# Assessing the capability of CNTs in improving the properties of Engine Oil

Nousheen Hamid[1], Abhishek Thakur[2]

[1] *M.Tech. Scholar,Universal Group of Institutions Lalru*

[2] *Assistant Professor, Universal Group of Institutions, Lalru*

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***Abstract*** *: It is the friction and wear that are the most important variables when it comes to working machines that are more sophisticated. There is only one way to significantly minimize wear and friction, and that is to use lubricating oil, which also helps to preserve the materials from wear. Carbon nanotubes have become more popular over the previous decade because to the multiple uses they have in many industries owing to their exceptional chemical, electrical, thermal, mechanical, and optical capabilities. This research will analyze the tribological properties of carbon nanotubes (CNTs) in the presence of a tribotester with four balls. Also, the tribological characteristics of SWCNTs and MWCNTs were assessed for use as an additive in SAE10W40 motor oil. In addition to the performance increase that multiwall carbon nanotubes give in the areas of anti-wear and friction reduction, this experimental finding also points to an increase in performance for lubricating oils containing multiwall carbon nanotubes over single-walled carbon nanotubes.*

***Keywords*****:** Lubricant, Tribological properties, Carbon Nanotubes, Friction.

## 1. Introduction :

Machines are very critical in all kinds of production, in domains like assembly, manufacture, and product customization. Part of the work-life of mechanical components has been decreased because to wear and friction, which, as a result, may lead to mechanical energy loss and, subsequently, more fuel is used to complete the same task. Additionally, it uses more power and rapidly overheats its functioning components, which may lead to equipment failure [1]. In order to get this level of processing done, the high levels of friction and wear seen in industrial processes must be controlled. In order to minimize equipment breakdowns, effective lubrication is necessary. Oil has long been used as a conventional medium to minimize friction and wear. Additionally, as a result of modern manufacturing techniques, friction has caused pressure and temperature to rise to the point where it cannot be sustained, and high speed causes the oil to lose its lubrication qualities, necessitating the enhancement of the oil's lubrication qualities. These complex issues have already been examined, and nowadays we have high-quality lubricants that have enhanced additives, which helps us face these situations with new options [2][3].

In an effort to learn more about the basics of the SbSbS4 compound, which might apply to the role of a solid lubricant and lubricant additive, Ives et al. (4) studied the physical characteristics of the compound. This prior study has demonstrated that this material has better EP efficiency, anti-wear characteristics, and high-temperature stability. But when the material is kept below temperatures of about 225°C, it turns out that SbSbS4's efficiency is really really lacking. In order to change the configuration of the particles with Oleic Acid, the CuO (50nm) nanoparticles were dispersed in liquid paraffin (at 0.2, 0.25, 2, and 3 percent) in an ultrasonic bath for 1 hour and 10 minutes. The test procedure included a four-ball system to calculate wear characteristics under load circumstances of 40kg at 1200 rpm rotation and a 15-minute test duration at a temperature of 60-70ºC. It was determined using an optical microscope that the wear scar was about 7mm in diameter (WSD). Enhanced friction and wear of liquid paraffin was shown by the morphology of the worn surface, according to researchers who had developed nanoparticle solutions [5]. An attempt was made to examine the anti-wear and intense pressure characteristics of multiwall carbon nanotubes-based mineral oil. Furthermore, it has been observed that compared to mineral oil that is free of additives, multi-walled carbon nanotube-based mineral oil (MCTO) has a load-bearing capacity that is 20% greater [6].

MWCNTs functionalized with groups provide functional groups that may reinforce the interfacial bonding energy between the nanotubes and the epoxy resin, resulting in lower interfacial energy dissipation and enhanced stiffness[7]. A decrease in friction and wear was possible by mixing base mineral oils with esters without using any standard anti-wear additives. This study by Rajendiran et al. mixed base mineral oils with esters, but did not use any standard anti-wear chemicals [8]. There is more to a study review than a mere repleacement of current information. A study review supports the basic understanding of lubrication that allows us to design and produce nano lubricants with higher tribological performance [9].

In a study done by Xiao et al., [10], researchers evaluated the tribological effectiveness of two-dimensional nanomaterials as additives. The second-dimensional nanomaterials are due to their unique chemical structure and lubricating qualities and hence have gained a lot of interest. A study conducted by Nikam et al., [11], discovered that nanoparticles might be employed as engine oil modifiers to enhance tribological qualities and reduce wear and friction. The use of graphite nanoparticles improved lubrication qualities was shown by Chang-Gun Lee et al., [12] who said, "Graphite nanoparticles aid lubrication qualities." In the presence of nanoparticles between the friction surfaces, the nanoparticles acted like a ball bearing, slowing down the contact between the plates. The authors, R. Chou et al. [13], conducted research on the nanoparticles to learn about how they became involved with the surface and what they did, which led to an improvement in the base oil's tribological conduct.

## 2. Materials and Methods:

### 2.1. Material Used:

Commercially available Engine oil with a viscosity of 82.5 cSt (centistokes) at 40 degrees Celsius was utilized as the base lubricant. In Table 1, the lubricants' characteristics are documented. Single wall carbon nanotubes (SWCNTs) and Multiwall Carbon Nanotubes (MWCNTs) were employed as solid additions to the base oil at different concentrations. In this case, SWCNTs were found to have an average size and length of 2.0 nm (nanometers) and 8.0 um, whereas MWCNTs were found to have an average size and length of 20.0 nm (nanometers) and 8.0 um.

Table 1. Specification of Lubricant oil.

| SAE Grade | 10W40 |
|---|---|
| Viscosity at 40°C, cSt | 82.5 |
| Viscosity at 100°C, cSt | 13.2 |
| Viscosity index | 156 |
| Density, g/ml at 15.6°C | 0.86 |
| Flash Point, °C | 212 |
| Pour Point,°C | 45 |

### 2.2. Synthesis

The mix was formed by adding SWCNTs and MWCNTs with 0.1, 0.5, 1, and 2 percent concentrations, respectively, then stirring them for 30 minutes, ultrasonically agitating them for 2 hours, and then spraying the solution with helium gas to cool the oil. The dispersion of SWCNTs and MWCNTs in the base lubricant was required for the products to remain dispersed, and ultrasonication was utilized to achieve this. Inaccurately: A substance agglomerated into small particles may act as a contaminant and increase the likelihood of scratches on friction surfaces. The nanolubricants were generated following an ultrasonic treatment of the mixture for two hours.

## 3. Fourier transforms infrared (FTIR) spectroscopy

Infrared light with a wavelength of roughly 11,000 to 110 cm−1 is used to irradiate the sample, with some of the radiation being absorbed and some flowing through. The radiation that is absorbed is transformed into vibrational or rotational energy by the sample. Because of this, the resulting spectrum acquired at the detector is between 4250 to 425 $cm^{-1}$, which is a representation of the chemical fingerprint of the materials. FTIR is a powerful technique for chemical identification due to the fact that every molecule has a unique fingerprint. To see whether the structural differences seen in the two series of samples may be supported by spectrum analysis, Fourier transform infrared (FTIR) spectra of SWCNT and MWCNT were obtained. The FTIR spectra of SWCNT and MWCNT that had been crushed into a powder form and compacted into a binder with KBr pellets were measured using a spectrometer with 200 scans and had their spectra recorded at a resolution of 10 cm−1. Fig 1: The FTIR spectra of the SWCNT and MWCNT are shown in this figure. When using FTIR to study SWCNT and MWCNT, the typical response exhibits peaks for C=C, which are assumed to be caused by carbon groups. According to previous research, carbon nanotubes' C=C stretching mode is more likely to be responsible for the absorption band at 1564 cm−1,1315 cm-1.

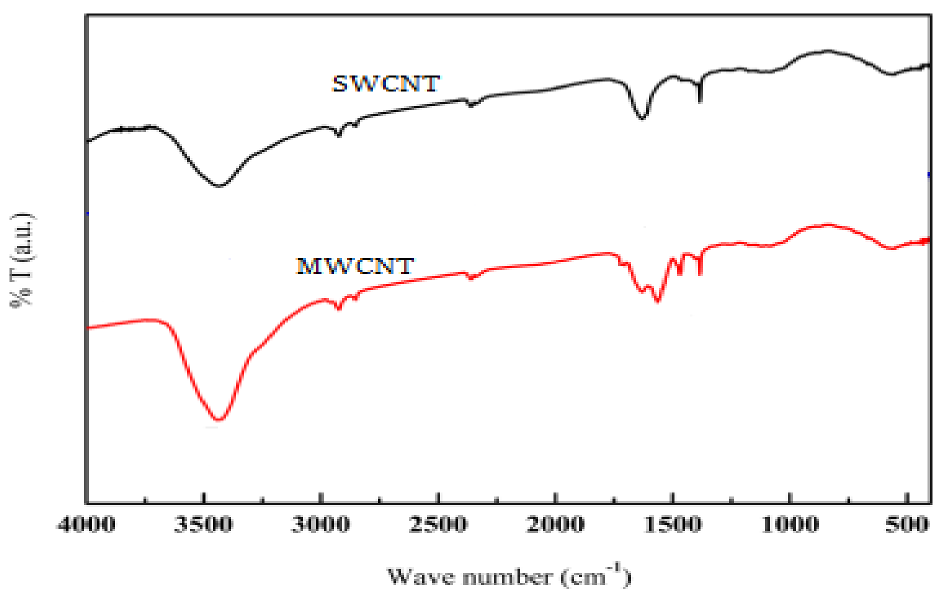


Figure 1 FTIR spectra of SWCNT and MWCNT

### 3.1. Kinematic viscosity with the temperature at different concentrations

Kinematic viscosity is primarily relied on for the lubrication process. When the temperatures reach 41 °C and 110 °C, the effects of varying concentrations of single-wall carbon nanotubes and multiwall carbon nanotubes on the viscosity of nano lubricants are estimated, as shown in the Tables 2 and 3. To find this out, a variation was made in the concentration of carbon nanotubes, and then it was found that raising the concentration of these nanotubes improved the kinematic viscosity of nano lubricants. While the viscosity-increasing rate is greater at higher concentrations, the viscosity-decreasing rate is substantially lower at lower concentrations.

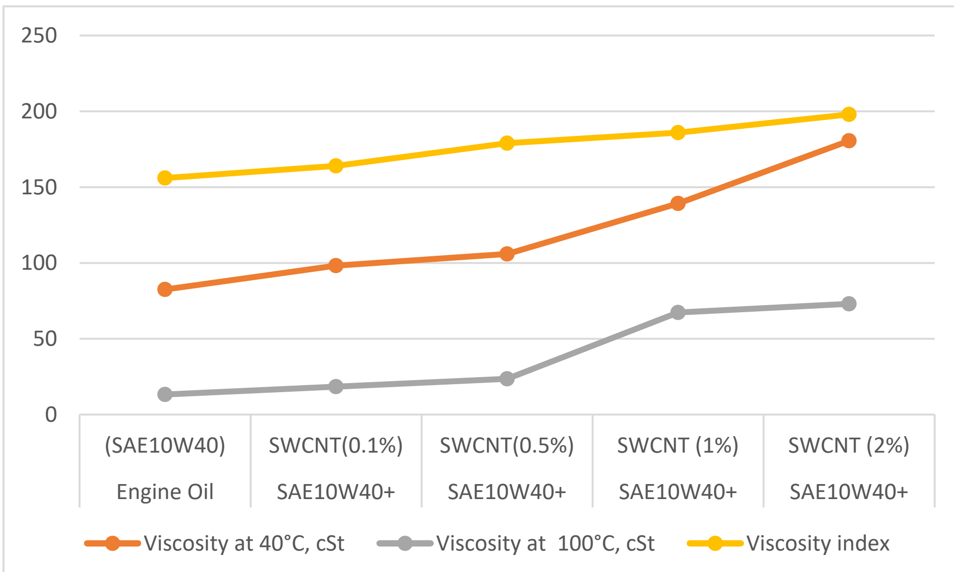


Figure 2a: Viscosity change of engine oil with additive SWCNT at different concentration with temperature

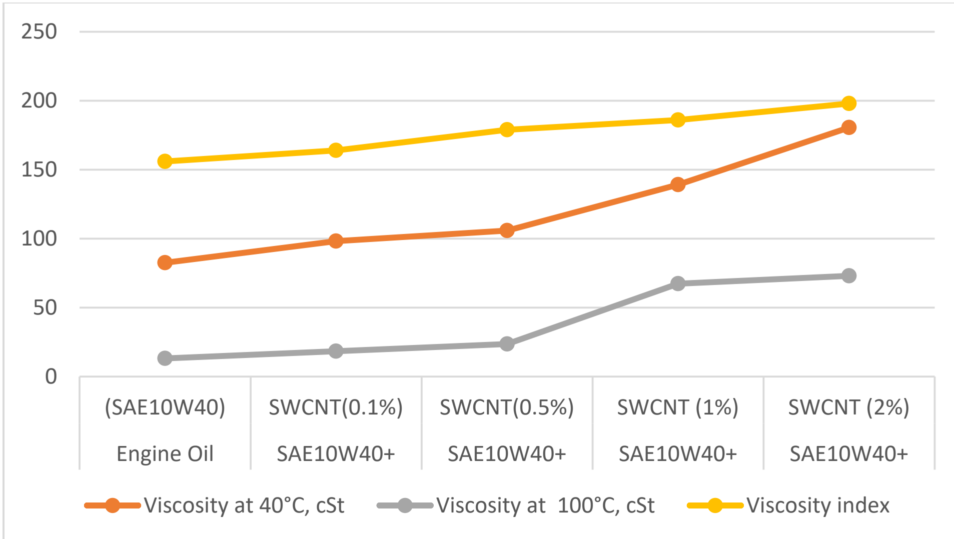


Figure 2b: Viscosity change of engine oil with additive MWCNT at different concentration with temperature

## 4. Results and Discussions :

The tribological tests conducted during this study determined the friction coefficient by measuring the friction torque. The graph shown in Figure 3 exhibits the influence of SWCNT and MWCNT concentrations on the friction coefficient of SAE10W40 engine oil. Additional SWCNT and MWCNT molecules can be seen mixing with SAE10W40 commercial engine oil in the diagram above. The formula results in a different friction coefficient when this engine oil is added to other types of engine oil. With regards to the coefficient of friction, CNTs have a lower coefficient of friction than engine oil that doesn't include any additives. Similarly, with MWCNTs, the average friction coefficient is lowered by 59%, but with SWCNTs, it is decreased by 47%; this may be related to the influence of viscosity. The friction coefficient of a fuel oil with a higher viscosity, is lower.

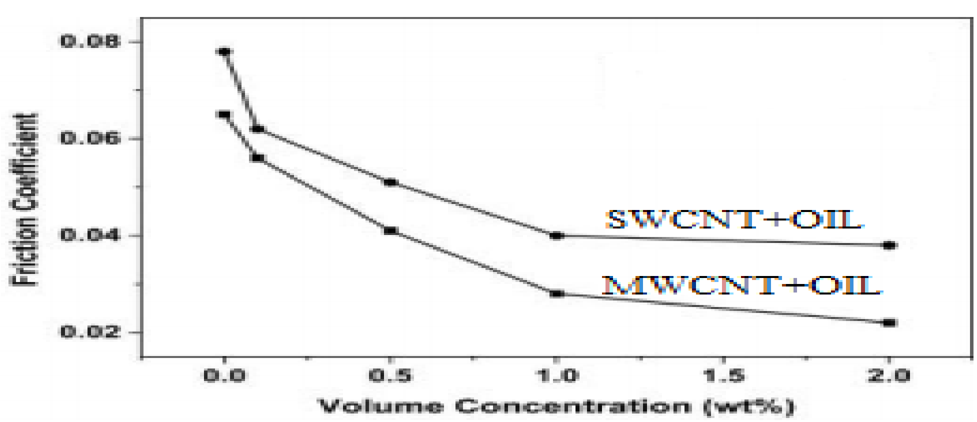


Figure 3: Depicts the Friction Coefficient as a function of SWCNT and MWCNT in Engine oil SAE10W40 at different volume concentrations

In Figures 4 and 5, the friction coefficient and wear scar width are plotted for lubricants including nanoscale additives and motor oil at concentrations which are ideal as a result of applied stresses. As a result, the wear scar diameter and friction coefficients were lowered greatly, due to the use of SWCNT and MWCNT in the engine oil. Multiwall CNTs is discovered to yield superior outcomes than the Single Wall CNT when used in engine oil.

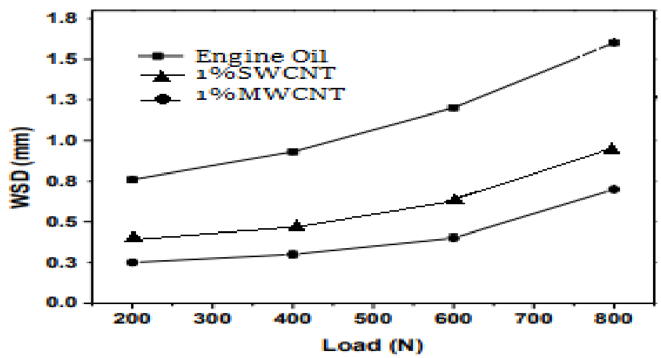


Figure 4: The wear scar diameter as a function of the applied load with the Engine Oil SAE10W40 and contain 1 wt. % SWCNT and 1wt. %MWCNT.

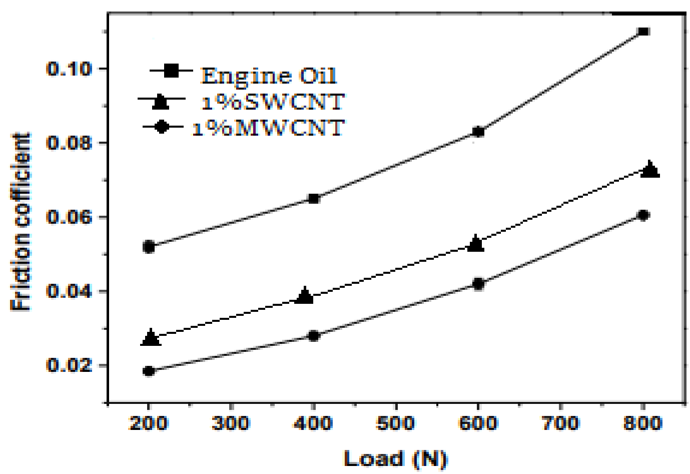


Figure 5: The friction coefficient is plotted against the applied load and Engine Oil SAE10W40 with 1 wt. percent SWCNT and MWCNT

**5. Conclusion :** This four-ball tribotester was used to evaluate the nano lubricity of SAE10W40 Engine oil, which contained SWCNTs and MWCNTs, and the nano lubricity of this oil was determined. The findings reveal that the addition of MWCNTs and SWCNTs to the Engine oil SAE10W40 enhanced the lubricating qualities of engine oil without additives. The research findings demonstrate that when MWCNTs are employed as additives in the engine oil, the worn scar diameter is reduced by 68 percent. To provide an equivalent in capability, a scar diameter reduction of 37% was seen in comparison to the industrial engine oil without SWCNT and MWCNT, where SWCNT is an addition. According to the friction coefficient values, MWCNTs show a lowered friction coefficient of 57%, whereas SWCNTs show a lowered friction coefficient of 49%; this might be ascribed to the influence of viscosity. Due to the presence of MWCNTs and SWCNTs nanoparticles on the worn surface, it is assumed that the anti-wear mechanism is related to the accumulation of MWCNTs and SWCNTs nanoparticles. This then decreases shearing stress, thereby improving tribological characteristics.

## REFERENCES:


*[1]. K. Holmberg, P. Andersson, A. Erdemir, Global Energy Consumption Due to Friction in Passenger Cars, Tribology International, vol. 47, pp. 221-34, 2012, doi:10.1016/j.triboint.2011.11.022*

*[2]. B. Bhushan “Principle and application of tribology” A wiley-Interscience Publication (1999) ISBN 0-471-59407-5.*

*[3]. SG. Ghalme, YJ. Bhalerao, Application of Nanoparticles as Additive for Lubricant- Nanomaterials in Tribology, Recent Patents on Material Science, vol. 10, iss. 2, pp. 88-96, 2017, doi: 10.2174/1874464810666180329143917*

*[4]. Ives,L. K et.al. , Investigation of the Lubrication Mechanisms of the Complex Metal Sulfide, SbSbS4, Annual rept. 1 Oct 80-30 Sep 81, NATIONAL BUREAU OF STANDARDS WASHINGTON DC*

*[5]. Asrul, M., N. W. M. Zulkifli, H. H. Masjuki, and M. A. Kalam. "Tribological properties and lubricant mechanism of nanoparticle in engine oil." Procedia Engineering 68, no. 1 (2013): 320-5.*

*[6]. Bhaumik, Shubrajit, S. Prabhu, and Kingsly Jeba Singh. "Analysis of tribological behavior of carbon nanotube based industrial mineral gear oil 250 cSt viscosity." Advances in Tribology 2014 (2014).*

*[7]. Shiuh-Chuan, and Chun-Yu Lai. "Dynamic behavior of nanocomposites reinforced with multi-walled carbon nanotubes (MWCNTs)." Materials 6, no. 6 (2013): 2274-2284.*

*[8]. Rajendiran, A., A. Sumathi, K. Krishnasamy, S. Kabilan, and D. Ganguli. "Antiwear study on petroleum base oils with esters." Tribology International 99 (2016): 47-56.*

*[9]. W. Dai, B. Kheireddin, H. Gao, H. Liang, Roles of nanoparticles in oil lubrication, Tribology International, vol. 102, pp. 88-98, 2016, doi: 10.1016/j.triboint.2016.05.020*

*[10]. Huaping Xiao, Shuhai Liu,2D nanomaterials as lubricant additive: A review, Materials & Design, Volume 135, 2017, Pages 319-332, ISSN 0264-1275,https://doi.org/10.1016/j.matdes.2017.09.029.*

*[11]. MM, Mr Nikam, Mr Shedage SB, Mr Mane, and Mr Gitay AJ. "Experimental Analysis of Lubricating Oil Using Nanoparticles as Modifiers for Tribological Properties." (2018).*

*[12]. Chang-Gun Lee, Yu-Jin Hwang, Young-Min Choi, Jae-Keun Lee, Cheol Choi and Je-Myung Oh, “A Study on The Tribological Characteristics of Graphite Nano Lubricants,” International Journal of Precision Engineering and Manufacturing Vol. 10(2009)*

*[13]. R. Chou, A.Hernandez Battez, J.J.Cabello, J.L.Viesca, A.Osorio and A.Sagastume, “Tribological behavior of polyalphaolefin with the addition of nickel nanoparticles,” Tribology International 43 (2010) 2327–2332.*