Performance Evaluation of MQL with Graphene Mixed Nano Fluids prepared at different Concentrations in Turning of Pure Titanium (TI6Al4V) Alloy

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Abstract. This paper presents an investigation into the minimum quantity lubrication mode with Nano fluid during turning of titanium (TI6AL4V) alloy. In heavy cutting conditions, minimum quantity lubrication (MQL) has been observed, that, Nano-cutting fluids which have enrich thermal conductivity than base fluid, are begun to be used in MQL system. The addition of the required nano particle ratio to the base liquid is one of the most important issues that arise in this method. Therefore, this study aimed to find the optimum distribution rate of graphene nano particles having excellent properties and machining parameters. To do this, graphene nano particles were added to a vegetable-based cutting solution. Nano-cutting fluids were prepared in different volumetric concentrations. When turning of titanium (TI6AL4V) alloy, these Nano fluids were used in the MQL system. Three different parameters were added to the experimental design to study the performance of Nano fluids under several cutting conditions. i.e., speed, feed rate and depth off cut. Apart from this experimental design, three tests were carried out at each concentration ratio while keeping the machining parameters constant to clearly see the impact of concentration rates on surface roughness, flank wear. And crater wear. In addition, while chipping/fracture, were observed under all cutting conditions

Keywords: Minimum quantity lubrication, cutting fluids, graphene nano particles, tool wear, TI6AL4V, Surface roughness.

1. INTRODUCTION

Many industrial companies are attempting to reduce cost of cutting, improve the quality of machined components, and machine more difficult materials these days. By reducing machining time with high-speed machining, MQL machining performance is increased. Softening temperature is used for cutting ferrous and rough materials such as steels, cast iron, and super alloys. The key goal of minimal quantity lubrication (MQL) is to minimize lubrication and cutting fluid risks. They looked at the behaviour of a recently proposed optimization technique that involves applying water to MQL. They found that by using this MQL, the surface roughness is higher than by using traditional methods, and the findings are quite similar to flood coolant [1]. Investigation into the surface integrity of titanium alloy TI6AL4Vrough machining. It was done under dry cutting conditions with uncoated carbide cutting tools. On the top white layer of the machined surface, there was a change in microstructure and an increase in micro hardness. Titanium and titanium alloys have a high chemical reactivity and poor thermal conductivity. With many tool materials. Sever tearing and plastic deformation of the machined surface were observed when machining titanium alloy TI6AL4V, especially after prolonged machining under dry cutting condition [2]. The effectiveness of a CBN method in machining titanium alloys they had the specifications, which led to the large-scale production and use of heat-resistant high-strength materials like titanium alloys. The machining efficiency was measured in terms of cutting power, precise cutting friction, cutting temperature, chip tension, and surface finish. A cutting tool's output is usually measured in terms of its life. The life of a tool is normally determined by a set of wear criteria. For titanium alloy machining, a cutting speed range of 185-220 is recommended [3]. Experiment on micro-milling TI6AL4V with the least amount of lubrication. They discovered that minimum quantity lubrication (MQL) is a low-cost, environmentally safe coolant. Under MQL and dry cutting conditions, he investigated the micro milling process of titanium alloy by examining tool

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wear, tool life, cutting vibration, surface finish, and burr shape. He demonstrates how the MQL approach improves tool life and reduces substrate adhesion in micro-milling. The MQL extends the tool's existence greatly. Under MQL conditions, flank wear was 45.7m at the end of cutting, compared to 69.6m for dry cutting [4]. Titanium alloy is commonly used in a variety of application in the, energy, aerospace and biochemical industries, owing to because of its outstanding material qualities, such as strong strength at high temperatures, light weight, and resistance to corrosion. For TI6AL4V, the machinability of MQL and cryogenic machining was compared to that of dry and wet machining in this report. With specially developed cryogenic spraying devices, for cryogenic machining, liquid nitrogen (LN2) was employed. A modern MQL method, in conjunction with the lubricant combined with a limited volume (-0.1 percent) Nano-platelets made of exfoliated graphite (xGnPs), was studied in addition to standard MQL to allow the contrast against other techniques. [5]. Utilization of Minimum Quantity Lubrication (MQL) with Water in CNB Grinding of Steel. They discovered that when there is a lot of heat generated, lubrication and cooling help to improve the quality of the work piece. The key goal of (MQL) is to minimize lubrication and cutting fluid risks. To do so, they examined the behaviour of a recently proposed optimization approach that involves applying water to MQL. As opposed to conventional methods, this MQL improves surface roughness and roundness error, and the effects are very similar to flood coolant. As MQL is combined with water, stronger outcomes can be achieved with a higher water addition [6]. The (MQL) System, also known as Micro lubrication system, is used as an alternative to flood cooling by minimizing the amount of cutting fluid used in the machining process. The aim of this study is to emphasize the advantages of using MQL while also emphasizing the negative health consequences. To handle this fine mist, mist collection or filtering equipment is usually needed, particularly in ferrous machining. Vegetable oil and synthetic oil should be used instead of mineral oil in these cases [7]. Different MQL characteristics, such as air pressure, have different impacts, quantity absorbed, and nozzle location experimentally, end milling titanium alloy is examined. The findings indicate the penetrating potential of MQL mist oil has a major impact during milling force and temperature. The penetration potential is affected by the spraying angle of the nozzle location. Because of the high viscosity of MQL oil, it was discovered in the spraying angle of the nozzle placement has a minor impact on penetration capability, according to this study. [8]. They looked at how the method of lubrication and the form of minimum quantity lubrication affect the Coated and uncoated high-speed steel twist drills with a diameter of 1.5 mm have a longer tool life. This demonstrates that, as opposed to a constant supply of MQL, A lack of supply results in a substantial reduction in tool life, especially for heat-sensitive drills; it also reveals that dry drilling is correlated with significantly accelerated tool wear for the majority of the twist. Drills tested in resulted in a tool life drop [9]. Sateesh, N., Sampath Rao at et conducted to investigate the environmental impacts of fiber composites. The main objective of the work is to investigate the degradation of GFRP composite which is exposed to different environmental conditions and its influence on the tensile strength.[15] Ganesh, R., Subbiah, R at el studied the effect of sintering temperature on physical, mechanical and wear properties of Al 2219 alloy matrix reinforced with SiC particulates of average particle size 23 μm for different weight fractions 10%, 15% and 20% fabricated by powder metallurgy (PM) method. The influence of sintering temperature on mechanical behavior and dry sliding wear behavior were investigated [16]. Hussaini, S.M., Krishna at el. focused on the development of FLD for austenitic stainless steel (ASS) 316 at 300 °C, which has been experimentally determined to be the most suitable temperature for warm forming of ASS 316. Experimental FLD has been constructed by performing hemispherical dome punch tests on different width specimens. Theoretical FLDs have been developed using Marciniak–Kuczynski analysis based on Hill's and Barlat's yield criteria and compared with the experimental FLD. Theoretical FLD based on Barlat's yield criterion is found to be in a close agreement with the experimental FLD. These FLDs can be used for designing various warm forming processes on ASS 316[17]. Kotkunde, N., Krishna, G at el has been determined experimentally the FLD for Ti-6Al-4 V alloy at 400 °C by conducting a hemispherical dome test with specimens of different widths. Additionally, theoretical FLDs have been determined using Marciniak Kuczynski (M-K) model. Various yield criteria namely: Von Mises, Hill 1948, Hill 1993 and Cazacu Barlat in combination with different hardening models viz., Hollomon power law (HPL), Johnson-Cook (JC), modified Johnson-Cook (m-JC), modified Arrhenius (m-Arr.), modified Zerilli–Armstrong (m-ZA) have been used in M-K analysis for theoretical FLD prediction. The material properties required for determination of yield criteria and hardening models constants have been calculated using uniaxial tensile tests. The predicted theoretical FLDs results are compared with experimental FLD. It can be observed that influence of yield criterion in M-K analysis for theoretical FLD prediction is predominant than the hardening model. Based on the results; it is observed that the theoretical FLD using Cazacu Barlat and Hill 1993 yield criteria with m-Arr. hardening model has a very good agreement with experimental FLD[18]. Hussaini, S.M., Singh, S.K at el. investigated circular blanks are deep drawn at room temperature, 150 °C and 300 °C using a 20 ton hydraulic press coupled with a furnace. Finite element simulations are carried out using Dynaform with LS-Dyna solver. Simulations and experimental results show an increase in the limiting drawing ration as the temperature increases and a decrease in the thickness of the drawn cup without any fracture. An artificial neural network model is developed for the prediction of the cup thickness at different locations. Based on the input variables, such as distance from the center of the cup, temperature and LDR, a back propagation neural network model to predict the thickness as output was develop. The comparison between these sets of results indicates the reliability of the predictions. It was found that there is a good agreement between the experimental and predicted values [19].

2. EXPERIMENTAL PROCEDURE

This chapter contains specific details about the instruments used for this research as well as the setup of the equipment for the experiment. The below are some of the main equipment's. A series of experiments were carried out in the current study using graphene adopted Nano Fluid-MQL was used to explore the impacts of varied feed frequencies, cutting speeds, and graphene nano particle concentrations on surface roughness, tool existence, and tool efficiency.

MQL setup
Cutting tool and work material
CNC lathe machine, etc.

MQL (Minimum Quantity Lubrication) does just as its name suggests. It uses very little fluid to minimize pressure at the cutting tool and work piece interface in comparison to flood or dry conditions, it produces improved machining performance.

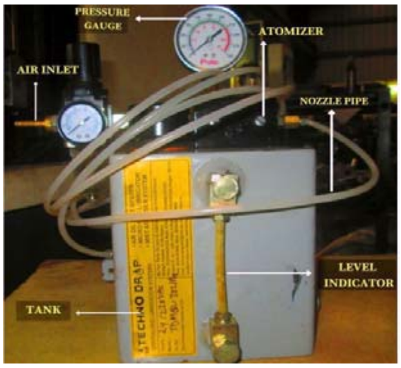

Fig 1: Minimum quantity lubrication (MQL) setup

2.1 Work material:

Titanium grade 5 (TI6AL4V) alloy is also known as "Commercially Pure Unalloyed Titanium". A 30mm diameter and 150mm length of this alloy is used as work material. As it is one of the hardest materials, it can full fill the requirement for the project. A set of turning experiments were done on this work material with a predefined set of cutting speeds, feed rates, depth of cut and cooling conditions.

Fig 2: Titanium grade5 (Ti6AL4V) alloy

2.2 chemical structure and Mechanical properties of TI6AL4V titanium grade 5 alloy.

Table 1: Chemical structure of TI6AL4V grade 5 alloy

Element	Ti	Al	V	Fe	O_2	C	N_2
Content (%)	87.6 - 91	5.5 - 6.75	3.5 - 4.5	≤ 0.25	≤ 0.20	≤ 0.08	≤ 0.05

Table 2: Mechanical properties of TI6AL4V grade 5 alloy

Property	Metric	imperial
tensile resistance	≥ 895 MPa	≥ 130000 psi
Strength of the yield	≥ 828 MPa	≥ 120000 psi
Ratio of Poisson	0.31	0.31
Modulus of elastic	105-120 GPa	15200-17400 ksi
Shear modulus	41-45 GPa	5950-6530 ksi
Breaking elongation	≥ 10 %	≥ 10 %
Reduction in area	20	20
Hardness rockwell	36	36
Fatigue strength	700Mpa	10200psi
Shear strength	760Mpa	110000psi

2.3 Physical properties of TI6AL4V

1. Melting range: 2,800-3,045°F (1,538 - 1,674°C)
2. Density0.160 lb/in3 (4.43 gm/cc)
3. Beta Transus Temperature: 1830°F (± 25); 999°C (± 14)

2.4 Cutting Tool

The job material was chosen because there was a scarcity of literature on this particular grade of titanium. Table 1 shows the chemical structure and table 2 shows the important mechanical properties. The tool inserts used were uncoated carbide inserts with a nose radius of 0.8 mm, a relief angle of 7 degrees, and a rake angle of 6 degrees. While the experimental work was mostly focused on sustainable production, cost efficiency was also considered, which justified the inserts chosen.

Fig 3: Uncoated Carbide Inserts (CNMG 120404)

CNMG A B C Specification:

C - Rhombic (Shape of the insert) with Nose Angle 800
N – 00 (Clearance/Relief Angle)
M - (Tolerance on size)
Corner point : 0.05 - 0.13 mm
Thickness : 0.13 mm
Inscribed circle : 0.05 - 0.15 mm
G - (Type of insert)
Hole shape : Cylindrical
Chip breaker type : Double sided
A - Cutting edge length, in mm B - Thickness, in mm
C - Nose radius, in mm

2.5 Nano-cutting fluid and MQL

MQL, a techno drap model was used in this experiment. The device was used to pulverize the Nano fluid and compressed air before delivering it to the machining zone. Preliminary studies were carried out prior to the main experiments to evaluate the main factors, which were then used in the main experiments, resulting in the following optimal operational parameters: The oil flow rate is 100ml/h, with a 45-degree spray angle and an 8-bar spray pressure. In the tests, During the creation of the Nano fluid 0.5 percent, cutting oil on vegetables with a kinematic viscosity is often measured in the CGS unit centistokes (cSt) of 10 cSt at 40°C, a refractive index of 1.46 N20D, and a flash point of 170°C was utilised., 1 percent, and 1.5 percent by volume of graphene nano particles were applied to the vegetable-based cutting oil during the preparation of the Nano fluid. To achieve a homogeneous mixture, graphene enriched Nano fluids were prepared in two stages. One of the most serious issues in the Cutting oil on vegetables with a kinematic viscosity of 10 cst at 40°C, a refractive index of 1.46 N20D, and a flash point of 170°C was used to make the Nano fluid 0.5 percent. Ascension However, these surfactants have a detrimental impact on the oil's properties (such as thermal conductivity). As a result, no surfactant was used in the preparation of the Nano fluid in this study.

3. Tools for Experimental Design and Measurement

In titanium grade 5 alloy feed rate, cutting speed and concentration ratio of nano particals were chosen as process parameters in turning experiments for TI6AL4V grade 5 alloy. Table 3 shows the levels of the aforementioned parameters, there are three variables in this experimental analysis, each of three stages. To allow efficiency Control factors and their interactions are differentiated, Taguchi's L27 experimental architecture was used. Surface roughness and instrument life were the experimental design's responses, apart from this experimental design, to clearly see the effect of concentration rates on surface roughness flank wear and crater wear, three runs were carried out at each concentration ratio (0.5, 0.1, and 0.15 vol percent) while maintaining the cutting parameters (feed rate of 0.12mm/rev and cutting speed of 100m/min) and machining time.

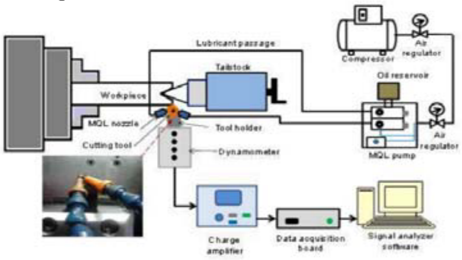

Fig 4: MQL experimental setup

3.1 Process parameters in turning and their levels.

Table 3: levels of the process parameters of TI6AL4V grade 5 alloy.

symbols	Process parameters	units	Levels		
			1	2	3
V	Cutting speed	RPM	100	150	200
D	The depth of the cut	MM	0.2	0.3	0.4
F	Feed rate	MM/REV	0.10	0.15	0.20
CT	Coolant type		1	2	3

3.2 The experimental plan, the experimental outcomes, and the ratios that were computed

Table 4: experimental plan and outcomes results

Run	Speed m/min	Feed mm/rev	Depth of cut	Cooling Condition	Ra µm	Flank wear Mm	Crater Wear Mm
1	150	0.2	0.4	2	1.38	0.41	0.37
2	150	0.15	0.3	2	1.36	0.36	0.33
3	150	0.15	0.4	1	1.90	0.49	0.48
4	100	0.15	0.3	3	0.95	0.28	0.24
5	100	0.15	0.2	2	1.45	0.34	0.31
6	150	0.15	0.2	3	0.79	0.20	0.15
7	150	0.2	0.3	3	0.86	0.31	0.25
8	150	0.15	0.3	2	1.36	0.37	0.34
9	200	0.15	0.3	1	1.75	0.47	0.45
10	150	0.1	0.4	2	1.35	0.39	0.36
11	150	0.15	0.4	3	0.82	0.28	0.25
12	150	0.1	0.2	2	1.31	0.33	0.28
13	200	0.15	0.3	3	0.40	0.26	0.22
14	100	0.15	0.4	2	1.47	0.43	0.41
15	200	0.1	0.3	2	1.06	0.35	0.31
16	150	0.1	0.3	1	1.83	0.45	0.43
17	100	0.2	0.3	2	1.51	0.43	0.4
18	200	0.2	0.3	2	1.18	0.35	0.32
19	100	0.1	0.3	2	1.44	0.43	0.39
20	150	0.15	0.3	2	1.36	0.36	0.33
21	200	0.15	0.2	2	1.13	0.33	0.27
22	100	0.15	0.3	1	1.98	0.47	0.46
23	150	0.15	0.3	2	1.36	0.37	0.35
24	150	0.15	0.3	2	1.36	0.36	0.34
25	150	0.2	0.2	2	1.37	0.33	0.3
26	150	0.2	0.3	1	1.96	0.47	0.44
27	150	0.1	0.3	3	0.61	0.24	0.21
28	150	0.15	0.2	1	1.86	0.43	0.42
29	200	0.15	0.4	2	1.15	0.42	0.38

4. DISCUSSION AND RESULTS

4.1 Taguchi technique

A loss function was used by Genichi Taguchi, which is the difference between the experimental and target values, which is then translated into the S/N ratio. The S/N ratio is the ratio of the mean to the standard deviation. Taguchi coined the terms "signal" and "noise," which refer to the response's desired (mean) and undesirable (standard deviation) values, respectively. Based on the specifications Taguchi classified the S/N ratio into three ranges based on response requirements: The better the medium, the better the higher, and the better the lower. The higher the machinability, the lower the efficiency metrics like Ra and Vb and crater wear are in this analysis. Means of the mean map, based on the S/N ratio maps, The results of the analysis of variance (ANOVA) were obtained, and discussed within the following discussion using the Minitab 19.0 software method.

4.2 Process parameters have an impact on turning performance surface roughness characteristics, crater wear & flank wear

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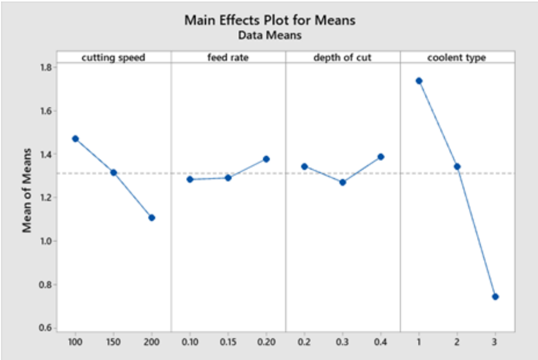

Fig 5: Means of surface roughness

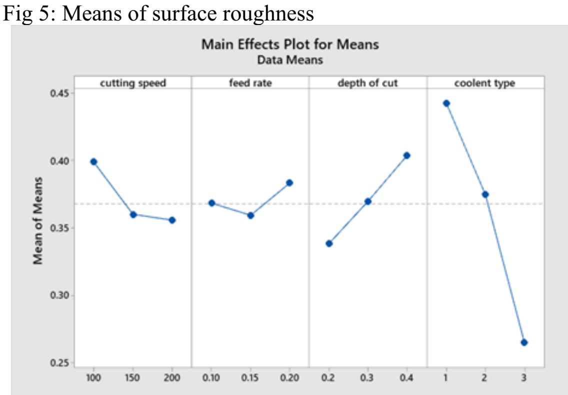

Fig 6: Means of flank wear

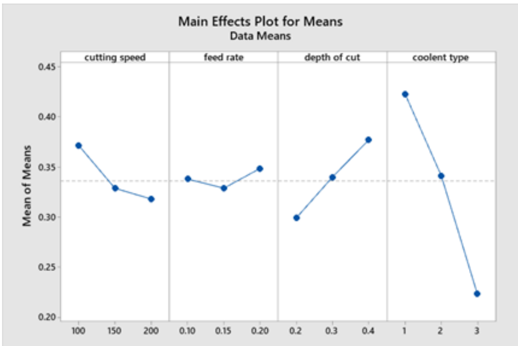

Fig 7: Means of crater wear

Cooling Conditions: 1 - Dry Machining, 2 - Soya bean MQL, 3 - Graphene Nano fluid MQL

The effect of Surface roughness and process parameters is depicted in Figure 5. It was discovered that as cutting speed increases, Ra decreases. This is due to increased pressure between the tool and the work piece as the cutting speed increases, resulting in higher cutting temperatures in the machining region, causing work piece thermal softening Lowest surface roughness due to reducing the number of smeared products on the surface of the machined' The Ra value improved when the rate of feed increases, as seen in Figure6. As the rate of feed increases, the work piece causes the more built-up edges on the result of the tool's flank face an eroded surface. It was discovered that as the depth of cut decreased, the Ra value increased as well. The surface roughness patterns obtained in the current study at Increasing the cutting speed, feed rate, and depth of cut, as needed, were consistent with previous findings in the During the machining of difficult-to-cut materials.

As shows the above Figure 6 reveals that flank wear increases Cutting speed, feed rate, and cut depth all increases. This is because the machining zone temperature rises as the cutting speed, feed rate, and depth of cut increase it causing more heat to concentrate on the tool's flank face, resulting in increased flank wear. These tool wear patterns are consistent with what has been discovered in the literature. By comparing MQL and dry cooling conditions, it was discovered that the cryogenic atmosphere had less flank wear. Because of the low-temperature LN2 spraying during the machining, site, the machining zone temperatures are low.

4.3 Optimal cutting conditions for Ra, Vb, and crater wear are chosen.

Table 4 shows response table based on the S/N ratio for surface roughness (Ra).The graph of the average S/N ratio obtained with the Minitab is a piece of software that allows you to keep track is shown in Figure 4. A S/N ratio that is higher indicates that the gap between what is desired and what is measured is as small as possible. speed of Cutting200 rpm, 0.10 mm/rev feed velocity, 0.4 mm depth of cut, and coolant form of cryogenic coolant are the parameters with the S/N ratio with the highest average for Ra, as seen in Figure 5. As a result, the expected process parameters that are optimal for achieving Using low surface roughness the Taguchi technique was discovered to be v = 200rpm, f=0.10mm/rev, d=0.4mm, CT stands for cryogenic coolant, as well as the related levels in Table 4.

4.4 Mean S/N ratio response table for surface roughness.

Table 5: S/N ratio for surface roughness

Level	Cutting speed	feed rate	depth of cut	coolant type
1	-3.16	-1.77	-2.30	-4.70
2	-1.97	-1.56	-1.45	-2.51
3	-0.01	-2.56	-2.54	2.91
Delta	3.14	1.00	1.08	7.61
Rank	2	4	3	1

4.5 mean S/N ratio response for tool flank wear.

Table 6: S/N ratio for flank wear

Level	Cutting speed	feed rate	depth of cut	coolant type
1	8.11	8.81	9.61	7.12
2	9.07	9.14	8.80	8.56
3	9.12	8.40	8.00	11.60
Delta	1.01	0.73	1.61	4.48
Rank	3	4	2	1

4.6 Mean S/N ratio response table for crater wear.

Table 7: S/N ratio for crater wear

Level	Cutting	feed	depth of	coolant

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	speed	rate	cut	type
1	8.78	9.61	10.84	7.54
2	9.98	10.08	9.60	9.40
3	10.18	9.28	8.66	13.15
Delta	1.39	0.79	2.17	5.60
Rank	3	4	2	1

4.3.1 Effect of process parameters on surface roughness (Ra) & flank wear (Vb) and crater erosion

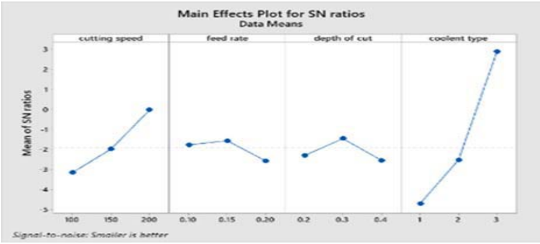

Fig 8: Surface roughness S/N ratio smaller is better

Fig 9: Tool flank wear S/N ratios smaller is better

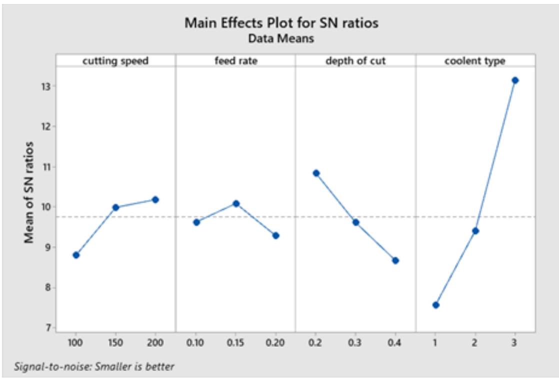

Fig 10: Crater wear's average S/N ratio smaller is better
Where: Cooling Conditions: 1-Dry Machining, 2-Soya bean MQL, 3 - Graphene Nano fluid.

It was discovered that as cutting speed increases, Ra increases and depth of cut decreases, the Ra value improved when the rate of feed increases, Figure 9 reveals that flank wear increases as cutting speed, feed rate, and depth of cut increase. This is because as cutting speed, feed rate, and depth of cut increase, the machining zone temperature rises, causing more heat to concentrate on the tool's flank face, resulting in increased flank wear.

4.3.2 For Ra,Vb and crater wear ANOVA was used.

ANOVA identifies a process variable that has the greatest impact on efficiency. Table 8 and Table 9 & 10 display the Results of ANOVA for Ra and Vb, as well as crater wear, respectively. Cutting speed comes first, then feed rate, coolant form, and the depth of the incision, all have a major impact on surface roughness Ra, as seen in table 8. demonstrates that cutting speed and feed rate, coolant form, and depth of cut all contributed 10.562%, 1.959%, 2.065%, 73.248%, 12.165%to Ra, respectively, the percentage contributions of coolant, cutting speed, and feed rate form on Vb, the cut depth is measured 4.741%,4.314%, s8.467%, 69.74%, respectively. According to the ANOVA study, cutting piece had a major impact on both Ra and Vb and crater wear.

Table 8: ANOVA of surface roughness

Source	DF	Seq SS	Adj MS	%Of contribution
cutting speed	2	27.43	11.75	10.56
feed rate	2	5.08	0.31	1.95
depth of cut	2	5.36	0.99	2.06
coolent type	2	190.27	95.13	73.24
Residual Error	18	31.60	1.75	12.16
Total	26	259.75	109.95	99.99

Table 9: ANOVA of flank wear

Source	DF	Seq SS	Adj MS	%of contribution
cutting speed	2	4.39	1.95	4.74
feed rate	2	3.99	0.636	4.31
depth of cut	2	7.84	4.07	8.46
coolent type	2	64.63	32.31	69.74
Residual Error	18	11.79	0.65	12.72
Total	26	92.66	39.63	99.99

Table 10: ANOVA of crater wear

Source	DF	Seq SS	Adj MS	%of contribution
cutting speed	2	7.39	2.86	5.09
feed rate	2	5.15	0.53	3.5
depth of cut	2	13.64	7.19	9.39
coolent type	2	101.57	50.78	69.86
Residual Error	18	17.48	0.97	12.03
Total	26	145.26	60.35	99.93

4.7 Modelling

In this research, Minitab 19.0 software was used to do linear regression analysis to create predictive mathematical models for the Vb and Ra dependent variables as a function of feed rate, cutting speed, depth of cut, and cooling environment. Each response hasn't been altered in any way. The prediction equations derived from the regression study respectively for Vb and Ra and crater wear are

Flank wear = 0.499-0.000*v +0.068*f +0.305*d 0.087*CT (1)

Surface Roughness = 2.805-0.003*v +0.236*f -0.064*d -0.4935*CT (2)

Crater wear = 0.494-0.000*v +0.018*f +0.363*d -0.098*CT (3)

Nomal probability plot response to flank wear is shown in figure 11. Flank wear is increasing with increasing the percentage of process variables

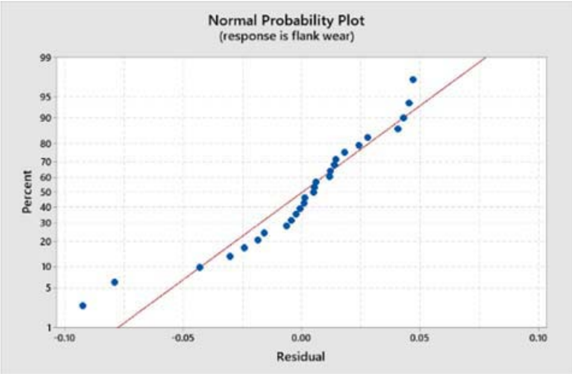

Fig 11: Flank wear

Nomal probability plot response to surface roughness is shown in figure 12. surface roughness is increasing with increasing the percentage of process variables

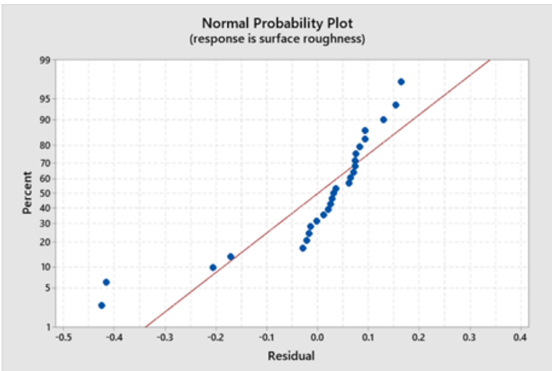

Fig 12: Surface roughness

Nomal probability plot response to crater wear is shown in figure 13. Crater wear is increasing with increasing the percentage of process variables

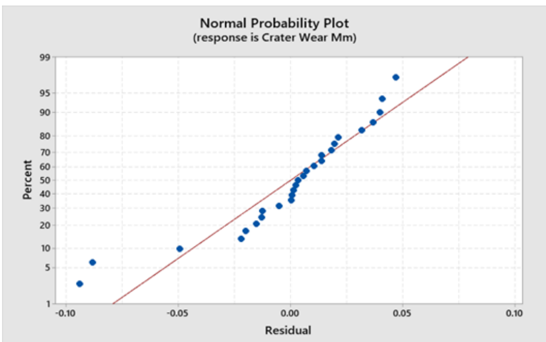

Fig 13: Crater wear

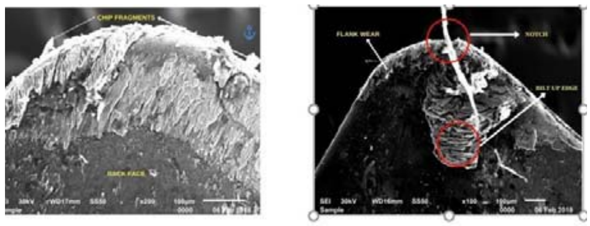

Fig 14: Tool wear morphology in dry machining

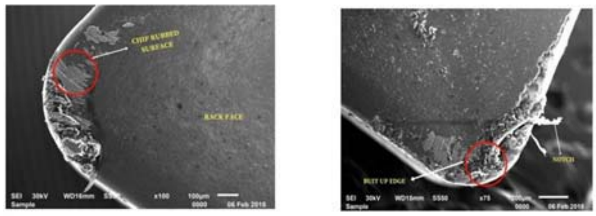

Fig 15: Tool wear morphology in MQL machining

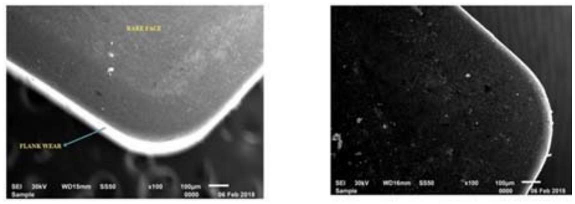

Fig 16: Tool wear morphology in NFMQL machining

Fig 14, 15 and 16 are get by giving input parameters inthe design export software, from this above figure we can conclude that, by using Graphene nano fluid based Minimum quantity lubrication technique with vegetable oil-based cutting fluid for turning of TI6AL4V grade 5 alloy with uncoated carbide insert, better output results are achieved with reduced cost of machining when compared with conventional machining.

5. CONCLUSION

The current study centered on the effects of graphene tool presence and nano particle concentrations and machining parameters, roughness on the surface and worn on the flanks and crater wear when turning of titanium TI6AL4V alloy with CNMG 120404 uncoated carbide insert. To obtain expected models, Taguchi techniques with multi regression equations (linear) were used. Validation experiments were completed at the end. S/N ratios are used to define parameter classes that have optimal wear on the flanks and minimal surface roughness, the cutting speed of 194.191 m/min at a feed rate of 0.18 mm/rev with a depth of cut of 0.27 mm, Optimum responses such as Surface roughness, Tool wear can be achieved as the feed rate increases, roughness can also increase. At minimum cutting speed, the surface roughness value is high and at high speeds, the roughness gets decreased. Depth of cut plays a key role while the change in cutting force Cutting force increases as the depth of cut increases.

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