared to plain oils without nanoparticle additive. [6]Ehsan-o-llah Ettefaghi studied the addition of copper oxide nanoparticles to engine oil and evaluate the produced changes in some of its properties. Also, viscosity, pour point, and flash point of nanolubricants, which are made at different concentrations and also their thermal conductivity coefficient as four quality parameters which are effective in the functionality of engine oil are evaluated. [7]M.Asrul studied the wear and friction properties of surface modified CuO nanoparticles suspension in liquid paraffin have been studied. Wear characteristics were evaluated using four-ball machine The lowest friction coefficient was 0 obtained for a nanoparticle content of 0.2% CuO and the highest was for a 3% CuO concentration for liquid Paraffin + CuO without modification suspensions. [8]Shubrajit Bhaumik investigated the antiwear and extreme pressure properties of multiwall carbon nanotube based mineral oil. The samples were tested for their antiwear and load bearing capacity according to ASTM G99 and ASTM D-2783 standards. The wear test results show a decrease wear in case of multiwall nanotube based mineral oil as compared with pure mineral oil. [9].Mustafa Akbulut studied the advent of nanotechnology research into lubricants and lubricant additives have experienced a prototype shift. as an alternative of conventional materials, new nanomaterials and nanoparticles have been recently under investigation as lubricants or lubricant additives because of their unusual properties. Now, there are many different types of nanomaterials with potentially interesting friction and wear properties described the literature. With increasing amount of possibilities, the key question is: what types of nanoparticles act as better lubricants [10]H. So studied the use of some extreme-pressure, antiwear additives in Mineral oils can generate different kind of boundary or chemical reaction films on sliding contact surfaces of some kinds of steel in boundary lubrication conditions. Using a sliding ball-on-disc arrangement lubricated with some kinds of EP or FM, the wear scars on the balls can always reach the same limit size at a particular applied load and sliding velocity. [11]

Lili Yan examined the Its tribological performances as additive in base oil 150SN were examined on a four-ball tester, and compared with those of ZDDP and MoDTC under boundary lubrication condition. Results showed that NNDM combine oil exhibited excellent load-carrying capacity, significantly reduced friction coefficient and wear rate of worn surface. [12]Z. Zalisz investigated the M3/2 sintered high speed steel and compound materials processed by initial admixing of 5 wt% TiC and 5 wt. % MnS powders, singly and in combination, were assessed in pin-on-disc tribometer. The load carrying capacities of the lubricated associates for the HSS systems, especially in presence of TiC additive, were five to seven times higher than for the cast irons [13]Helong Yu examined Surface-modified serpentine powders with an average size of dispersed into mineral base oil to advance the lubricating properties of oil. Results show that a nanocrystalline tribofilm, with a thickness of 500–600 nm, is formed on the worn surface under the lubrication of oil with serpentine [14]

III. EXPERIMENTAL DETAIL

A. Nanoparticles Used

The different types of nanoparticles used in this work are as follows,

- Nickel (carbon coated)
- Silicon oxide(SiO2)

B. Material Preparation

The nanoparticles are dispersed in SAE40 engine oil. The Precision balance is use for measuring weight of oil and nanoparticle additives and magnetic stirrer is used for dispersion of nanoparticle in oil.

Fig. 1: Precision balance

Fig. 2: Magnetic Stirrer

C. Wear Test

Test carry out according to the standard test method for measurement of wear preventive characteristics of lubricating fluids, using an ASTM D4172 and four ball tester. The four ball tester has the unique capability of evaluating lubricants for their wear preventive, extreme pressure, and frictional properties.

Fig. 3: Samples for wear test

D. Tribological Testing

Four-Ball tester TR-30L model is versatile equipment combining the features of both Four Ball Extreme Pressure and Four ball wear test machines. In this tester three 12.7 mm diameter steel balls are clamped together and covered with lubricant to be evaluated, a fourth ball of same dia referred to as top ball is held in a special collect inside spindle, rotated by AC motor .

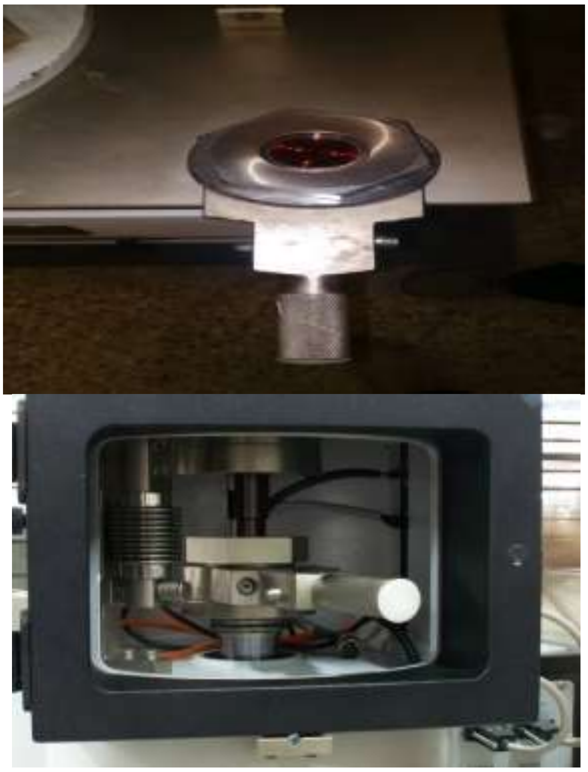

Fig. 4: Ball Pot Assembly

The top ball is rotated in contact with three fixed bearing balls, which are immersed in sample oil. Inside the ball pot the balls are held in position against each other by a clamping ring and force applied by tightening lock nut, additional provision to heat and control temperature of oil sample is also provided at bottom of ball pot. Normal load is applied on the balls by loading lever and dead weights placed on loading pan. The ball pot is supported above the loading lever on a thrust bearing & plunger and beneath plunger a load cell is fixed to loading lever to measure normal load. The frictional torque exerted on the three balls is measured.

IV. Results and Discussion

Sample lable	oil	Concentration of nanoparticle by wt%	Wear scar diameter
O	SAE 40	-	596
N1	SAE 40+Ni	0.5	452
N2	SAE 40+ Ni	1	512
N3	SAE 40+Ni	2	564
S1	SAE 40+ SiO_2	0.5	528
S2	SAE 40+ SiO_2	1	560
S3	SAE 40+ SiO_2	2	516
NS1	SAE 40+Ni+ SiO_2	0.25+0.25	588
NS2	SAE 40+ Ni+SiO_2	0.5+0.5	584
NS3	SAE 40+Ni+ SiO_2	1+1	592

Table 1: Results of wear Test

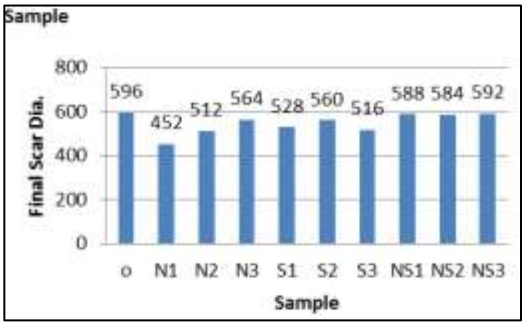

Fig. 5: Wear scar diameter

The results show that both nanoparticles as additives in SAE 40 OIL at a various concentration have better anti-wear and antifriction properties than the pure SAE 40 oil. Graph shows the less wear scar diameter as compare to the sample which not contains additives. For sample b1 (0.5 wt % of nickel carbon coated) shows less wear scar diameter

V. Conclusion

Results show that on addition of nickel carbon coated nanoparticle 0.5 wt% with SAE 40 oil the antiwear and load bearing capacity of the lubricant as improved.

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