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A Review on Tribological Behaviour for Lubricating Oil with the Addition of Nanoparticle Additives

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Abstract: ***In this Paper We Study different types of additives and their effect on lubricating oil for improve the tribological properties of lubricants. The positive design of machine elements depends upon essentially on the understanding tribological values like wear and friction. Nanoparticles put into lubricating oils can increase the properties of extreme pressure, anti-wear and friction reducing. Efficiency and service life of the machine were also improved. These nanoparticle were added in lubricating oil at different percentages in different applications .This investigation is useful for comparing the effect of additives on engine oil properties like wear, Viscosity ,coefficient of friction, flashpoint and fire point. The various test conducted on sample and evaluation of tribological properties test was calculated on a four ball oil testing machine according to ASTM D 4172 B. The measurement of viscosity is carried out by Redwood viscometer . Result show that the each set of Nanoparticle significantly reduces the friction coefficient ,wear, viscosity etc of friction pairs. The wear surfaces were examines by scanning electron microscope (SEM).***
Key words: Friction coefficient, Lubricating oil, nanoparticles , SEM &Wear scar diameter etc.

I. INTRODUCTION

Lubrication is an important theory in the field of tribology. Know a day the demand for lubricating oils has been increasing day by day. Thus, the trend of "minimal additivities" has been in focus for all oil companies. The different types of lubricants, mineral oils are the most commonly used lubricants in process industries , automobile engine etc Mineral oil contains nearly 90 % base oil and 10% additives. The nano sized additives has varying as per researcher.

The Tribology deals with study of lubrication, friction, and wears properties liquid for prevention of surfaces having relative motion between two parts under load. The word is coming since the Greek word tribos meaning rubbing, so the literal conversion would be the science of rubbing." In some type English language equal is friction and wear or lubrication science, alternatively used .Nanotechnology is regarded as the most innovative technology of the 21st century. There are many surveys on the tribological properties of lubricants with different nanoparticles added. Mostly lubricants contain 90% base oil (most often petroleum fractions, called mineral oils) and less than or equal to 10% additives. Oils is a general cover all liquid lubricants, whether they are rock crystal/Mineral oils, natural oils, synthetics or even process fluids. Similarly Greases are oils, which cover a thickening agent to create them semi-solid.

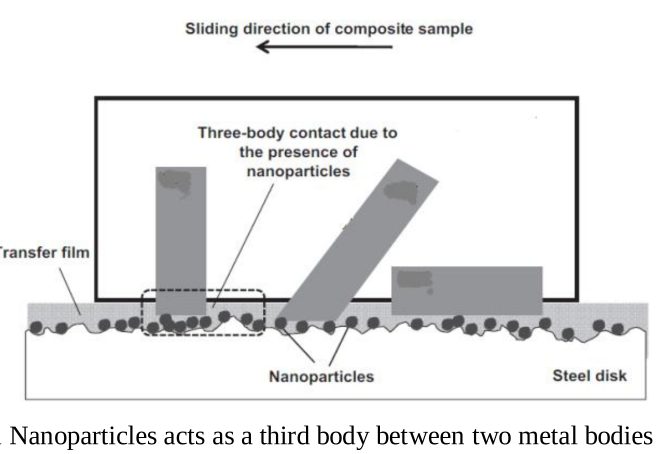

Fig.1 Nanoparticles acts as a third body between two metal bodies

M. Asrul etal The result shows that lowest coefficient of friction was 0.185 obtained for a nanoparticle content of 0.2% concentrated CuO and the highest was for a 3% CuO concentration at 0.247 for liquid Paraffin +CuO . [1] Qingming Wan et al Result shows that the nano-BN oils could considerably improve the anti-friction and anti-wear properties of the base oil, and lower nanoparticle concentration exhibited better tribological performance.[2] Sangram J. Patil et.Efficiency and service life of the machine were also improved. In this study different nanoparticles like CeO2,Cu, CuO & TiO2 adding and result shows comparatively study of tribological properties like anti-wear and friction reducing properties of nano- lubrication oils.[3] E. Prakash et al The results show that these CaCO3 nanoparticles show good performance in antiwear and friction-reduction, extreme pressure properties and load-carrying capacity.[4] S. Bhaumik et. al.There was a reduction in both coefficient of friction (28.5 % approx.) and specific wear rate (70 % approx.) From the results predicted minimum 0.2 wt.% CuO nanoparticles were required to enhance the antiwear property of the lubricant.[5] S.N.Mandlik et. al Addition of nanoparticle in oil increases the viscosity of oil. Result shows that Nickel with 0.5% with SAE 40 oil increases the viscosity of oil at various temperatures & decreases the wear rate of oil.[6] Ajinkya S. Pisal et. The obtained results show result exhibits good friction reduction and anti-wear properties and also decreased the coefficient of friction by 24% and 53% at 0.5wt% concentration respectively, as compared with standard engine oil without CuO nanoparticles.[7]

II. MATERIALS AND METHOD

A. Materials

1) *Base oil* - The mineral oil of 10w30 had been chosen as it is being used in multi cylinder engine.
2) .*Additives* Hexagonal boron nitride(Hbn)

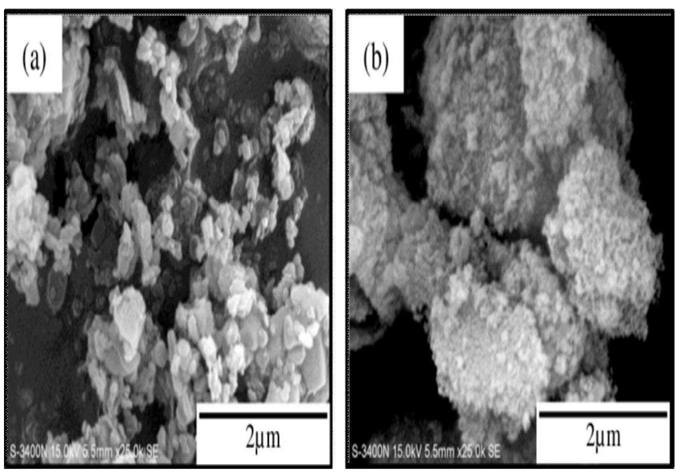

Fig 2: Hexagonal boron nitride(Hbn) Powder

Table II. Specification of Hexagonal boron nitride(Hbn) nanoparticle

Hexagonal boron nitride (Hbn)	
Appearance	White
Purity	99 %
APS	80-150 nm
SSA	$7.4m^2$ /g
Morphology	Hexagonal
Bulk Density	$0.4g/cm^3$
Al	78 ppm
Fe	78 ppm
Cl	38 pm

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3) Nickel oxide (Nio)

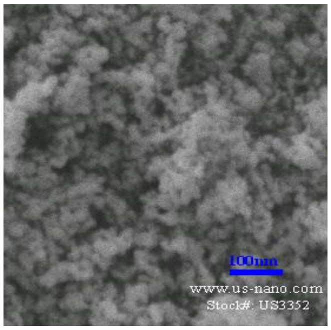

Fig. 3 :Nickel oxides (Nio) Nanoparticle

Table III. Specification of Nickel oxides (Nio) Nanoparticle

Nickel oxides (Nio) Nanoparticle	
Appearance	Grey powder
Purity	99%(metal basis)
APS	20 nm
SSA	60-100 m^2 /g
Morphology	Nearly Spherical
Bulk Density	0.7-0.8 g/cm^3
Nio	>99.5 %
Al	<0.03 %
Fe	<0.2 %
Zn	<0.01 %
Cu	<0.02 %

B. A magnetic stirrer

This Analog Hot Plate/Magnetic Stirrer features a stainless steel heating plate. Designed with double PT sensors, it also features a hot top indicator for safety along with an adjustable safety cut off.

Fig.4: Magnetic stirrer mfg.

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C. Four ball tester.

This set up is used for testing of wear and extreme pressure specially Ducom make such system. Fig 5 shows setup of ball fitting.

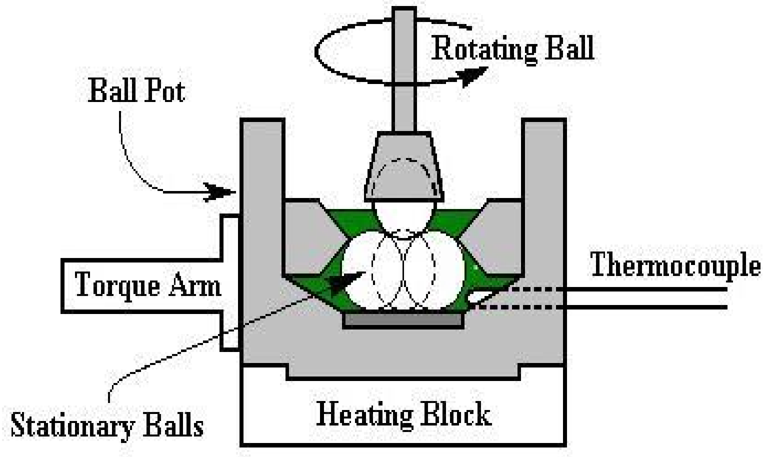

Fig.5 : Four ball tester Sketch

Fig.5 : Four ball tester test section ,mfg.by Ducom,Bangalor,India.

D. Preparation of testing materials

The conventional method magnetic stirrer mixer was used for Preparation of nanolubricants. The concentration of nanoparticles with 10W30 engine oil was prepared to 0.5 wt. %.shown in Table. IV

Table IV. Sample Preparation of nanoparticle.

Samples	Title	Content of nanoparticle(g/ 100 ml)
1	SAE 10W30	
2	SAE 10W30 +HBN	0.5
3	SAE 10W30 +NiO	0.5

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III. EXPERIMENTAL

A. *Viscosity test.*

Kinematic viscosity of the base oil and also nanoparticle lubricant samples which were made at (0.5 wt. %) different concentrations, were measured on the basis of American Society for Testing and Materials Redwood viscometer (ASTM) D-445.In this test 100ml of oil was used for each test. The each test taken 50^0, 60^0 and 70^0 C also each test was repeated three time and the measured results are shown in table V.

Table V. Kinematic viscosity results

Sample	50^0C	60^0C	70^0C
1	54.28	47.17	26
2	68.2	53.38	39.95
5	56.28	33.16	29.97

The rate of oil resistance against flowing is called viscosity. The obtained results are shown in table V and fig. 7, 8, 9,&10, shows bar graph of kinematic viscosity at 50^0C , 60^0C and 70^0C. The highest amount of increase in viscosity with respect to the SAE 10W30 is 81.12 cst which is HBN 0.5Wt% concentration and 50°C temperature.

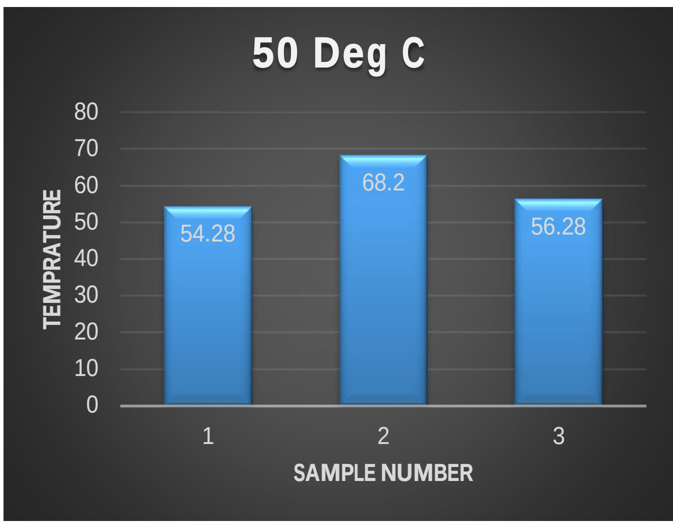

Fig.7: Kinematic viscosity graph of 50^0C Temperature.

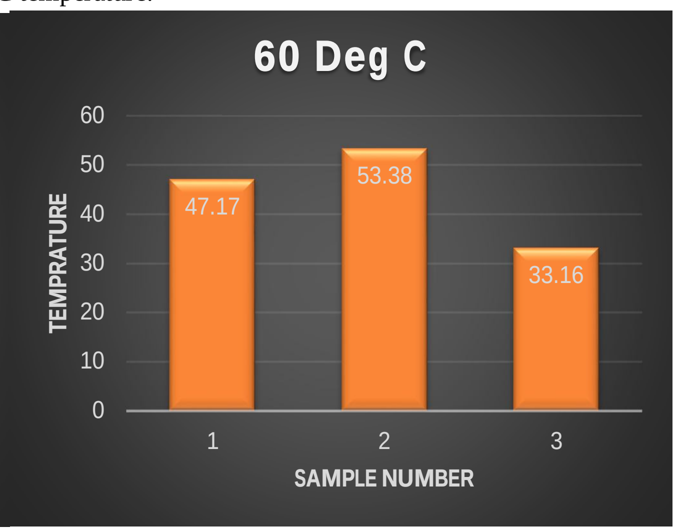

Fig. 8: Kinematic viscosity graph of 60^0C Temperature.

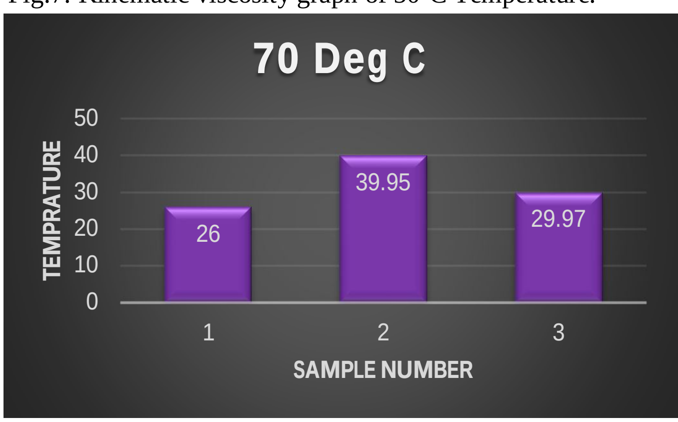

Fig. 9: Kinematic viscosity graph of 70^0C Temperature.

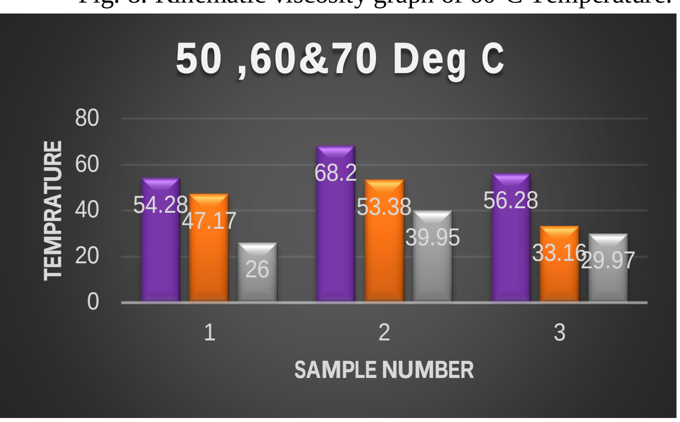

Fig. 10: Graph of kinematic viscosity of nanoparticle Additives with SAE10W30 oil at various temperature

B. *Tribological tests*

The tribological test was done with the help of four ball tribotester TR-30L-IAS (MFG. by DUCOM, Bangalore, India). All test components compulsory clean before and after each test by using acetone. The wear tests were performed at ASTM D4172B ,speed 1200rpm, load 40kg (392 N), Temp- 75^0C and test duration 1 hour shown in fig.12 the four bearing steel ball 12.7 mm diameter

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were used for this test.

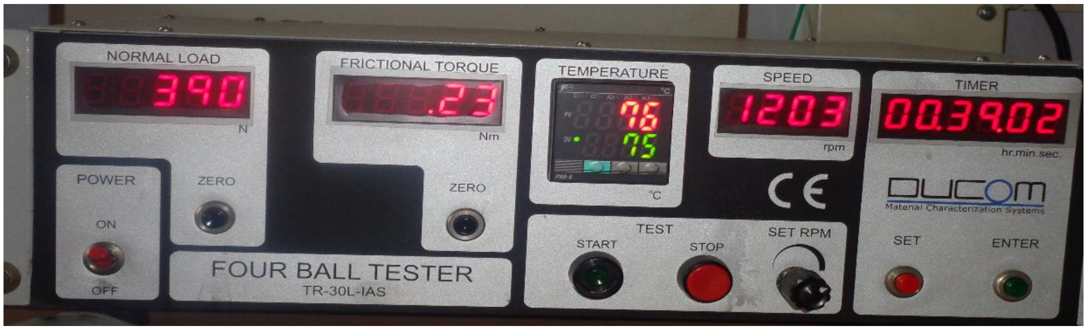

Fig.11: ASTM D4172B conditions of tribotester.

IV. RESULT AND DISCUSSION

Table VI. Results of wear test

Wear sample	Composition of sample	Wear scar diameter (µm)
		Average Diameter
W_1	SAE 10W30	563
W_2	SAE 10W30 +0.5 %HBN	322
W_5	SAE 10W30 +NiO	348

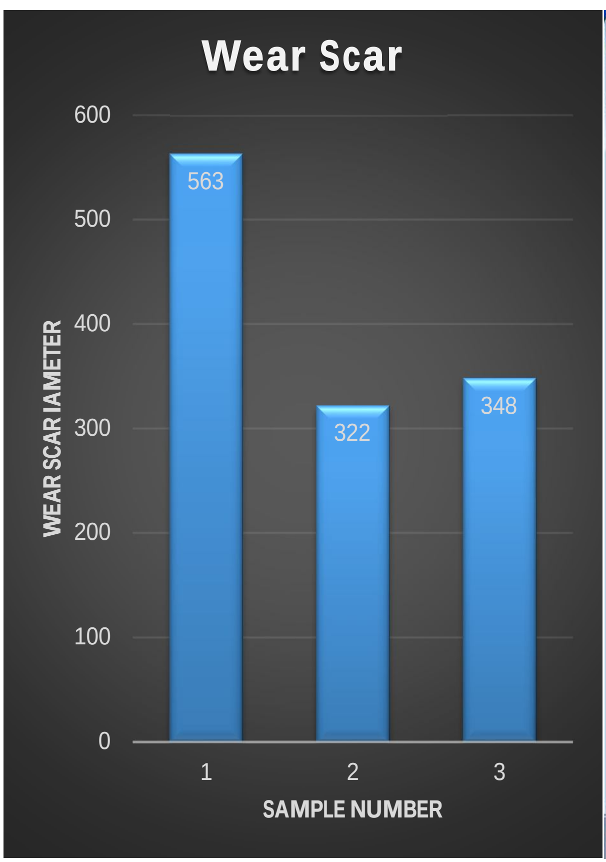

Fig 12 : Graph of wear scar diameter

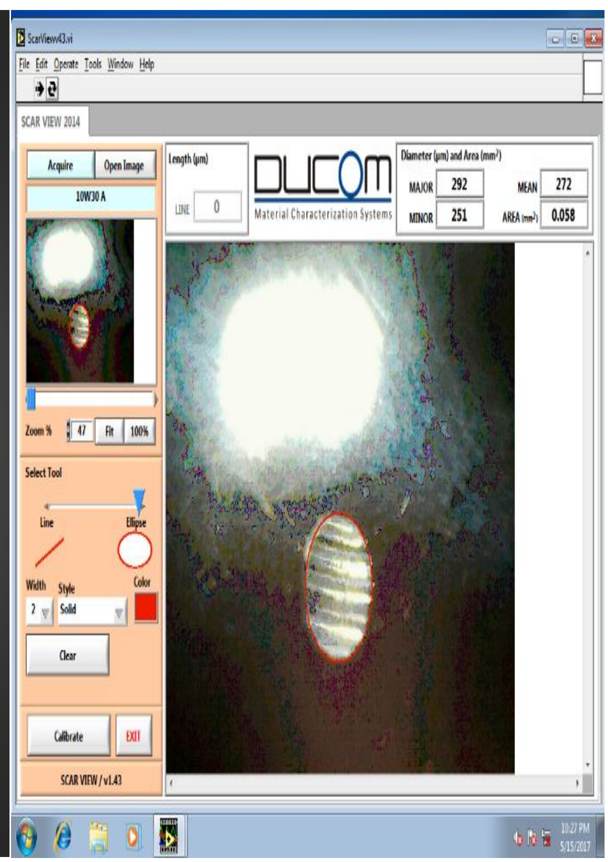

Fig 13 : SEM micrograph worn surface on SAE 10W30 ball under lubricated.

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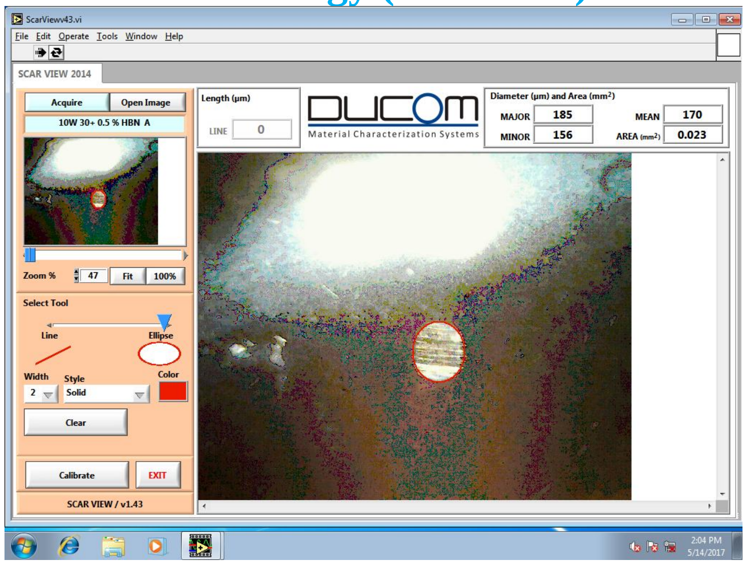

Fig 14 : SEM micrograph worn surface on SAE 10W30 +1.0 % HBN Wt ball under lubricated.

The result shows that the concentrated nanoparticle in base oil possesses outstanding anti wear property decease not only its reducing wear scar diameter but also decrease in coefficient of friction shown in fig.13 and fig.14. The lowest coefficient of friction was obtained at 0.5 % HBN blend with SAE 10W30 base oil.

The wear scar diameter and coefficient of friction have been reduced by effectively at different concentration. The lowest friction coefficient (COF) was 0.05809 obtained from engine oil and the highest was 0.1141 from 1.5 wt. % HBN+NiO with 10W30 lubricating oil. Shown in table VII.

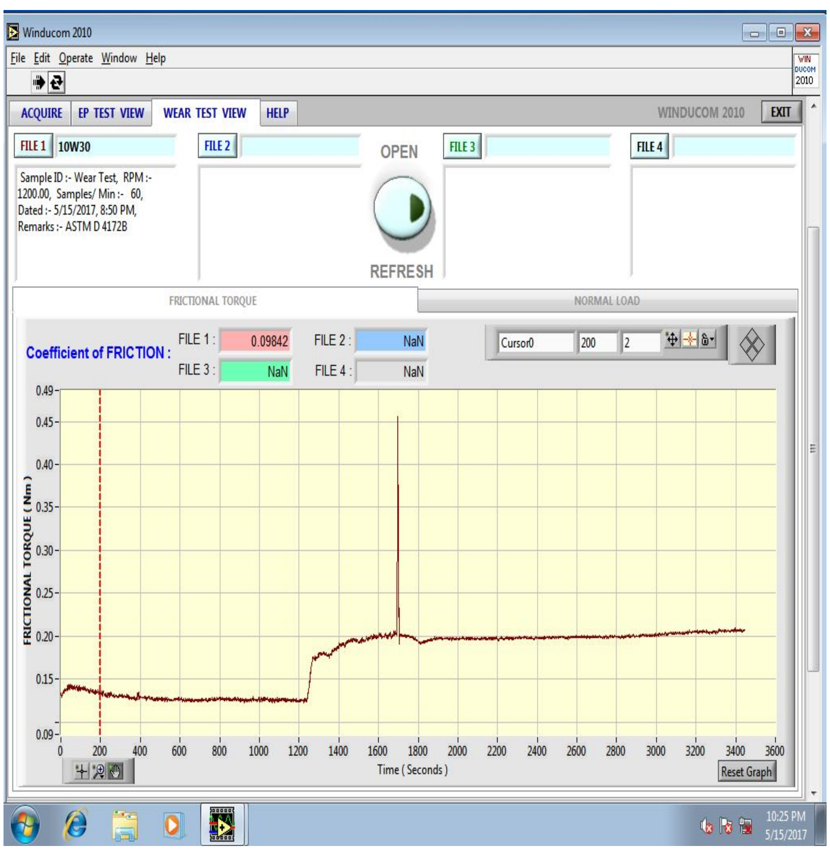

Fig.15: Graph of frictional torque (Nm) Vs time (sec) for sample W1 (SAE10W30 base oil)

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Table VII Coefficient of friction

Sample Name	Coefficient of friction
1	0.09848
2	0.09510
5	0.07689

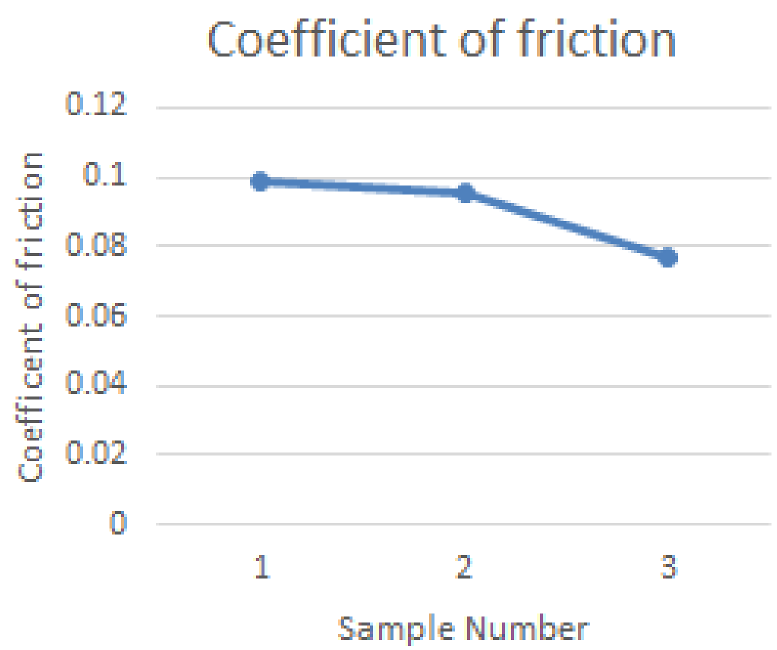

Fig.19: Graph of Coefficient of friction for all test samples.

V. CONCLUSION

So finally, it can be discus that HBN and Nickel effectively mixture with SAE 10W30 base oil and were shown the improved tribological results.

As a result the viscosity of nanolubricants were increase at higher temperature and finest results come HBN 0.5 % wt concentration. The wear scar diameter have been summary effectively at different concentration. The lowest friction coefficient (COF) was 0.05809 found.

All nanolubricants decreased the average friction coefficient and wear with respect to SAE 10W30 lubricating oil. and if percentage of nanoparticals increases the wear of ball. The friction reduction was between 10 to 50 %.

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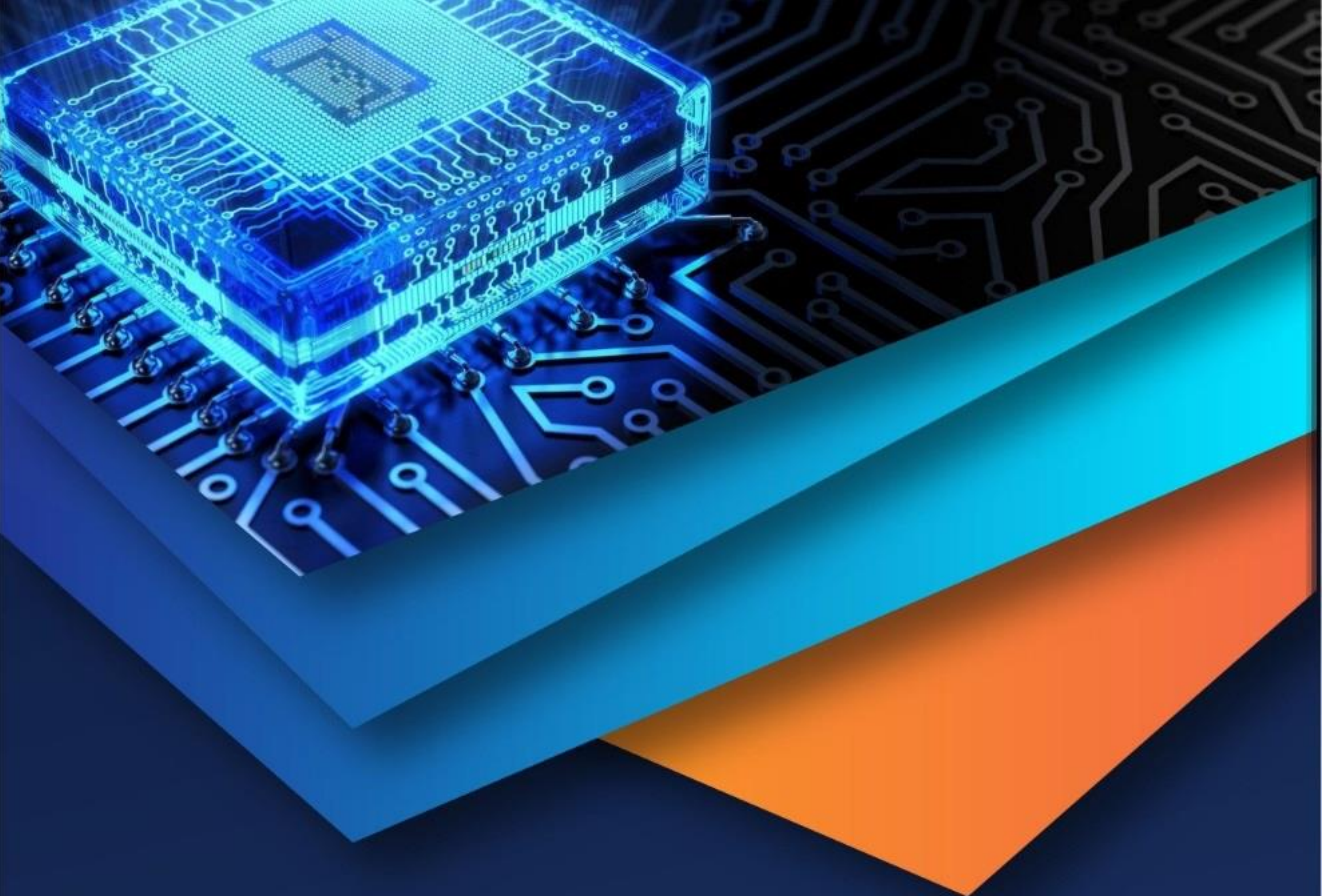

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