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An experimental investigation on tribological characteristics of graphite/MWCNT mixed hybrid cutting fluids

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KEYWORDS

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ABSTRACT

The cutting fluid normally used in the industries to increase the tool life, smoothens the manufacturing process, improves the efficiency of the production system. Commercial cutting fluid (CCF) used in industries are hazardous to the environment and human beings, so conventional cutting fluid is being replaced by eco-friendly cutting fluid, which produces better results in terms of increased tool life, better surface finish, and skin friendliness. The performance of Micro Graphite (GPT), Multiwall Carbon Nanotube (MWCNT) and Zinc Oxide (ZnO) additives are absorbed in weight percentage using same parameters (120N, 200rpm, and blended oil (50 percent GCL and 50% CONT). When compared to GCL+CONT, commercial fluid additive (GPT, ZnO) added cutting fluids, MWCNT additives had the lowest coefficient of friction. Compared to GPT added fluid and commercial cutting fluid ZnO added fluid exhibited lowest COF and Wear rate. The blend of GLC +CONT with addition of Micro graphite and Nano-particles additives placed in a multiwall of a Carbon Nanotubes must show in the test's better performance against CCF because the pressures between the tool and the metal part, are being absorbed in a shape with better balance and with a pressure vector distribution that should deliver a positive behavior against the CCF test.

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1.0 INTRODUCTION

The commercial cutting fluids which are being used in the industry worldwide is non – biodegradable, harmful to the environment, also decrease the tool life of the machine. Both Glycerol and coconut oil is normally skin friendly for the human being. Wichmann et.al. (2013) attempts were made to replace mineral oil-based metal working fluid with glycerol and water-based fluid. It was tested in the grinding process and the biodegradability and corrosion behaviours were investigated. Mineral oil can be partially replaced with glycerol and water-based cutting fluids. Additives added glycerol fluid corrosion properties and film thickness was investigated to improve the glycerol-based fluid properties adding additives is the best solution. The glycerol based fluid was used in Al_2O_3 and CBN based grinding wheels during the material removal process compared to commercially available mineral oil glycerol based fluid reduced the addition wear. When CCF is used in cutting operations (milling, drilling, planning, broaching, turning and grinding) the process is open, is not confined in a box or an engine, so fumes and little drops can affect the workers. The factories have the need to implement HSE controls. The use of GCL + CONT in cutting oils could be an alternative with fewer risks (Qu et al., 2021; Winter et al., 2012). Alumina Oxide (Al_2O_3 - INCONEL 690) as additive is good, in order to work with hard metal pieces but will be the best to work with alloys or more mild metal as cooper, tin or bronze. Other additives as MoS2 could be used with very hard metals and the different additive type the concentrations, should be adjust. Also, the blend and the Bio-base stocks or mineral base stock used (Sen et al., 2019; Suvin et al., 2020).

If a mineral base stock is used the HSE operation level can be affected and the Rheological performance and the Tribological properties can change, but if tests are performed with a bio-component as CONT or GLY the results can be similar (Sah et.al., 2021) the parameters (thermal, wettability, rheological) and tribological characteristics of nano-particle-added jatropha-based cutting fluids were examined. The characteristics of the additive-added cutting fluid were compared to those of an ionic liquid-based cutting fluid. The author concluded that additives improve fluid properties and tribological behaviour when compared to ionic liquid. Using lubricating oil, the friction and wear properties of a newly created alloy material were investigated. Using, other bio-oils as Jatropha to implement the use and production in any country, the results in Rheological performance and the tribological properties could be similar against CONT in alloy materials too (Murakami et al., 2012; Murakami et al., 2007). Plant oil-based cutting fluid was used in the hard metal grinding process. The nano graphene added fluid gives a better result in the hard metal grinding process when different ratios of nano graphene (0.05, 0.1, 0.15, and 0.2 in wt. %) particles were added with the base oil by Li, Ming, et al., The functions in hard metals are more demanding, then to add MWCNT will have better performance because this material works synergistically with the CONT because the MWCNT give more anti-wear protection improving the life of the tool (less R&O) and when the forces are reducing, there is less energy consumption and of course the COF will be less (Li et al., 2020).

Reviewed by the properties and oxidation of various vegetable oils are compared to commercially available cutting fluids. According to the findings of various authors, vegetable-based oil is the best substitute for non-biodegradable or mineral-based cutting fluids (Shashidhara and Jayaram, 2010; Fox and Stachowiak, 2007). During the drilling process, five different combinations of vegetable-based cutting fluid were used. When compared to commercially available cutting fluid, the blended vegetable-based cutting fluid performs well in chip breaking cutting force and improving tool life by Belluco and Chiffre (2004). The machining performance of boron compound additives added to ethylene glycol base fluid during the hard milling process was investigated. In the milling process, commercially available boron fluid was used to compare the additives added fluid properties. The results show that adding additives to the cutting fluid improves milling performance by Kursuncu and Yaras (2018). In the titanium alloy turning process, pure soybean, micro graphite added cutting fluid, and commercially available fluid were used. In all fluid conditions, tool wear, cutting forces, and surface roughness were measured. When compared to other fluids, soybean-based micro graphite-added cutting fluids outperform others in terms of tool wear by Revuru et al (2018).

The properties of blended lubricating oil and tribological characteristics were compared to mineral-based oil. The cost-benefits ratio is positive too when the Nano particles of MoS2 are added due to this material is an anti-wear and anti-Rust material. In terms of performance and cost effectiveness, blended biodegradable oil is the best replacement for non-biodegradable oil (Sajeeb and Rajendrakumar, 2019; Aiman and Syahrullail, 2017). The quantities of 0.25, 0.5, 0.75 and 1.0% in any bio-oil cutting oil working in hard metals can show benefits as less rugosity and better finished. All these enhanced features promote the quality in the production. The conclusion is that is a very good alternative to blend these bio-oils with Nano Additives and MWCNT (Padmini et al., 2016).

Based on the findings and conclusions of past studies, the researcher needs to propose a biodegradable and skin-friendly cutting fluid to replace non-biodegradable cutting fluid. As a result of this knowledge, the author believes that no one has tried a cutting fluid made of mixed glycerol and coconut oil with micro graphite and MWCNT. Finding the tribological qualities of a biodegradable cutting fluid is one of the most significant components, so this study looked into the tribological behaviour of additives added to cutting fluid.

2.0 MATERIALS AND METHODS

In this research work, studied the tribological characteristics of blended GCL+CONT oil by using pin on disc wear tester. Once the best cutting fluid combination was identified, the additives (Micro GPT, Nano ZnO and MWCNT) were introduced in various percentages. The tribological behavior of graphite, ZnO and MWCNT dispersed fluids were then compared to that of commercial cutting fluid. Finally, the performance of additives in wear testing was investigated using SEM analysis. The cutting fluids of GLC+CONT Micro Graphite, ZnO and MWCNT is obvious that the results in the Wear Test (PODT) using the SEM Analisys must be show better features against a conventional oil because the Nano additive produce less wear in the tool and less roughness in the part surface, according (Nuraliza et al., 2016).

2.1 Coconut Oil, Glycerol, and Additive Specifics

Pure coconut oil acquired straight from a shop specializing in coconut oil extraction. Pure glycerol, graphite additives, ZnO and MWCNT were acquired from Chennai Parry's Corner. The purchased, Batch no MCR -20747 glycerol purity is 97.08% with impurities of sulphated ash 0.02 %and water 2 %. The water-soluble micro graphite with a purity of > 99.9%, a density of 1.8g/cm3, Zinc Oxide length of 37-46 nm and MWCNT with a purity of 95%, an outer diameter of 9nm, and a length of 10-30μm were used as additives.

2.2 Fluid Samples Preparation

The glycerol and coconut oil is not blends each other directly it can be absorbed in the Figure 1. O'connell et al (2002) used Sodium Dodecyl Sulphate (SDS) to dispersion of carbon nanotubes (CNTs) absorbed that it's given the better result.

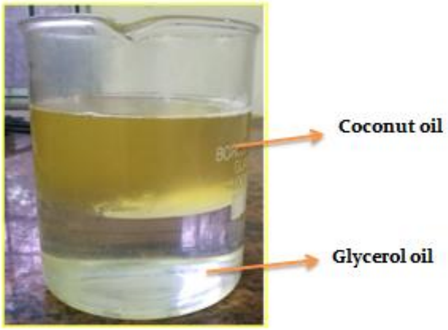

Figure 1: Before Blending of GCL+CONT.

Figure 2: Prob Sonicator blending process.

Tian et al (2011) used 2mg SDS for 200ml DI water and properly mix the single-walled nanotubes (SWNTs). In this study, 2mg of SDS was added to 100ml of fluid to bland the GLY+CONT oil. It was thoroughly mixed (Figure 3) with the aid of a prob sonicator (Figure 2), which was used to stir for 10 minutes at a 30 second interval. The tribological behaviour of polyalphaolefin base fluid and MWCNT additives in various concentrations (0.025-0.15 wt. %) was investigated, as well as 120 days of additive sedimentation (Kumar and Harsha, 2020). In terms of tribological properties, the nano additives of ZnO and MWCNT additives added fluid performed better, and no sedimentation was observed.

Khan et al (2019) conduct work with the coconut base oil to prepare the nano fluid the nano particles of Cu and Ag is added in different weight percentage the fluid tribological properties was investigated. With the reference of this in this research the base fluid of 50%GLY+50%CONT oil for the 100ml fluid, the particles of Graphite, ZnO and MWCNT was mixed with different weight percentage concentration (0.06%, 0.08%, 0.1%, 0.12%, 0.14%). The fluid properties of flash point, pour point and viscosity was determined as per ASTM D92, ASTM D3 and ASTM7279 respectively.

Figure 3: After Blending of GCL+CONT.

2.3 Test Specimen Preparation

The purpose of this study was to investigate the tribological behaviour of the Pin on Disk wear tester. EN8 material was used to make a pin specimen with a diameter of 10mm and a length of 50mm. The pin material's hardness was originally 15 HRC (Hardness Rockwell C), but it was increased to 32HRC using the quenching process. The disk was made of EN31 material, which has a hardness of 34 HRC and was hardened to 64 HRC using the quenching process.

2.4 Tribology Test using Pin on Disk Method

The vegetable lubricant wear performance was analyzed by using Pin on disk wear tester in two different load (50N, 100N) and six speed (300, 600, 800, 900, 1000 rpm) condition by Noorawzi and Syahrullail (2016).

Figure 4: Pin on Disk wear testing setup.

According to the wear test ASTM standard G99-17 the test was performed in three (120, 140, 160N) different load and three (200, 400, 600 rpm) different speed condition. The least coefficient of friction exhibited parameters (140N and 400rpm) and fluid combination (50%GLY + 50%CONT) the different concentration (0.06%, 0.08%, 0.1%, 0.12%, and 0.14%) additives (GPT, ZnO and MWCNT) fluid and commercial cutting fluid was tested to compare the additives performance in tribological behavior. The entire test was conducted in 40.5mm track radius and 120ml fluid was used in 60mins time duration. The pin on disk wear testing machine setup shown in the Figure 4.

3.0 TAGUCHI DESIGN OF EXPERIMENT

A Taguchi is designed to experiment that allowed to choose a process that functions more comfortably in the operating environment. Taguchi design state that not all factors that causes uncertainty can be controlled. These uncontrollable factors are called noise factors. This design tries to identify controllable factors which can be used to minimize the effect of the noise factors an orthogonal array is used in Taguchi design to estimate the effects of factors in the values of mean and variation. An orthogonal array means that its determinant is either +1 or -1 by it looks balanced so that values levels are distributed equally. Because of this, each value can be judge severally against of all the opposite values, so that the effect of one value does not affect the approximation of another value. This method is used to reduce the time and cost related to the experiment when separate designs were used. In order to investigate the Sound Factors (Taguchi Experiment) is very important to use the orthogonal pattern with all used oils and to use also the "Grey Relational Analisys" according to Osuch-Slomka et al (2013) and surfactants to reduce the surface tension.

According to Dharmalingam et al (2013), in a pin on disk wear tester, the wear behaviour of metal matrix hybrid composites was investigated. The best result was discovered using grey relational analysis. Osuch-Slomka et al (2013), the wear test was carried out using a three-level three-factor L9 orthogonal array, and the tribological test parameter optimization was done using Taguchi design. From Amrita et al (2014) three different weight ratios of nano graphite were mixed with water, along with three different types of surfactants and three different weight percent. The L9 orthogonal array and Taguchi design of experiments were used to create the composition. As a result of this concept, shown in Table 1, is an experiment with a three-level, three-factor L9 orthogonal array was conducted in this study.

Table1: L9 Orthogonal array experimental parameters

Parameters	**Description**	**Level 1**	**Level 2**	**Level 3**
A	Load	120	140	160
B	Speed	200	400	600
C	Glycerol + coconut oil	75 + 25	50 + 50	25 + 75

4.0 RESULTS AND DISCUSSION

4.1 CCF, GLY, CONT and Additives Added Fluid Physical Properties

The viscosity, flash point, and fire point of the various fluid combinations are shown in Table 2. When compared to commercial cutting fluid and coconut oil, pure glycerol has the maximum viscosity at 40°C of 174.3cSt and 12.1cSt at 100°C. The viscosity, flash point, and fire point are nominal in a 50%GLY+50%CONT oil condition. In addition, raising or reducing the glycerol ratio with coconut oil increases the viscosity of the fluid.

The findings of pin on disc wear tests also revealed that 50%GLY+50%CONT had the lowest COF and wear rate. As a result, it is evident that the fluid's viscosity is one of the elements that influences COF and wear rate. The physical properties of the blended fluid show that the additives have increased the viscosity, flash point, and fire point.

Table 2: The physical properties of fluids.

Fluid samples	**Viscosity (cSt)**		**Flash point (°C)**	**Fire point (°C)**
	40°C	**100°C**		
Cutting fluid	69.2	9.6	224	239
Glycerol	174.3	12.1	202	211
Coconut	159.6	11.5	201	213
25%GLY+75%CONT	168.2	11.9	216	224
50%GLY+50%CONT	162.8	11.7	214	222
75%GLY+25%CONT	165.4	11.4	218	228
50%GLY+50%CONT+.06GPT	166.2	11.1	214	226
50%GLY+50%CONT+.08GPT	169.6	11.6	212	223
50%GLY+50%CONT+.1GPT	174.9	11.9	219	230
50%GLY+50%CONT+.12GPT	181.3	11.3	217	228
50%GLY+50%CONT+.14GPT	186.1	11.4	213	221
50%GLY+50%CONT+.06ZnO	161.4	11.8	213	226
50%GLY+50%CONT+.08ZnO	163.2	12.0	216	223
50%GLY+50%CONT+.1ZnO	165.1	12.1	217	230
50%GLY+50%CONT+.12ZnO	177.5	11.9	216	228
50%GLY+50%CONT+.14ZnO	181.2	11.8	215	221
50%GLY+50%CONT+.06MWCNT	156.6	12.1	215	227
50%GLY+50%CONT+.08 MWCNT	160.2	12.4	220	231
50%GLY+50%CONT+.1 MWCNT	167.5	12.6	216	226
50%GLY+50%CONT+.12 MWCNT	174.7	12.3	218	225
50%GLY+50%CONT+.14 MWCNT	179.1	12.1	216	228

4.2 CCF and Blended Fluid COF

In the nine different parameter condition commercial cutting fluid and blended fluid COF result was listed in the Table 3. In all sets of experiments, the coefficient of friction of the glycerol+ coconut oil combination is lower than the commercial cutting fluid is clearly understood from the Figure 5. At 120N load, 400rpm speed, and the fluid combination of 50 %GLY+50 %CONT condition the lowest COF of 0.023092 micron was observed in the novel cutting fluid combination. At the last run combination, the highest load (160N) and speed (600rpm) were used, resulting in the highest COF of 0.071518 being absorbed.

The proportion of coefficient of friction (COF) is as follow;

(a) 75% Glycerol (GLY) and 25% Coconut Oil (CONT)
(b) 50% Glycerol (GLY) and 50% Coconut Oil (CONT)
(c) 25% Glycerol (GLY) and 75% Coconut Oil (COCO)

Table 3: Coefficient of Friction of glycerol + coconut oil and commercial cutting fluid.

SL No.	Load (N)	Speed (RPM)	Proportion	GLY+CONT	CCF
1	120	200	1	0.031732	0.046765
2	120	400	2	0.023092	0.036832
3	120	600	3	0.034446	0.045889
4	140	200	2	0.05859	0.079543
5	140	400	3	0.02378	0.034345
6	140	600	1	0.03173	0.054656
7	160	200	3	0.024319	0.033201
8	160	400	1	0.026107	0.037054
9	160	600	2	0.071518	0.065614

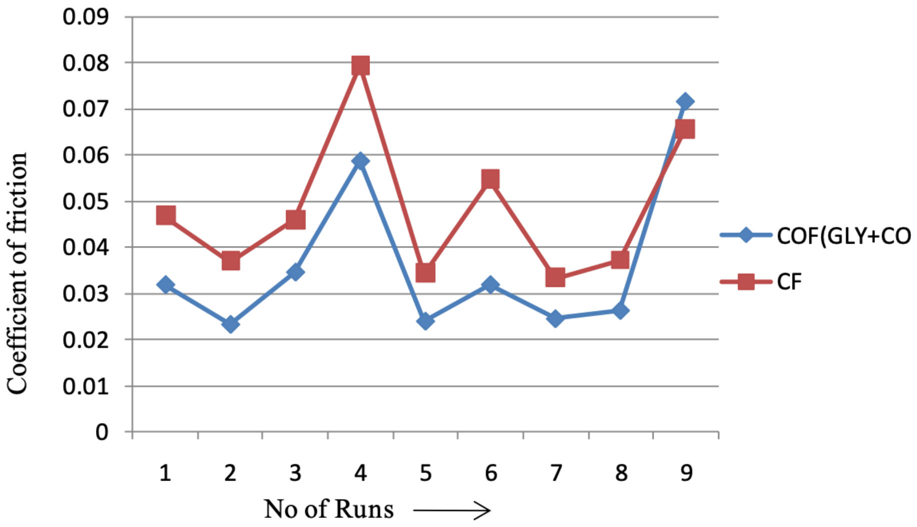

Figure 5: Blended fluid vs Commercial cutting fluid (CCF) COF comparison chart.

4.3 Prediction of COF using Minitab software

The experimental results were used to predict the best combination of results using Minitab software. One of the best qualities of cutting fluid is exhibiting the lowest COF. The Figure 6 shows the best combination of parameters: 140N load, 200rpm speed, and 75 %GLY+25 %CONT condition. The S/N ratio plot was created using the smaller is better concept, as shown in the Figure 7, which shows the least COF with parameters of 120N load, 400rpm speed, and a fluid mixture of 50% GLY+50% CONT.

The percentage contributions of load, speed, and fluid combination to the COF are clearly shown in the Table 4, with load influencing 50.38%, cutting fluid combination influencing 35.18%, and speed influencing 14.42%. As a result, it should be noted that lowering the COF load should be considered the primary parameter.

Figure 6: Main effect plots for COF.

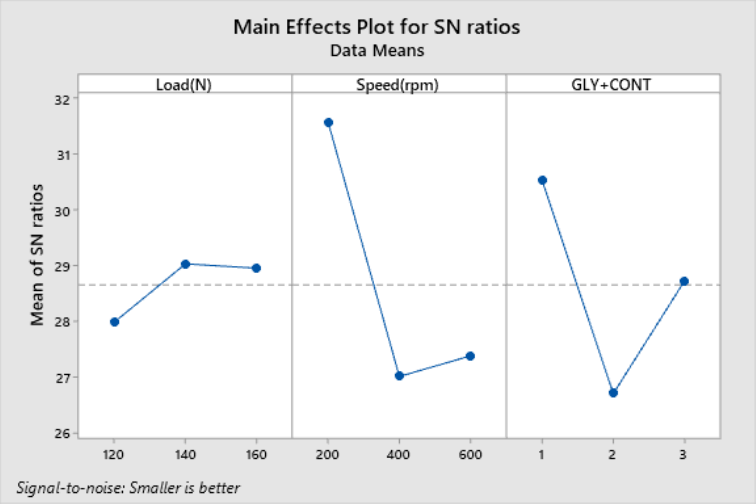

Figure 7: S/N ratios plots for COF.

Table 4: Analysis of Variance for SN ratios (COF).

Source	DF	Seq SS	Adj SS	Adj MS	% Contribution
Load(N)	2	31.599	31.599	15.799	50.386
Speed(rpm)	2	9.048	2.048	1.024	14.427
GLY+CONT	2	22.067	22.067	11.033	35.186
Residual Error	2	0	0	0	
Total	8	62.714			100

According to the delta value and ranking mentioned in the Table 5, load is the first considerable parameter to increases the COF, Followed by cutting fluid and speed is next level influencing factors.

Table 5: S/N ratio COF ranking table.

Level	Load (N)	Speed (rpm)	GLY+CONT
1	31.58	27.98	30.54
2	27.01	29.03	26.7
3	27.38	28.95	28.73
Delta	4.57	1.05	3.83
Rank	1	3	2

Table 6: Minitab predicted parameters and least COF.

Load(N)	Speed(rpm)	GLY+CONT	COF (Prediction)	COF (Experimental)
120	400	2	0.02011	0.023780

In the Table 6 above, the Minitab software predicts a least coefficient of friction of 0.02011 Micron for the L9 taguchi design of experiment in 120N load, 400rpm speed, and 50%GLY +50% CONT parameter condition for the L9 taguchi design of experiment. Out of this nine experiment the least COF of 0.023780 Micron is absorbed in 140N load, 400rpm speed and 50 %GLY + 50 %CONT parameter condition. As a result, it's clear that the predicted and experimental outcomes are nearly identical.

4.4 Blended Fluid Wear

In terms of wear, the novel cutting fluids demonstrated a lower wear rate than CCF in all nine parameter conditions, as shown in the Table 7 and Figure 8. The lowest wear rates 0.0000024 microns and 0.0000018 microns were achieved in both commercial cutting fluid and Novel blended cutting fluid under conditions of 140N load, 400rpm speed, and 25% GLY+75% CONT. Maximum wear rates of 0.0000047 and 0.0000063 Microns were recorded in blended (50% GLY + 50% CONT) oil and commercial cutting fluids, respectively, under 140N load and 200rpm speed.

The wear rate is reduced when increasing the speed and reducing the load in the same fluid condition (50% GLY + 50% CONT) as can be seen in the test run 2. The wear rate is greatly reduced when both load and speed are increased, and this can be absorbed from test run 9. As a result, it's evident that optimising load and speed are critical elements in lowering the wear rate.

The Table 8 clearly depicted the percentage contributions of load, speed, and fluid combination to wear rate. The load 43.07 % is the major contribution, cutting fluid and speed contribution 39.99 %and 16.22 %respectively. The ranking Table 9 clearly shows that load plays a major role in increasing the wear rate in the test parameters. As a result, lowering the wear rate necessitates a thorough examination of the load and fluid contribution.

Figure 9 and Figure 10 plot were created in Minitab software using experimental data, and they clearly show the best combination of parameters for achieving the lowest wear rate. According to the plots and predicted results mentioned in the Table 10, the combination of 120N load, 200rpm speed, and 50% GLY+50% CONT parameter combination has the lowest wear rate.

Table 7: Experimental parameter and corresponding wear rate.

SL No	Load (N)	Speed (rpm)	Proportion	GLY+CONT (Microns)	CCF (Microns)
1	120	200	1	0.0000023	0.0000033
2	120	400	2	0.0000032	0.0000038
3	120	600	3	0.0000022	0.0000036
4	140	200	2	0.0000047	0.0000063
5	140	400	3	0.0000018	0.0000026
6	140	600	1	0.0000023	0.0000036
7	160	200	3	0.0000019	0.0000027
8	160	400	1	0.0000021	0.0000024
9	160	600	2	0.0000039	0.0000054

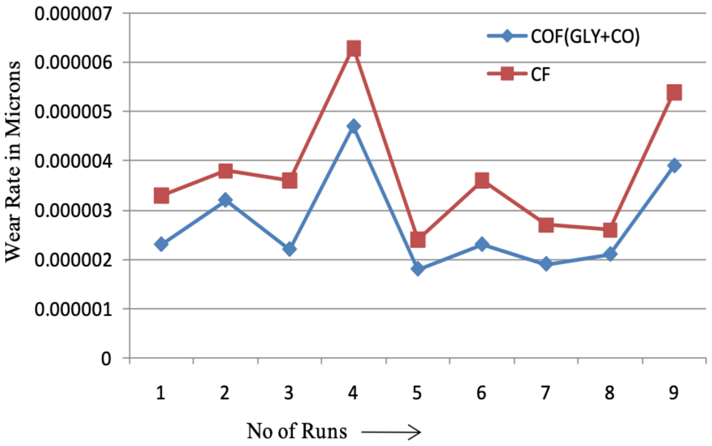

Figure 8: Blended fluid vs Commercial cutting fluid (CCF) wear comparison chart.

Table 8: Analysis of Variance for SN ratios (wear).

Source	DF	Seq SS	Adj SS	Adj MS	% Contribution
Load(N)	2	29.969	29.969	14.9845	43.07
Speed(rpm)	2	11.282	11.282	5.641	16.22
GLY+CONT	2	27.822	27.822	13.911	39.99
Residual Error	2	0.5	0	0	0.72
Total	8	69.575			100.00

Table 9: S/N ratio COF ranking table.

Level	Load (N)	Speed (rpm)	GLY+CONT
1	112.5	111.2	114.9
2	115.1	119	108.8
3	113.9	111.4	117.9
Delta	2.6	7.7	9.1
Rank	3	2	1

To verify the predicted result, a test was conducted with the same predicted parameters, and it was discovered that the predicted and experimental results are nearly identical. As the Load is the main factor to produce wear and to increase the COF the Load Distribution in the Tool and piece surfaces, when the MWCNT and the Load will be better distributed, so the operations performance will be improved (Table 9 and 10) in all blend ratios. In hard metals can be used MoS2 (Nano particles) but in yellow metals as Cooper, aluminum, brass and bronze. Using an oil with Al2O3 (Nano particles) as Ant-wear additive, and the wear prediction and the Noorawzi and Samion (2016) theory can be confirmed.

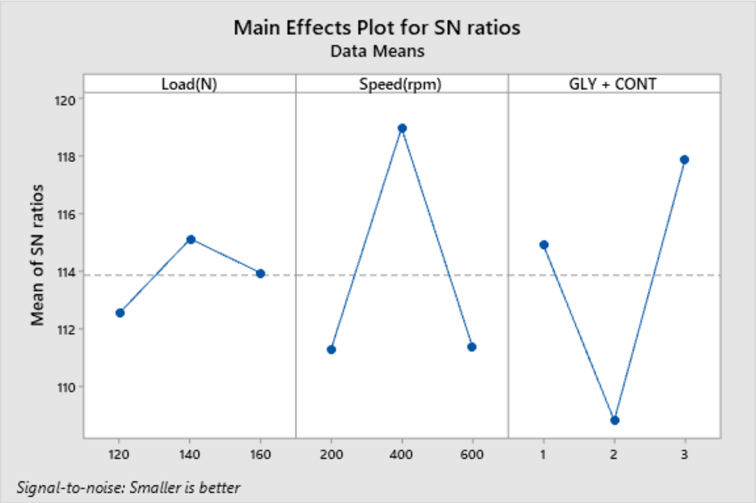

Figure 9: Main effect plots for COF.

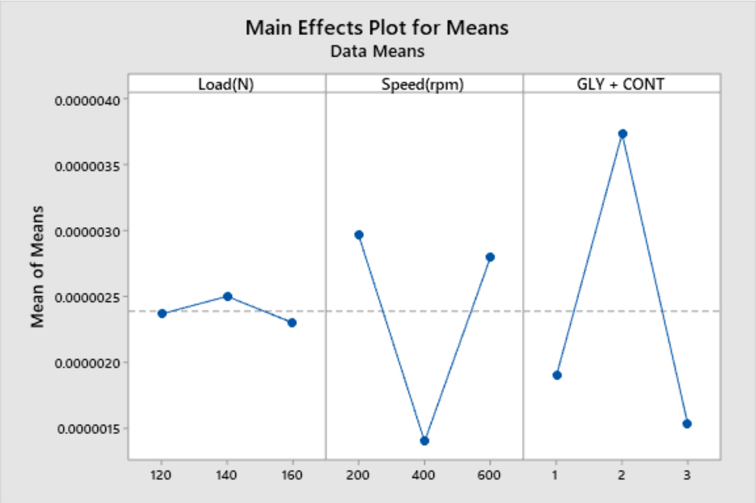

Figure 10: S/N ratios plots for COF,

Table 10: Minitab Predicted parameters and least wear rate.

Load(N)	Speed(rpm)	GLY+CONT	COF (Prediction)	COF (Experimental)
120	200	2	0.00000158	0.00000161

4.5 Additives Performance in COF and Wear

In the hard metal machining process, cutting fluid plays an important role in reducing tool wear. The additives of GPT, ZnO and MWCNT were used to improve the fluid properties in wear in this study, and the wear behaviours were investigated using the least wear rate predicted parameter of 120N load, 200rpm speed, and 50% GLY+50% CONT condition.

The comparison of blended fluid (50% GLY+50% CONT),CCF and the additives of GRP, ZnO and MWCNT in different ratio added cutting fluid COF and wear rate result is shown in the Figure 11 and Figure 12 respectively. The novel and commercial cutting at the parameters of 120N load and 200rpm condition exhibited the COF 0.058092 and 0.076832respectively. It clearly shows that additives act major role to reduce the COF.

Compared to micro graphite added fluid the MWCNT added cutting fluid performance better. Also, the result shows that in the different concentration of additives 0.06 to 0.1% the COF gradually decreased. When compared to blended (50%GLY +50%CONT) oil, commercial cutting fluid, micro graphite added fluid, and zinc oxide added fluid, MWCNT 0.14% added fluid had the lowest coefficient of friction (0.01735) (Noorawzi and Samion, 2016). The tribological properties of palm oil and petroleum-based oils were compared. The test was carried out in a pin on disc wear tester with five different speed conditions and two different loads (50N and 100N) conditions.

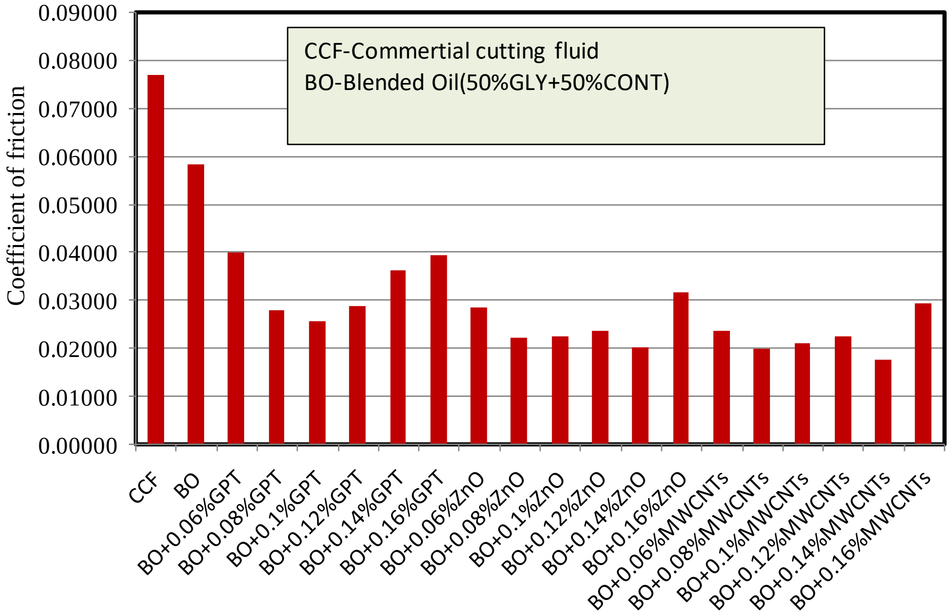

Figure11: CCF, BO, Additives added fluid COF compression chart.

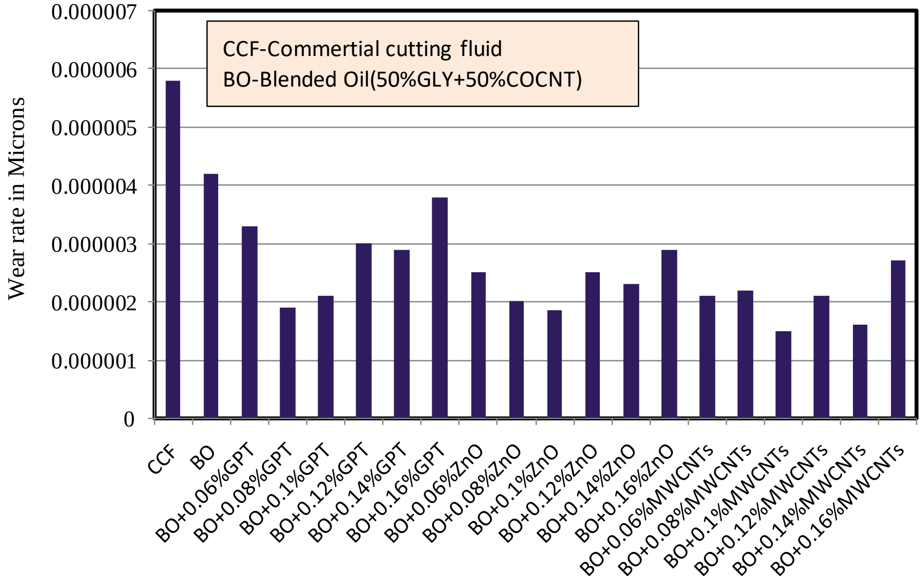

Figure 12: CCF, BO, Additives added fluid wear rate compression chart.

The test was carried out based on this knowledge in generally the result shows that after the 0.12% of additive concentration both friction and wear rate was increased. Compared to CCF and Blended oil the performance MWCNT additives was better in both COF and wear. The 0.1 % MWCNT concentration with the blended fluid produced the lowest wear rate. The GRP, ZnO and MWCNT aditivación (0.14%) should be used to prepare the Bio-Cutting Oil, in order to achieve the best Bio-Cutting Oil with Tribological properties enhanced. The non-use of additives will accelerate the wear mainly because the adhesive wear produces high temperatures between the tool and the metal piece and the heat it is a booster wear. As a result of COF and wear, the ZnO added fluid performs nearly as well as the MWCNTs additives added fluid. However, when compared to commercial cutting fluid, micro graphite, and nano zinc oxide added fluid, the performance of MWCNTs added fluid is superior in all ranges.

4.6 SEM Investigation on Specimen Wear Analysis

The CCF, Blended oil, blended oil with additives (Micro Graphite, ZnO and MWCNT) added fluid least wear rate absorbed specimen SEM image (Figure 13) was investigated. It is obvious from the Figure 13(a) that commercial cutting fluid was used on specimens that were consistently worn in lined type. Adhesive wear occurs on the surfaces when no additives are introduced to the cutting fluid test (50%GLY +50%CONT) used in the wear. It can be absorbed from Figure 13(b). When using GPT particles with the novel cutting fluid, the graphite particles are adhesion to the surface and reduce wear rate, as seen in the Figure 13(c). When friction between the pin and the disc occurs, ZnO additives adhere to the surface and act as a lubricant, as seen in the Figure13 (d), lowering the COF and Wear rate when compared to GPT added fluid. The Figure13 (e) clearly shows that compared to GPT added cutting fluid MWCNT added novel cutting additives adhered with the surface and protect the surface against wear.

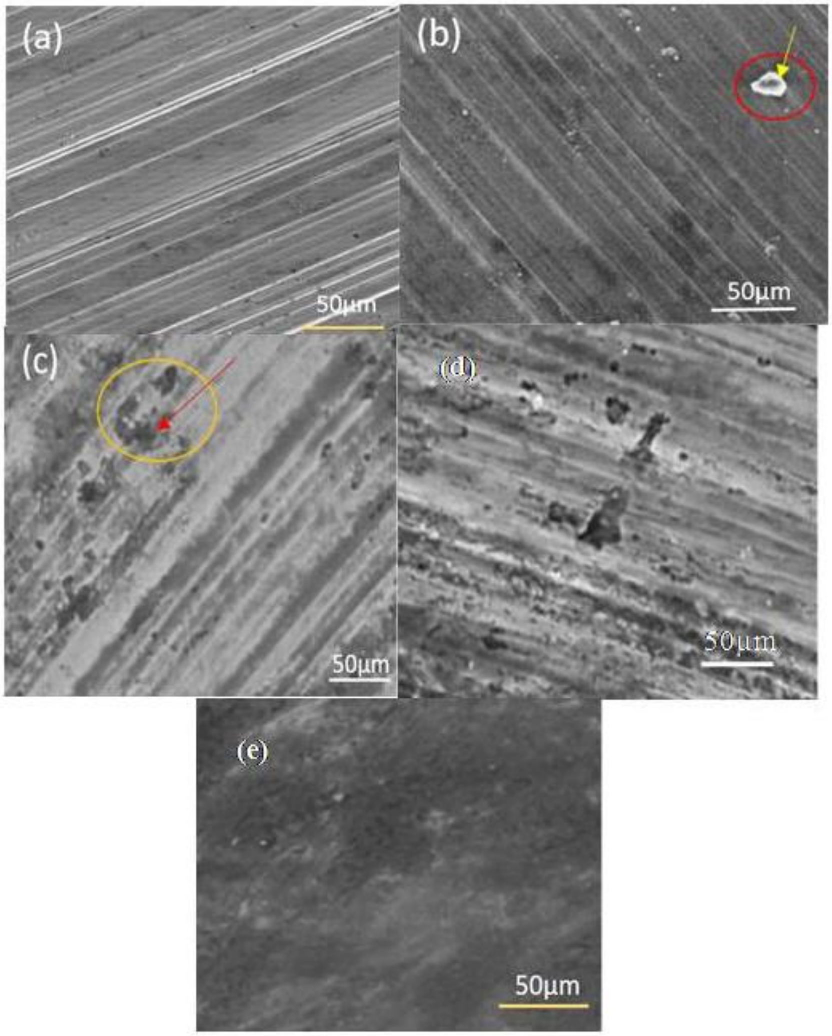

Figure 13: Least wear rate Exhibited sample specimen SEM image (a) Commercial cutting Fluid sample specimen (b) Blended 50%GLY +50%CONT (c) Blended oil + 0.8%GPT (d) Blended oil + 0.1%ZnO e) Blended oil + 0.1%MWCNT.

CONCLUSIONS

In this work, in order to replace commercial cutting fluids, the blended fluid (glycerol +coconut oil), and Additives (Micro Graphite, MWCNT) added fluid tribological properties was investigated. The following points are concluded in this experimental study.

(a) The coefficient of friction and wear rate of the blended cutting fluid (GLY+CONT) was lower than the commercial cutting fluid in all parameters.

(b) The coefficient of friction and wear rate are reduced significantly when the particles are added with the blended oil.

(c) In the different concentration (0.06 to 0.1%) of graphite added fluid 0.08% GPT added fluid is exhibited the least coefficient of friction and wear rate. The friction and wear rates have been increased above 0.08% of Graphite.
(d) In comparison with commercial cutting fluids, blended oil and micro graphite added fluid, the 0.1% MWCNT added cutting fluid wear rate is lower.
(e) When compared to commercial cutting fluid, blended (GLY+CONT), and GPT added fluid, mineral compound of ZnO additives performs better. Furthermore, It performs nearly as well as MWCNT-added fluid.
(f) The wear test results, and SEM images clearly shows that the additives are adhered with the surface and protected against wear when used with the novel cutting fluid.

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