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INFLUENCE OF NANO-AL_2O_3 PARTICULATES WITH MUSTARD OIL AS CUTTING FLUID IN TURNING OPERATION

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***Abstract*—Nano-fluids are used widely to reduce the negative effects of the heat and friction on both tool and work piece. Nanofluid prepared in this work is mustard oil with Al2O3 nano powder and water mixed with Al2O3 nano powder. The aim of this work is to determine the effect of Nano-fluids and cutting parameters on tool bit temperature, work piece temperature, surface roughness, material removal rate and cutting forces in turning of mild steel material. The cutting operations were carried out on a conventional lathe machine with High Speed Stainless Steel as a cutting tool at different spindle speeds (N), feeds and depth of cut. It observed material removal rate is increase of Al2O3 and mustard oil compared to the Al2O3 and water nanofluids as well surface roughness is poor.**

Keywords— ***Nano Cutting Fluid; Mustard oil; Nano Al_2O_3; MRR; Surface roughness; Depth of Cut***

1. INTRODUCTION

Cutting fluids are used in machining to diminish friction, lessen the workpiece and wipe away the chips. With the utilization of cutting fluid, the tool wear reduces and machined surface quality rises. Usually the cutting fluids also keep the machined surface away from corrosion. They also diminish the cutting forces which occur in the managing of power. [1]–[3]. A radical development in the need for friendly lubricants by customs and stringent state laws for the adoption of these lubricants as brought a moment to use plant oils as biodegradable lubricants. Therefore, vegetable oils have been studied to take over oil lubricants. The result of lubricants like Nanofluids was based on vegetable oil or water as a base fluid. It affects this to the specialized properties and the objective estimate of vegetable oils and water. Nanofluids are helped to shorten the negative effects of the warmth and friction on both tool and workpiece[4], [5]. The cutting fluids produce three specific effects in the process such as heat elimination, lubrication on the chip–tool interface and chip replacement. Issues of handling fluids in machining related to ecosystem, health, and construction cost are desire to be clarified and benefits to reduce their usage allows to be reached for this modern trend lubricant[6]–[9].

In the enterprise, oftenest arises in reciprocal contact (i.e., bearings, isolates and gears) were greased with special oils to limit friction and wear. Many scientific investigators have been reported on the tribological properties of nanoparticles–based lubricants and the facts regarding any automatic process in relationship to friction and wear, depend upon the aspects of the nanoparticles, such as shape, size and combination within the lubricant. The excerpt of cutting fluid based on (i) machining processes (ii) workpiece material and (iii) cutting tool material. Several empirical and scientific procedures have been established for the measurement of conditions achieved in cutting processes. Das et al. [1] investigation on effect of cutting fluids on various machining forces, tool flank wear and chip thickness are carried-out using the minimal quantity lubrication system (MQL). The results exhibited flank wear and, nanofluid were offered good with water soluble coolant and compressed air. Sun et al. [10] worked on new cooling approach with cryogenic compressed air during turning on Ti–6Al–4V alloy. They investigated cutting forces, chip design and chip temperature at dry condition. The bringing about of cryogenic compressed air on the cutting force and chip formation diminishes with a raise in cutting velocity and feed rate.

This research probes the agglomeration condition of stock nanopowder and the sum of dispersion energy required to attain optimum nanofluid dispersion. This exploration work directed to assume the variation of tool tip temperature, work piece temperature, surface finish, and material removal rate, cutting forces during machining with varying coolant such as Al2O3-water and Al2O3-mustard oil.

2. Materials and Methods

Alumina is the most cost efficient and used substance in the group of engineering ceramics.

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Alumina nano particles are light, nontoxic and non-sparking. The dry powder taken for this analysis was Nanotech alumina nanopowder from Nano phase technologies with a grain diameter of 50nm, vide in Fig.1b. Oil seed crops occupy a significant aspect in the horticulture and industrial recession of the province like India. Mustard Oil is likewise one of the significant oil nuts from which it produces edible oil. The Mustard Oil cake is utilized as cattle feed.

(a) (b)

Fig. 1 Aluminium oxide (a) Powder (b) Particulates

Table 1 Weight percent of mustard oil and Al2O3 for sample preparation

Type of oil	Volume (ml)	% Al_2O_3	% of Fluid
Mustard + Al2O3	200	2	98
Water + Al2O3	200	2	98

To examine the distribution of nanoparticle size in the nanofluids, by employing various base fluids (water and mustard oil) and aluminium oxide as filler for establishment of 200 ml samples was able. They usually use magnetic stirrers in biology and anthropology, where they can be applied inside closed vessels or operations, with no complicated rotary seals. It uses Mildsteel workpiece with diameter ø25mm and width 100 mm work material. Different lubricants are Al2O3 amalgamation of Mustard oil and water nano lubricants shown in Table 1 and in Fig. 2. The nanolubricant with no added surfactant often agglomerates after 4 hours. The additional mustard oil surfactant into the pure nanolubricant helps to curtail the agglomeration and build strong bonding between the base oil and the nanoparticles. The surfactant contributes substantially to the dispersion stability of Al2O3 nanolubricant. Fig. 2 illustrates the tendency of nanolubricant pure and nanolubricant with additional mustard oil. These materials are used grade in automobile corporations and machine tool industries. The machining effective parameters such as speed, feed and depth of cut were adopted in this examination. It identified cutting forces with lathe tool dynamometer. Surface roughness often slashed to roughness, is a factor of surface texture measured with Talysurf (Model: TR200). Temperature guns have electronic sensors (Model: HTC MT-4) that implement them to gather the value of heat energy arriving from a substance whose heat would otherwise be complex to control. The material removal rate (MRR) can be determined from the volume of material removal or from the weight change before and after machining.

(a) (b)

Fig. 2 Amalgamation of Al2O3 in water and mustard oil lubricants

3. EXPERIMENTAL RESULTS AND DISCUSSION

3.1. Infulance of Temperatures on workpiece and tool bit

Identified the driving temperature condition of tool and work piece at steady acceleration of 300 rpm and feed of 0.5 mm/s with changing depth of cut (i.e. 0.5, 1, and 1.5mm). In this petition, three types of cutting fluids with nano particulates (Al_2O_3) are employed (i) Mustard oil (ii) Water (iii) Engine oil. It indicates the achieved results in Fig. 3. The temperature is one of the most influential aspect which affects tool behavior and tool operation. It is noted that the cutting temperature during MQL condition is cheaper than dry and wet turning. In MQL the cutting fluid molecules can stand up to tool chip interface in the forge of short slips. During wet turning, the heat is elicited only by convective heat transfer, but MQL facilitates both convective and evaporative heat transfer contributes to dropping of cutting temperature[11].

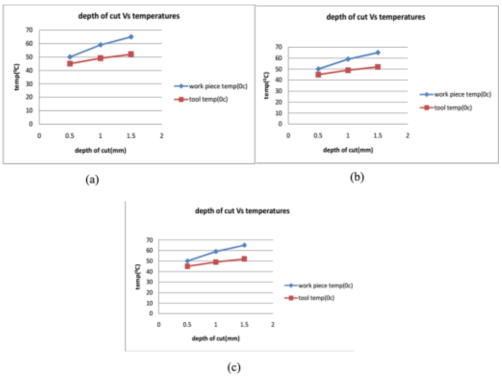

Fig. 3 Depth of Cut Verses Temperature **(a)** Al2O3-mustard oil (b) Al2O3-water (c) Engine oil (20w-40) as cutting fluid

3.2. Evalution of Cutting forces

Influence of velocity, feed , cutting fluid and depth of cut on cutting forces along longitudinal and transverse axis as illustrated in Fig. 4. The results were reported lower cutting forces of mustard oils can be associated to better lubricate, greater viscosity index, and further thermal conductivity related to mineral oils. This is because the altered version has better protection to molecular breakdown or an atomic rearrangement at a greater temperature, for it improved which the existence or omission of oxygen particles[12].

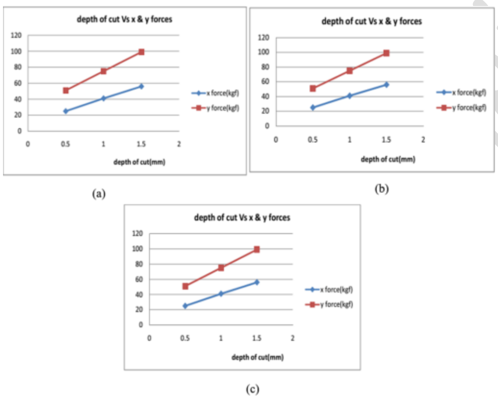

Fig. 4 Depth of cut Verses cutting forces (a) Al2O3-mustard oil (b) Al2O3-water (c) Engine oil(20w-40) as cutting fluid

3.3. Influence of Surface roughness (SR) and Material Removal Rate (MRR)

Effective parameters such as speed, feed and depth of cut were affected on MRR and SR. the speed and feed were retained as steady at 360 rpm and 0.5mm, respectively with changing depth of cut and composition of cutting fluid. Nano particles with mustard oil exhibited low surface roughness with maximising MRR, as revealed in Fig. 5a and Fig. 5a. During MQL condition, it correctly places fluid at the contact of the tool and the work piece. Hence the chips are quickly pulled out and provide better surface finish.

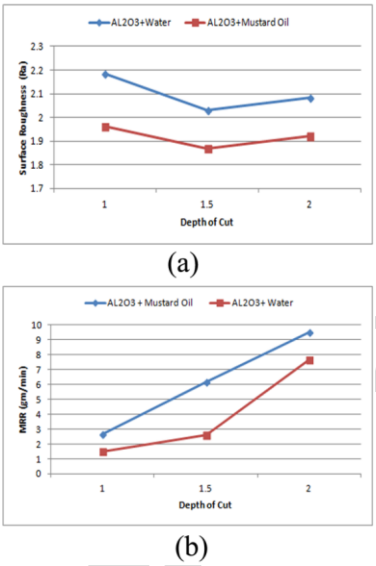

Fig. 5 (a) Depth of cut verses surface roughness (b) Depth of cut verses MRR

While wet machining with pure nanolubricant shows lowest gain of average tool wear throughout the experiment. It is obvious that wet machining by using nanolubricant with mustared oil shows an extremely warm and approximately the same kind of average tool wear as the pure nanolubrication. The variation in average tool wear between the two wet machining conditions becomes less important towards the end of the experiment. This proves that considerable aid of nanolubricant with mustared oil on the expansion of tool life. Hence, the modern system of nanolubricant with surfactant produces a tremendous potential in extending the life of cutting tools and diminishing the agglomeration of suspended nano particles in the base fluid.

4. CONCLUSIONS

The present effort has showed preparation and synthesis of Al_2O_3 and mustard oil, Al_2O_3 and water amalgamations nano cutting fluids with various 3gm weight proportion of filler Al_2O_3 and its functions in lathe turning on mildsteel. The surface roughness (Ra), Tool and work piece temperature, material removal rate and cutting forces were tested at various sequences of machining parameters. We reached the ensuing developments, in this effort.

- There is a reduction of 22°C in tool bit and 13.9°C in workpiece using Al_2O_3 and water amalgamation nano lubricant compared to using Al_2O_3 and mustard oil
- There is a reduction of 6kgf of force in x direction and 5.3kgf of force in y direction by using Al_2O_3 and water amalgamation nano lubricant compared to using Al_2O_3 and mustard oil

- It is observed that material removal rate is increase of 2.4gm in $Al_2O_3$and mustard oil compared to the Al_2O_3 and water nanofluids at speed 360rpm and feed of 0.5mm.
- It is observed that surface roughness is poor of 0.18microns by using Al_2O_3 and water compared to Al_2O_3 and mustard oil

Hence, it is concluded that cooling effects and cutting forces are optimum in Al_2O_3 and water amalgamation nano lubricant compared to using Al_2O_3 and mustard oil. Also, it is concluded that higher material removal rate and fine surface finish will obtain by using Al_2O_3 and mustard oil compared to the Al_2O_3 and water.

REFERENCES

[1] A. Das, S. K. Patel, B. B. Biswal, N. Sahoo, and A. Pradhan, “Performance evaluation of various cutting fluids using MQL technique in hard turning of AISI 4340 alloy steel,” *Meas. J. Int. Meas. Confed.*, vol. 150, p. 107079, Jan. 2020.

[2] A. DAS, S. Patel, B. Biswal, and S. Das, “Performance evaluation of aluminium oxide nano particles in cutting fluid with MQL technique in turning of hardened AISI 4340 alloy steel,” *Sci. Iran.*, vol. 0, no. 0, pp. 0–0, 2019.

[3] H. Hegab, U. Umer, I. Deiab, and H. Kishawy, “Performance evaluation of Ti–6Al–4V machining using nano-cutting fluids under minimum quantity lubrication,” *Int. J. Adv. Manuf. Technol.*, vol. 95, no. 9–12, pp. 4229–4241, 2018.

[4] A. Ghadimi and I. H. Metselaar, “The influence of surfactant and ultrasonic processing on improvement of stability, thermal conductivity and viscosity of titania nanofluid,” *Exp. Therm. Fluid Sci.*, vol. 51, pp. 1–9, 2013.

[5] R. Siva Sankar Raju, G. Srinivasa Rao, and M. Muralidhara rao, “Optimization of Machinability Properties on Aluminium Metal Matrix Composite Prepared By In- Situ Ceramic Mixture Using Coconut Shell Ash - Taguchi Approach,” *Int. J. Conceptions Mech. Civ. Eng.*, vol. 3, no. 2, pp. 17–21, 2015.

[6] H. Hegab, U. Umer, I. Deiab, and H. Kishawy, “Performance evaluation of Ti–6Al–4V machining using nano-cutting fluids under minimum quantity lubrication,” *Int. J. Adv. Manuf. Technol.*, vol. 95, no. 9–12, pp. 4229–4241, 2018.

[7] A. Saini, S. Dhiman, R. Sharma, and S. Setia, “Experimental estimation and optimization of process parameters under minimum quantity lubrication and dry turning of AISI-4340 with different carbide inserts,” *J. Mech. Sci. Technol.*, vol. 28, no. 6, pp. 2307–2318, 2014.

[8] J. Shah, M. Ranjan, K. P. Sooraj, Y. Sonvane, and S. K. Gupta, “Surfactant prevented growth and enhanced thermophysical properties of CuO nanofluid,” *J. Mol. Liq.*, vol. 283, pp. 550–557, 2019.

[9] R. Rosnan, M. N. Murad, A. I. Azmi, and I. Shyha, “Effects of minimal quantity lubricants reinforced with nano-particles on the performance of carbide drills for drilling nickel-titanium alloys,” *Tribol. Int.*, vol. 136, pp. 58–66, 2019.

[10] S. Sun, M. Brandt, and M. S. Dargusch, “Machining Ti-6Al-4V alloy with cryogenic compressed air cooling,” *Int. J. Mach. Tools Manuf.*, vol. 50, no. 11, pp. 933–942, Nov. 2010.

[11] R. WAYDANDE and D. GHATGE, “Performance Evaluation of Different Types of Cutting Fluids in the Machining of Hardened Steel – A Review,” *Int. J. Mech. Prod. Eng.*, vol. 4, no. 3, pp. 34–39, 2016.

[12] L. Yang, K. Du, X. S. Zhang, and B. Cheng, “Preparation and stability of Al2O3 nano-particle suspension of ammonia-water solution,” in *Applied Thermal Engineering*, 2011, vol. 31, no. 17–18, pp. 3643–3647.