EXPRIMENTAL ANALYSIS OF TRIBOLOGICAL PROPERTIES OF LUBRICATING OIL USING NANOPARTICLE ADDITIVES

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ABSTRACT

The present paper is based on the influence of addition of carbon coated nickel nanoparticle and silicon oxide nanoparticle and their combinations on the tribological behavior of engine oil. Samples were prepared of varying percentage of nanoparticles in engine oil (0.5, 1 and 2 wt %). The wear test was conducted using four ball tribotester according to ASTM standard 4172b, viscosity, flash and fire point was evaluated using redwood viscometer and flash and fire point apparatus. The Experimental results shows that both nanoparticles as additives in engine oil at various mixing percentage have better antiwear properties than the pure engine oil. Also viscosity, flash and fire point of nanoparticles with different concentrations gives an effective functionality of engine oil.

Keyword: - *Antiwear, Lubricating oil, Nanoparticles, Viscosity*.

I. INTRODUCTION

Recent research papers have reported that the addition of nanoparticles to lubricant is effective for the reduction of wear and friction in mechanical systems. Because of the remarkable tribological properties of nanoparticles, nanotechnology is regarded as the most revolutionary technology of the this century. [1]The anti-wear mechanism of nanoparticles when they are used as additives in lubricants can be explained in three different ways: nanoparticles may be melted and welded on the rubbing surface, reacted with the specimen to form a protective layer of nanoparticles , or tribo-sintered on the surface. However, some authors state that nanoparticles can also act as small bearings on the rubbing surfaces. nanoparticles penetrate into lubricated EHD contacts via a mechanical entrapment mechanism to form a boundary film influencing friction and wear, and these nanoparticles are entrained into sliding contacts only when the film thickness is smaller than the particle size contributing to the film thickness. The above mentioned anti-wear mechanisms of the nanoparticles take place only under mixed and boundary lubrication. Results show that nanoparticles can improve the tribological properties of the base oil, displaying good friction and wear reduction characteristics even at concentrations below 2 wt%. [2] 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 anti-wear 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 behaviour of lubricants with the addition of copper nanoparticles has been studied by some authors. In all these cases, when copper coated nanoparticles (none of them was carbon-coated ones were tested as oil additives, the results showed that the oils with the addition of these nanoparticles exhibit 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.

II. LITERATURE SURVEY

Numerous nanoparticles have recently been investigated for use as oil additives. Nano-powders of some metals and their compounds exert an especially effective influence on the characteristics of lubricants. The use of nanoparticles that include Cu, CuO, Fe, Ni, TiO2 and other metallic nanoparticle additives in lubricating oils provides good friction reduction and anti-wear behavior

Juozas Padgurskas, Raimundas Rukuiza studied the Tribological investigations on mineral oil containing Fe, Cu and Co nanoparticles and their combinations. The tribological tests showed that each set of nanoparticles significantly reduced the friction coefficient and wear of friction pairs. The use of Cu nanoparticles provides the most effective reduction of friction and wear in each combination of nanoparticles. Surface analysis shows that the constituent elements of nanoparticles precipitated on the contact surface during the use of the oils with nano-additives.. [1]

J.L. Viesca , A. Herna´ ndez Battez studied the influence of the addition of 25 nm carbon-coated copper nanoparticles on the tribological behavior of a polyalphaolefin (PAO6) and compares this behavior with the case of non-coated copper nanoparticles, determining the influence of coating. A block-on-ring tribometer, a four-ball machine, The study concludes that the addition of carbon-coated copper nanoparticles decreases wear and increases the load-carrying capacity of PAO6. This tribological improvement is due to the deposition of nanoparticles on the rubbing surfaces and probably by their action as tiny bearings. The carbon-coated copper nanoparticles did not behave better than non-coated ones. [2]

R. Chou, A. Herna ndez Battez examined the the influence of addition of 20 nm diameter nickel nanoparticles on the tribological behavior of synthetic oil (polyalphaolefin, PAO6). A TE53SLIM tribometer for testing at medium loads and a four-ball machine (ASTM D2783) were used in this research.. The study leads to the conclusion that the addition of nickel nanoparticles to PAO6 results in a decrease in friction and wear and an increase in the load-carrying capacity of base oil. This tribological behavior is closely related to the deposition of nanoparticles on the rubbing surfaces. [3]

Sudeep Ingole , Archana Charanpahari examined the effects of titanium dioxide additives on the lubricated friction and wear behavior of self-mated E52100 bearing steel were investigated using a reciprocating pin-on-disk apparatus. The additives were (a) nano-sized titanium dioxide (TiO2), in the form of anatase, and (b) commercially available TiO2 (P25) which contains a mixture of rutile and anatase phase. The friction and wear characteristics were examined at a constant applied load and rate of reciprocation. All concentrations of P25 increased the coefficient of friction, but the addition of TiO2 nanoparticles reduced the variability and stabilized the frictional behavior. [4]

Y.Y. Wu, W.C. Tsui study examined the tribological properties of two lubricating oils, an API-SF engine oil and a Base oil, with CuO, TiO2, and Nano-Diamond nanoparticles used as additives. The friction and wear experiments were performed using a reciprocating sliding tribotester. The experimental results show that nanoparticles, especially CuO, added to standard oils exhibit good friction-reduction and anti-wear properties. The addition of CuO nanoparticles in the API-SF engine oil and the Base oil decreased the friction coefficient by 18.4 and 5.8%, respectively, and reduced the worn scar depth by 16.7 and 78.8%, respectively, as compared to the standard oils without CuO nanoparticles. [5]

D.X. Peng Y. Kang studies the tribological properties of liquid paraffin to which diamond and SiO2 nanoparticles, which prepared by the surface modification method using oleic acid, had been added and observed by scanning electron microscopy (SEM) and infrared (IR) spectroscopy. Also, the dispersion capability and stability dispersivity of both modified nanoparticles in liquid paraffin were measured using a spectrophotometer. The measurements show the dispersion capacity and the dispersing stability of oleic acid-modified diamond and SiO2 nanoparticles in liquid paraffin. The tribological properties are evaluated using a ball-on-ring wear tester. The results show that both nanoparticles as additives in liquid paraffin at a tiny concentration have better anti-wear and antifriction properties than the pure paraffin oil. [6].

Z.S. Hu, J.X. Dong studies the Nanoparticle amorphous lanthanum borate with a particle size of 20–40 nm was prepared with a Replacing Solvent Dry technique and characterized using TEM and XRD. Its tribological properties as a wear resistance additive of lubricating oil were evaluated with a four-ball tribotester. The wear scar was characterized with XPS. The wear resistance and load carrying capacity of 500SN base oil was improved by the lanthanum borate. Diboron trioxide and FeB were formed on the wear scar surface. These tribochemical reaction products as well as some depositions formed a wear resistance film on the rubbing surface, which provided the oil with an excellent load carrying capacity. [7]

Jingfang Zhou, Zhishen Wu studied the LaF3 nanoparticle surface coated by organic compounds containing S and P was synthesized by the chemical surface modification method. The particle size and structure were characterized using a their tribological behaviors were evaluated on a four-ball machine. The results showed that LaF3 nanoparticles as an oil additive can strikingly improve the load-carrying capacity and anti-wear property of the base oil and had better friction-reduction when compared to that of ZDDP. It can be found that the boundary film on the worn surface was composed of LaF3 nanoparticles depositing film and tribochemical reaction film of the elements of S and P, which contributed to excellent tribological properties of LaF3 nanoparticle modified by compound containing S and P as an additive in liquid paraffin. [8]

III. PROBLEM STATEMENT

The conventional lubricants used for various mechanical systems consist of different types of conventional additives. The additives help to improve the lubricating and anti-wear properties of the lubricant. But these conventional additives have certain limitations at heavy loads. They are not able to maintain their original properties and thus show poor lubricating and anti-wear properties at these heavy loads. So there should be development in the additives so as to increase the working range of the lubricant.

IV. METHODOLOGY

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

1) Nickel (carbon coated)

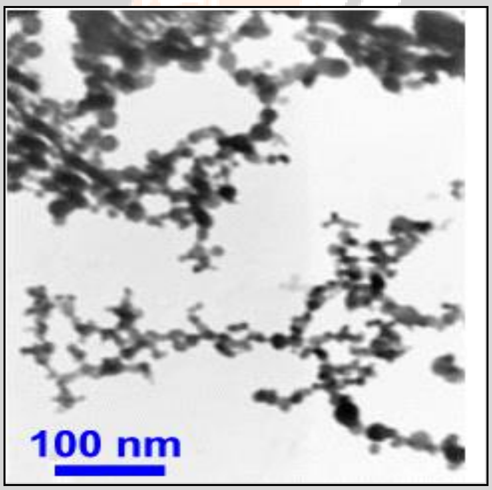

Fig. 1 SEM Micrographs of Nickel (Ni) carbon coated

2) Silicon oxide(SiO2).

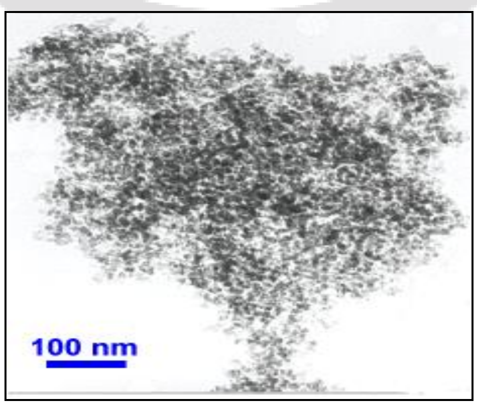

Fig.2 SEM Micrographs of Silicon Oxide (SiO2)

A. Material Preparation

The nanoparticles are dispersed in SAE40 engine oil. The magnetic stirrer is used for dispersion of nanoparticle in oil.

V. EXPERIMENTATION

The design of experiments is done on the basis of factorial design. In this project, we have two different types additives and three different concentration in different lubricating oils. we have the study of the effect of these variables on wear scar diameter, viscosity, & flash and fire point temperature. Lubricant 1 -SAE 40

1st Additive –nickel (Ni) carbon coated nanoparticle
2nd Additive – Silicon Oxide (SiO_2) nanoparticle
3rd additive-blending of Nickel and silicon oxide nanoparticle
0th concentration-0%
1st concentration-0.5%
2nd concentration -1%
3rd concentration -2%

TABLE I : DESIGN OF EXPERIMENT

Sr no	**Lubricant**	**additive**	**Concentration of additive**	**Labels for flash and fire point**	**Labels for viscosity test**
1	1	0	0	A	a1
2	1	1	1	B	b1
3	1	1	2	C	c2
4	1	1	3	D	d1
5	1	2	1	E	e1
6	1	2	2	F	f1
7	1	2	3	G	g1
8	1	3	1	H	h1
9	1	3	2	I	i1
10	1	3	3	J	j1

A. Flash and Fire point test:

ASTM D92 –Standard test method used to calculate flash and fire points by open cup tester. This test method shall be used to measure and describe the properties of materials, products, or assemblies in response to heat and a test flame under controlled laboratory conditions. The test cup filled to a specified level with the sample. The temperature of sample is increased rapidly at first and then slows at slow constant rate as the flash point is approached. At specified intervals a small test flame pass across the sample the lowest temperature at which the application of flame causes the vapors above the surface of liquid to ignite is taken as a flash point. to determine the fire point the test continued until the application of test flame causes the oil to ignite and burn for five seconds.

TABLE II :RESULTS OF FLASH AND FIRE POINT

Sr No	Name of the sample	Flash Point(temp)	Fire point (temp)
1	A	255	260
2	B	264	269
3	C	256	265
4	D	257	268
5	E	260	272
6	F	262	271
7	G	280	292
8	H	253	268
9	I	258	264
10	J	252	260

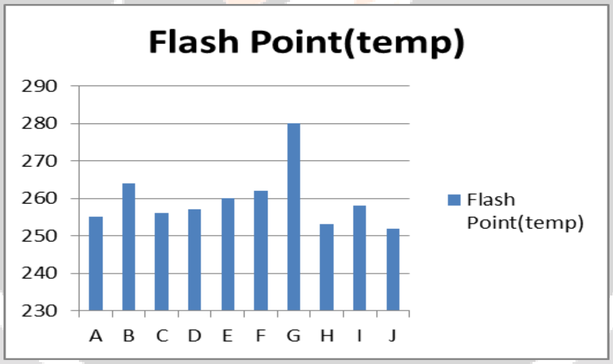

Fig.3 Graph of Flash point for samples

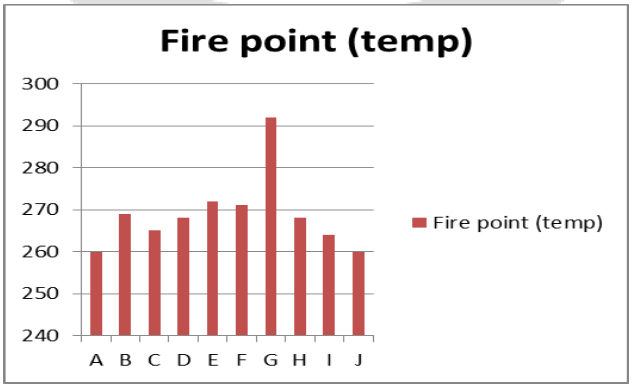

Fig 4: Graph of Fire point for samples

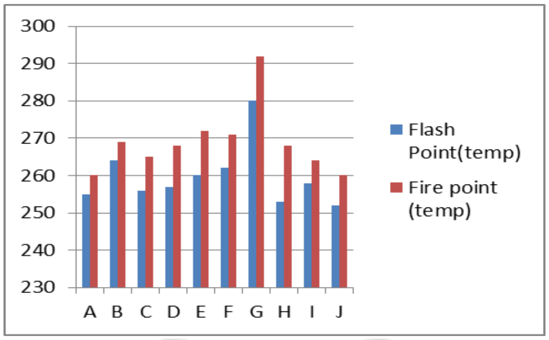

Fig 5: Graph of Flash & Fire point for samples

B. Viscosity test:

The viscosity of the nanolubricants was measured using a Redwood viscometer.50ml of oil was used for each trial.Time required for emptying 50ml of oil was measured and viscosity was calculated using Redwood formula.Three trials were conducted for each sample. The variations of kinematic viscosities were obtain at a temperature of 50-70^0 C

TABLE III: RESULTS OF VISCOSITY OF NANOPARTICLE WITH OIL

Sample	**Kinematic viscosity Cst**		
	50	60	70
a1	161	107	66
b1	177	121	86
c1	171	107	68
d1	146	107	70
e1	160	109	70
f1	163	108	69
g1	145	106	84
h1	147	118	68
i1	149	94	68
j1	158	110	85

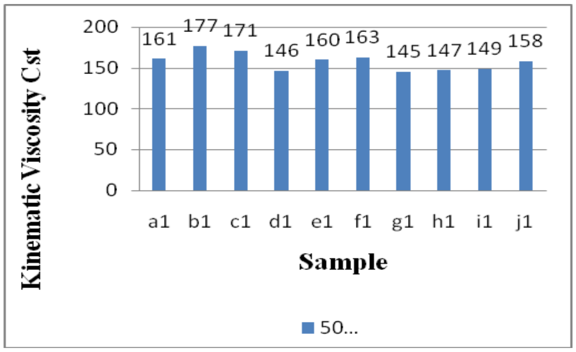

Fig. 6 Graph of kinematic viscosity of nanoparticle additives with SAE40 oil at 50^0 C

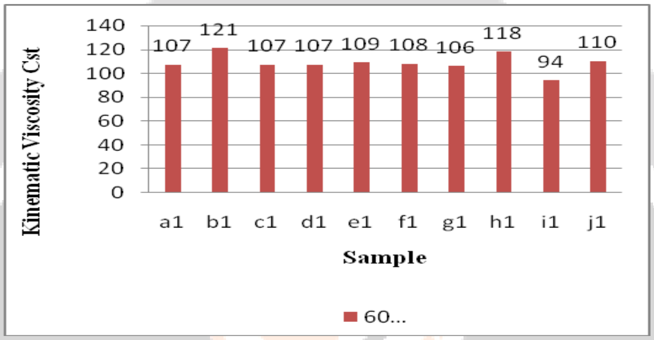

Fig 7: Graph of kinematic viscosity of nanoparticle additives with SAE40 oil at 60^0 C

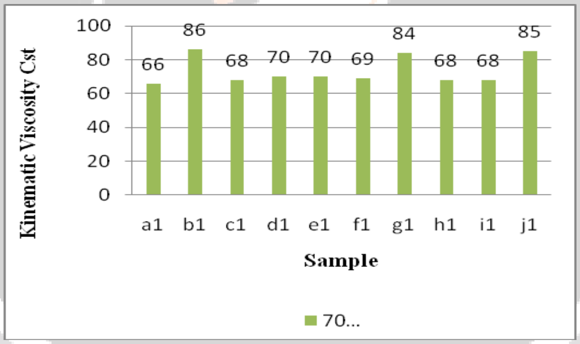

Fig 8: Graph of kinematic viscosity of nanoparticle additives with SAE40 oil at 70^0 C

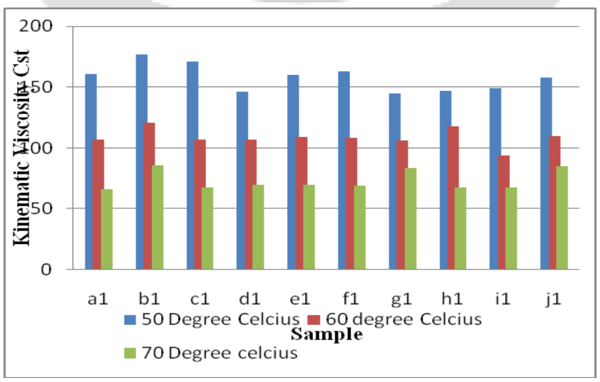

Fig 9: Graph of kinematic viscosity of nanoparticle additives with SAE40 oil at various temperatures

VI. CONCLUSION

1) Addition of Nickel (Carbon Coated) and silicon oxide in SAE 40 Engine oil increases theFlash and fire point of sample.
2)The graph shows that silicon oxide with 2 wt % with SAE 40 oil high flash and fire point.
3)Addition of nanoparticle in oil increases the viscosity of oil. And graph shows that Nickel with 0.5% with SAE 40 oil increases the viscosity of oil at various temperatures.
4) Addition of nanoparticle additives in oil decreasesthe wear rate of oil.

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BIOGRAPHIES

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