Experimental Analysis of Lubricating Oil Using Nanoparticles as Modifiers for Tribological Properties

Mr.Nikam M.M[1]., Mr. Shedage S.B[2]., Mr. Mane B.S[3]., Mr. Gitay A.J[4].

[1] PG Scolar, Mechanical Engineering Dept. Yashoda Technical Campus, Satara
[2] Assistant Prof, Mechanical Engineering Dept. Yashoda Technical Campus, Satara
[3]PG Scolar, Mechanical Engineering Dept. Yashoda Technical Campus, Satara
[4]Assistant Prof, Mechanical Engineering Dept. S.S.M.A.P, Ahmednagar

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Abstract - *Nanoparticles are proved to be useful as modifiers in the engine oil to enhance its tribological properties to reduce wear and friction of the engine. In this research molybdenum disulphide (MoS2) and copper oxide (CuO) nanoparticles are added to engine oil SAE20W50 and tribological properties are analyzed. Test samples were made with varying percentage of MoS2 and CuO nanoparticles in engine oil (0.25, 0.5 and 1 wt. %). Redwood viscometer was used to carry out viscosity tests for different samples at three different temperatures. The flash point and fire point tests were carried on Cleveland open cup apparatus. The experimental observations show that MoS2, CuO nanoparticles added in engine oil exhibits good friction reduction and anti-wear properties and also decreased the coefficient of friction as compared with standard engine oil without MoS2, CuO nanoparticles. This tribological behavior is closely related to the deposition of nanoparticles on the rubbing surfaces*

***Key Words*: MoS_2, CuO nanoparticles, tribological properties, engine oil, friction coefficient, wear**

1. INTRODUCTION

Nowadays nanoscience is one of the most expansively developing spheres of world's science and its achievements can be applied in different areas of science and technology. Nanomaterials as an example which are in the form of so called nanostructures (nanotubes, nanowires, Nano powders and others) which are widely used in many human activity fields- from cancer treatment to engineered textiles or energy storage to rocket explosives and propellant . In upcoming decades various new fields of nanostructures application will arise. One of them seems to be the unexplored area of nanostructures use as additives modifying properties (especially tribological) of lubricating or cutting oils.

Nanotechnology is regarded as the most revolutionary technology of the 21st century. It can be used in many fields of material science into a new era. In recent years numerous investigations have been carried out on the tribological properties of lubricants with different nanoparticles added in it. A number of papers from different authors all over the world have concluded that it is significantly effective to add nanoparticles to lubricant for reducing wear and friction. Among those that were added into oils, MoS2 nanoparticles have received much attention and exhibited excellent applications for their good friction reduction and wear resistance properties. The interfacial conditions which affect the reduction of wear are geometry, normal load, sliding speed, relative surface motion, surface roughness, vibration and lubrication. 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. As the addition of a dispersing agent or the use of a surface modification preparation technique stabilizes the nanoparticles, inorganic nanoparticles have received considerable attention in the lubrication field. Nanoparticles have received considerable attention because of their special physical and chemical properties. The preparation of organic–inorganic complex nanoparticles was causing more interest in science and industry. Though, some of them were analyzed and studied as water base lubrication additives. In recent years, with the development of nanomaterial, many scientific researchers added nanoparticles into lubricating oils to improve extreme pressure, anti-wear, friction reducing properties, the efficiency and service life of machinery. The application of advanced nanomaterials has played an active role in improving and reforming traditional lubrication technology.

When nanopartilces are used as additives in lubricants the anti-wear mechanism can be explained in three various ways: nanoparticles can be melted and welded on the rubbing surface, reacted with the specimen to form a protective layer, or tribo-sintered on the surface. However, some authors state that nanoparticles can also act as small bearings on the rubbing surfaces. Nanoparticles get pierced in lubricated EHD contacts to form a boundary film. These nanoparticles are entrained into sliding contacts only when the film thickness is smaller than the particle size contributing to the film thickness. The already discussed 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 1 wt%. Although, they do not estimate the tribological behavior of coated nanoparticles used as lubricant additives with the non-coated ones.

2. 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. Yet conventional modifiers surely have few 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 by using MoS2 and CuO nanoparticles individually and by blending them at various concentration of nanoparticles.

2.1 Objectives

- To study the effect of blending of two types of nanoparticle additives on tribological properties of lubricating oil as anti-wear and EP properties.
- To study the effect of nanoparticle additives on viscosity, flash and fire point of oil.

2.2 Methodology

- Selection of suitable nanoparticles depending upon size, shape, structure and function.
- Selection of a lubricant oil regarding its particular application
- Preparation of material to be tested i.e., preparation of nanoparticles for their specific concentration and quantity of lubricant to be tested.
- Carrying out different types of tests as per standards i.e., flash and fire point test and lastly viscosity test.
- Evaluation of expected results and experimental results.

3. MEHODOLOGY

1. Viscosity tests (ASTM D445)
2. Flash and fire point tests (ASTM D92)

4. MATERIALS USED

4.1 Materials

The SAE 20W50 engine oil was used as the base oil. The pure lubricants contains some additives for friction reduction and anti-wear, but the base oil purchased does not. Pure lubricants are manufacturers of industrial lubricant, automobile oil and greases. The properties of base oil are given in table no.1.

Table -1: Properties of Base oil SAE 20W50

Properties	Range
Appearance	Brown
Density at 15°C	879 kg/m^3
Viscosity at 40°C	156 cSt
Viscosity at 100°C	17.7 cSt
Viscosity Index	103
Flash Point (°C)	210
Fire Point (°C)	241

MoS2 and CuO nanoparticles, as shown in Figure 1 and 2 are purchased from Mahavir Sales Corp, Ahmednagar.

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

Fig -2: Molybdenum disulphide (MoS_2) in form of nano powder

4.2 Preparation of Nano-oil

The rate of dispersion and stability of nanoparticles inside the base fluid are the most effective factors of the Nano 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. Oleic acid is used as surface modifier and by preparing lubricant samples in concentrations of 0.25 wt%, 0.5 wt% and 1wt% using a magnetic stirrer. The bibliographic research shows the concentration of nanoparticles in the range of 0.2-1 wt% gives best results.

Table -2: Properties of the materials MoS_2 and CuO

Nanoparticles	Properties
MoS2	Appearance: shiny dark gray Purity: 99.9 % (metal basis) Morphology: spherical True density: 5.06 g/cm3 Crystallographic Structure: cubic Making Method: Laser evaporating

CuO	Appearance: brown black powder Purity: 99% (metal basis) APS: 25-55 nm SSA: 13.98 m^2/g Morphology: nearly spherical Bulk density: 0.79 g/cm^3 True density: 6.4 g/m^3

5. EXPERIMENTATION

Table -3: Design of experiment details

Sr. No	Lubricant	Additive	Conc. of additive (g/100ml oil)	Wear Test
1	SAE20W50	-	-	W1
2	SAE 20W50	MoS2	0.25	W2
3	SAE 20W50	CuO	0.25	W3
4	SAE 20W50	MoS2+CuO	0.25+0.25	W4
5	SAE 20W50	MoS2	0.5	W5
6	SAE 20W50	CuO	0.5	W6
7	SAE 20W50	MoS2+CuO	0.5+0.5	W7
8	SAE 20W50	MoS2	1	W8
9	SAE 20W50	CuO	1	W9
10	SAE 20W50	MoS2+CuO	1+1	W10

As mentioned in above table different samples as per additives added into them. Samples for viscosity tests are denoted as V1 to V10. Also, samples for flash and fire point's tests are denoted as F1 and F10.

Fig -3: Samples of viscosity test

Fig -4: Samples of flash and fire test

6. RESULTS OF TRIBOLOGICAL TESTS

6.1 Results of Viscosity Tests

Sample	Time required to collect oil			Kinematic viscosity (cSt)		
	50^0 C	60^0 C	70^0 C	50^0 C	60^0 C	70^0 C
V1	255	137	132	55.39	28.82	27.67
V2	257	140	138	55.84	29.51	29.05
V3	259	156	142	56.28	33.16	29.97
V4	260	165	148	56.50	35.20	31.34
V5	258	222	164	56.06	41.0	34.98
V6	260	174	155	56.50	37.24	32.93
V7	265	226	169	57.62	48.92	36.11
V8	271	185	161	58.95	39.72	34.30
V9	270	180	158	58.73	38.60	33.62
V10	298	235	177	64.95	50.93	37.92

The samples V1 to V10 are the various samples for testing having various percentages of nanoparticles of molybdenum disulphide and copper oxide and blending of both nanoparticles in the SAE20W50 lubricating oil. Experimental results shows the viscosity of oil at 50°C, 60° C and 70° C are increased as compare to the sample which does not contains additives. The graph and result table shows that viscosity of engine oil had directly relation with the concentration of nanoparticles. For sample V10 (Base oil +1%MoS2+1%CuO) shows highest viscosity at various temperature.

6.2 Results of Flash and Fire Point Tests

Sr. No	Name of the sample	Flash Point(temp)˚C	Fire point (temp)˚C
1.	F1	210	241
2.	F2	213	237
3.	F3	217	241
4.	F4	216	235
5.	F5	221	246
6.	F6	218	245
7.	F7	216	243
8.	F8	214	240
9.	F9	215	239
10.	F10	218	244

The samples F1 to F10 are the various samples for testing having various percentages of nanoparticles of molybdenum disulphide and copper oxide and blending of both nanoparticles in the SAE20W50 lubricating oil. Experimental results shows the flash point and fire point temperature are increases as compare to the sample which not contain additives. The graph shows that the flash and fire point for sample F5 (base oil +0.5%MoS2) and F6(base oil+0.5%CuO) shows highest flash and fire point temperature.

7. CONCLUSIONS

In the present research, properties of lubricating oil (SAE20W50) is evaluated by addition of MoS2 and CuO nano-particle at three different concentrations.

From the results of this present investigation and the discussion presented in the earlier chapters, the following conclusions are drawn. The following conclusions are obtained from experimental results.

1. Addition of nanoparticle in oil increases the viscosity of oil. And graph shows that sample V10 (Base oil+1%MoS2+1%CuO) shows highest viscosity at various temperatures.

2. Addition of molybdenum sulphide and copper oxide in base oil(SAE 20W30 mineral oil) increases the flash and fire point of sample. The test results show sample F5 (Base oil+0.5%MoS2) and F6 (base oil+0.5% CuO) show high flash and fire point.

3. This shows that the nanoparticles has the potential of acting as a performance enhancer (additive) in the lubricant. So to achieve better properties determining the appropriate concentration is a very important.

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