An Experimental Effect of ZnO Nanoparticles in SAE 20W50 Oil

Mr.V.P. Suresh Kumar[1*], Mr.N.Manikandan[1], C. Subakaran[2], Y.G. Sterbin Jeso[2]

[1] Assistant professor, P.A. College of Engineering and Technology, Pollachi, Coimbatore, Tamilnadu, India
[2] U.G Scholars, P.A. College of Engineering and Technology, Pollachi, Coimbatore, Tamilnadu, India

---***---

Abstract - *In Mechanical parts, friction between two sliding surfaces is one of the major problems which causes wear and reduce its life. Lubrication system is designed in order to reduce the wear and increase the mechanical efficiency. The lubricant used in the system varies between different applications. In automobile engines various grade oils are used such as SAE grade 20, 30, 40, 50 and 60. In order to increase the performance some additives can be added to it. Past researches suggest the addition of nanoparticles improves the performance of lubricant. In our paper we investigated SAE 20W50 oil with ZnO nanoparticles. Viscosity is measured with different concentrations of ZnO additives at various temperatures ranging from 30°C to 50°C. The enhancement of viscosity ranges from 30% to 37% which can make a significant change in mechanical efficiency.*

Key Words: Lubrication, SAE 20W50, ZnO Nanoparticle

1. INTRODUCTION

The lubricant is necessary for an engine to reduce the friction resistance to minimum and to ensure maximum mechanical efficiency. It protects the engine against wear and it also contributes in cooling the piston and other regions of the engine where friction work is dissipated. Viscosity is the most important property of a lubricant. Lubricants with low viscosity for engine may cause increased metal-to-metal contact, friction, wear and high oil consumption. In order to improve the performance and fuel economy of internal combustion engines, it is important to reduce the overall engine frictional losses. Advances in engineering led to the development of chemical additives which when combined with motor oil increased its viscosity index making it possible for a single oil to meet both the low temperature and the high temperature grade specifications. Recently, many researchers have observed the improvement in properties of lubricants by dispersion of nanoparticle. However, the dispersion of nanoparticles significantly modifies the thermophysical properties of base fluid [1]. Aberoumand et al. [2] reported viscosity and thermal conductivity of Nano lubricants as the most important parameter for the industrial applications and proposed the correlations for the same. Mohamed Kamal Ahmed Ali Et ol.[3] suggested that the addition of nanoparticles to engine oils can fill scars and grooves of the friction zone. At the same time, nanoparticles chemically react with engine oil to form a tribo-film above the nanoparticles when the contact pressure and temperature are enough to cause a reaction between the nanoparticles in the lubricating oil and friction surfaces. The deposition of nanoparticles makes the worn surface flat and smooth, which can result in an improvement in the tribological characteristics of internal combustion engines. His results show that the tribological characteristics are affected by composition, shape, concentration, grain size, and dispersion stabilization of nanoparticles in base engine oils. Ehsan-o-llah Ettefaghi et ol.[4], evaluated the variation in the rate of flash point and pour point of Nano-lubricants, which were made as a function of concentration, it was observed that both parameters had their best amount of enhancement and pay attention to higher stability of Nano-lubricants with lower concentration, the oil/MWCNTs sample with 0.1 wt% concentration can be suggested as the most suitable sample for improving the properties of engine oil. Ehsan-o-llah Ettefaghi et ol. [5] concluded that Among the different methods which have been used for dispersing nanoparticles inside the base oil, using planetary ball mill was determined as the most important method for stabilization of nanoparticles inside SAE 20W50 engine oil. Also, the physical properties of Nano lubricants were measured based on the American Society for Testing and Materials standard methods. Over the past decades, many studies have stated that the addition of nanoparticles, such as metal [13], metal oxide [14], metal sulfides [15] and [16], carbonate [17], borate [18], carbon materials [19], organic material [20] and rare-earth compound [21] to lubricants is effective in decreasing both friction and wear [22]. The friction-reduction and anti-wear behaviors are improved due to individual features of the nanoparticles, for example, their size, shape, and physicochemical nature [23].

In the present experimental study, using two-step method, the ZnO–SAE 20W50 oil hybrid nanofluid has been prepared as the experimental sample. The viscosity of the studied nanofluid was measured in different solid concentrations ranging from 0.25% to 1.5% and temperatures (ranging from 30 °C to 50 °C). Moreover, based on the experimental data, a new correlation to predict the dynamic viscosity of the nanofluid in terms of temperature and solid concentration has been proposed.

V.P. Suresh Kumar, A.Baskaran [27], et ol. reports that the performance of vapour compression refrigeration system enhances with ZnO nanoparticle with R134a and R152a.

Table 1. A summary of several studies conducted on nanofluids viscosity

Nanofluid	Volume fraction (%)	Temperature range (^oC)	Findings	Refs.
Al_2O_3/EG-water	1-4	15-60	Viscosity ratio increased up to 4.3	[6]
TiO_2/EG-water	1-4	15-60	Viscosity ratio increased up to 1.7	[6]
Al_2O_3/EG-water	0.2-1	30-70	Viscosity ratio increased up to 1.8	[7]
SWCNTs/EG	0.0125-0.1	30-60	Viscosity ratio increased up to 3.2	[8]
Fe_3O_4/water	0.1-3	20-55	Viscosity ratio increased up to 2.3	[9]
TiO_2/BG-water	0.5-2	30-80	Viscosity ratio increased up to 1.6	[10]
ZnO/EG	0.25-5	24-50	Viscosity ratio increased up to 1.3	[11]
MWCNTs/water	0.05-1	25-55	Viscosity ratio increased up to 1.5	[12]

2. SAMPLES PREPARATION

In our investigation we have mixed ZnO nanoparticles with SAE 20W50 oil. The samples are prepared in various concentrations such as solid volume fractions of 0.125%, 0.25%, 0.5%, 0.75% and 1.0% and 1.5% ZnO with few quantities of lubricating oil. The nanoparticles are highly reactive to the fluids as its surface to volume ratio is high and can be prepared by mixing with magnetic stirrer. Then the mixture is uniformly dispersed with ultrasonic vibrator.

Table 2. Characteristics of ZnO nanoparticles

Characteristic	Value
Purity	+99%
Color	milky white
Size	35-45 (nm)
True density	5.606 (g/cm^3)
Specific surface area (SSA)	~65 (m^2/g)
Thermal conductivity	19 (W/m.°C)
Specific Heat	544 (J/kg.°C)

Table 2. Characteristics of SAE 20W50 Oil

Characteristic	Value
Kinematic viscosity @ 100 °C	1.8×10^{-5} (m^2/s)
Viscosity Index (VI)	90
Flash point	246 (°C)
Pour point	-9 (°C)
Total base number (TBN)	4.1 (mg KOH /g)
Density @ 15 °C	0.906 (g/cm^3)
Specific Heat	1900 (J/kg.°C)

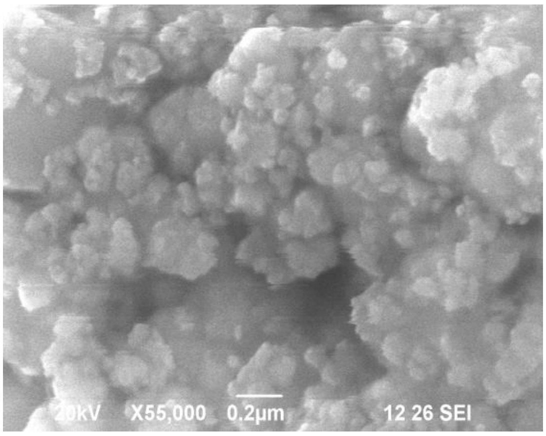

Fig-1 SEM image of ZnO nanoparticle at 0.2micro meter

Table 2 and 3 denotes the characteristics of ZnO nanoparticles and SAE 20W50 oil respectively. ZnO is known for its anti-corrosive property and SAE 20W-50 viscosity oil gives good high temperature performance by providing a thicker oil film on bearing surfaces as well as better sealing of piston rings. SAE 20W-50 is recommended for older naturally aspirated petrol and diesel engines of passenger cars, mini bus taxis, light commercial vehicles and contractor equipment involved in start/stop operations with short service intervals. By adding the both together better performance can be achieved.

3. THEORETICAL INVESTIGATION

3.1 VISCOSITY

Many research papers have established the effect of parameters such as particle size, volume fraction, viscosity of Nanoparticles and also the base liquids. Einstein [24] (1956) was the first to calculate the effective viscosity of a suspension of spherical solids using the phenomenological hydrodynamic equations. Einstein [24] derived the equation (1) for proposing a viscosity of non-interacting particles which is suspension in a base fluid when the volume of concentration was lower than 5%.

$$\mu_{eff} = \mu_l\,(1+2.5\emptyset) \quad \text{...... (1)}$$

The correlation suggested by Brinkman [25] for particle concentrations less than 4% was derived in equation (2):

$$\mu_{nf} = \mu_{bf}\,(1-\emptyset)^{2.5} \quad \text{...... (2)}$$

The correlation which was suggested by Wang et al [25] is established in equation (3):

$$\mu_{nf} = \mu_{bf}\,(1+7.3\emptyset+123\emptyset^2) \quad \text{...... (3)}$$

The effect of Brownian motion was derived by Bachelor [26] the formulae for this effect is given in equation (4):

$$\mu_{nf} = \mu_f\,(1+2.5\emptyset+6.5\emptyset^2) \quad \text{...... (4)}$$

4. EXPERIMENTAL INVESTIGATION

The viscosity of the ZnO nanofluids was measured by Saybolt viscometer. Say bolt viscometer consists of a water bath and oil bath, both provided with two thermometers inside them. There is a ball valve, which is located at center of oil bath to flow of oil through the orifice. A heater with regulator is fixed for heating purpose. The measured kinematic viscosity was converted to dynamic viscosity for comparison with the exiting experimental data. The kinematic viscosity was calculated by using the formula,

$$V=(A*t)-(B/t)$$

Where
A - 0.00226 cm^2/s^2
B - 1.8 cm^2
t - Time of collection of oil

Fig-2 Say bolt Viscometer.

5. RESULT AND DISCUSSION

Thus, the lubricants at different volume fractions (0.25%, 0.5%, 0.75%, 1%, 1.25% and 1.5%) at various temperatures (Ranging from 30°C to 50°C) is measured and the values are tabulated. The values obtained is analyzed. At certain temperature 30°C the viscosity value of Nano lubricant is compared with the conventional oil and it is found that viscosity increases by 30% to 37% as the volume fraction increases.

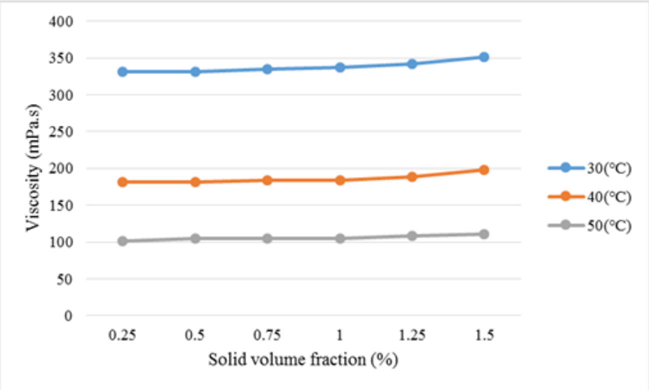

Fig-3 Volume fraction vs Viscosity

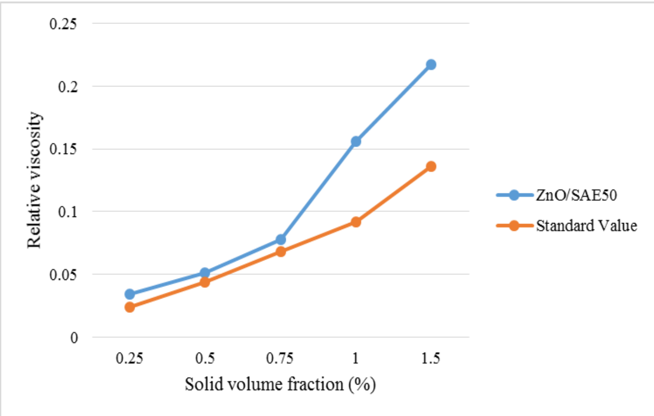

Fig-4 Volume fraction vs Relative Viscosity

6. CONCLUSION

Since the temperature and pressure conditions under which most automobile engines operate are reasonably standardized. The lubrication oil used is mostly a well experimented and it meets the requirement of the engine but still nanoparticle addition, increase the heat transfer properties and also increase the operating life of engine parts by mitigating the frictional power loss percentage in engines through the use of nanoparticle additives with engine oils. Though the experiments give positive results some preventive measures should be investigated in order to improve the stabilization of nanoparticles with the base oil.

ACKNOWLEDGEMENT

We sincerely thank Principal & Chairman of P.A college of Engineering and Technology for providing us the laboratory equipment to ensure our project and we also thank the department of Mechanical Engineering for all the needs and guidance's.

REFERENCES

[1] Kanjirakat A, Sadr R, Yrac R, Amani M (2016) High-pressure rheology of alumina-silicone nanofluids. Powder Technol 301:10251031

[2] Aberoumand S, Jafarimoghaddam A, Moravej M, Aberoumand H, Javaherdeh K (2016) Experimental study on the rheological behavior of silver-heat transfer oil nanofluid and suggesting two empirical based correlations for thermal conductivity and viscosity of oil based nanofluids. Appl Therm Eng 101:362–37.

[3] Mohamed Kamal Ahmed Ali* and Hou Xianjun, Improving the tribological behavior of internal combustion engines via the addition of nanoparticles to engine oils. Nanotechnol Rev 2015; 4(4): 347–358

[4] Ehsan-o-llah Ettefaghi, Hojjat Ahmadi, Alimorad Rashidi, Amideddin Nouralishahi, Seyed Saeid Mohtasebi, Preparation and thermal properties of oil-based nanofluid from multi-walled carbon nanotubes and engine oil as nano-lubricant, International Communications in Heat and Mass Transfer

[5] Ehsan-o-llah Ettefaghi , Hojjat Ahmadi, Alimorad Rashidi, Seyed Saeid Mohtasebi and Mahshad Alaei, Experimental evaluation of engine oil properties containing copper oxide nanoparticles as a nanoadditive, International Journal of Industrial Chemistry 2013.

[6] T. Yiamsawas, O. Mahian, A.S. Dalkilic, S. Kaewnai, S. Wongwises, Experimental studies on the viscosity of TiO2 and Al2O3 nanoparticles suspended in a mixture of ethylene glycol and water for high temperature applications, Applied Energy, 111 (2013) 40-45.

[7] H.W. Chiam, W.H. Azmi, N.A. Usri, R. Mamat, N.M. Adam, Thermal conductivity and viscosity of Al2O3 nanofluids for different based ratio of water and ethylene glycol mixture, Experimental Thermal and Fluid Science.

[8] M. Baratpour, A. Karimipour, M. Afrand, S. Wongwises, Effects of temperature and concentration on the viscosity of nanofluids made of single-wall carbon nanotubes in ethylene glycol, International Communications in Heat and Mass Transfer, 74 (2016) 108-113.

[9] D. Toghraie, S.M. Alempour, M. Afrand, Experimental determination of viscosity of water based magnetite nanofluid for application in heating and cooling systems, Journal of Magnetism and Magnetic Materials, 417 (2016) 243-248.

[10] M.K. Abdolbaqi, N.A.C. Sidik, A. Aziz, R. Mamat, W.H. Azmi, M.N.A.W.M. Yazid, G. Najafi, An experimental determination of thermal conductivity and viscosity of BioGlycol/water based TiO2 nanofluids, International Communications in Heat and Mass Transfer, 77 (2016) 22-32.

[11] M. Hemmat Esfe, S. Saedodin, An experimental investigation and new correlation of viscosity of ZnO–EG nanofluid at various temperatures and different solid volume fractions, Experimental Thermal and Fluid Science, 55 (2014) 1 -5.

[12] M. Hemmat Esfe, S. Saedodin, O. Mahian, S. Wongwises, Thermophysical properties, heat transfer and pressure drop of COOH-functionalized multi walled carbon nanotubes/water nanofluids, International Communications in Heat and Mass Transfer, 58 (2014) 176-183

[13] Liu G, Li X, Qin B, Xing D, Guo Y, Fan R. Investigation of the mending effect and mechanism of copper nano-particles on a tribologically stressed surface. Tribol Lett 2004;17(4):961 e6.

[14] Greco A, Mistry K, Sista V, Eryilmaz O, Erdemir A. Friction and wear behaviour of boron based surface treatment and nano-particle lubricant additives for wind turbine gearbox applications. Wear 2011;271(9 e10):1754 e60.

[15] Battez AH, Gonzalez R, Viesca JL, Fern andez JE, Fernandez JD, Machado A, et al. CuO, ZrO 2 and ZnO nanoparticles as antiwear additive in oil lubricants. Wear 2008;265(3 e4):422 e8.

[16] Chen S, Liu W, Yu L. Preparation of DDP-coated PbS nanoparticles and investigation of the antiwear ability of the prepared nanoparticles as additive in liquid paraffin. Wear 1998;218(2):153 e8.

[17] Rapoport L, Feldman Y, Homyonfer M, Cohen H, Sloan J, Hutchison JL, et al. Inorganic fullerene-like material as additives to lubricants: structureefunction relationship. Wear 1999;225e229(Part 2):975e82.

[18] Hu ZS, Dong JX. Study on antiwear and reducing friction additive of nanometer titanium borate. Wear 1998;216(1):87e91.

[19] Huang HD, Tu JP, Gan LP, Li CZ. An investigation on tribological properties of graphite nanosheets as oil additive. Wear 2006;261(2):140e4.

[20] Rico EF, Minondo I, Cuervo DG. The effectiveness of PTFE nanoparticle powder as an EP additive to mineral base oils. Wear 2007;262(11e12):1399e406.

[21] Zhang Z, Yu L, Liu W, Xue Q. The effect of LaF3 nanocluster modified with succinimide on the lubricating performance of liquid paraffin for steel-on-steel system. Tribol Int 2001;34(2):83 e8.

[22] Zhang BS, Xu BS, Xu Y, Gao F, Shi PJ, Wu YX. CU nanoparticles effect on the tribological properties of hydrosilicate powders as lubricant additive for steel esteel contacts. Tribol Int 2011;44(7 e8):878 e86.

[23] Wu YY, Tsui WC, Liu TC. Experimental analysis of tribological properties of lubricating oils with nanoparticle additives. Wear 2007;262(7 e8):819 e25.

[24] A. Einstein, N.B. Eine, D. Moleküldimensionen, J. of Ann. Phys 324.,1906 p.289–306.

[25] H. Brinkman: The viscosity of concentrated suspensions and solutions, J. of Chem. Phys 20.,1952, p.571.

[26] G. Batchelor: The effect of Brownian motion on the bulk stress in a suspension of spherical particles, J. of Fluid Mech 83.,1977, p. 97–117.

[27] V.P. Suresh Kumar., A.Baskaran., K. Manikandan Subaramanian, Performance study of vapour compression refrigerant system using ZrO2 with R134a and R152a, International Journal of Scientific and Research Publications (IJSRP), Volume 6, Issue 12, December 2016 Edition".