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Influence of nano solid lubricant emulsions on surface roughness of mild steel when machining on lathe machine

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ABSTRACT

Now a day's turning process is a widely used metal removal process in manufacturing industry that involves generation of high cutting forces and temperature. Lubrication becomes critical to minimize the effect of these forces and temperature on cutting tool and work piece. For this specific study investigation carried out to increase the surface finish of the work piece machined on lathe with addition of nano particles were synthesized by solution combustion process and size was found to be 28 nm from X-Ray Diffraction [XRD]. A thin layer of Al_2O_3 nano particles on steel can be obtained by various means i.e., liquid and solid process of particle deposition under various machining process. While turning of mild steel rod, three parameters are varied i.e., spindle speed, feed rate and depth of cut. During machining Al_2O_3 nano particles are sprayed over it. This will lead to form a thin layer over the surface that will change in properties like surface roughness and hardness. Observed better surface roughness for coated material compared to that of base material. Coating thickness also observed at various conditions during machining process.

Keywords: XRD; Al_2O_3 nano particles, Surface roughness, coating thicknes and Hardness

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INTRODUCTION

Now a day's turning process is a widely used metal removal process in manufacturing industry that involves generation of high cutting forces and temperature. Lubrication becomes critical to minimize the effect of these forces and temperature on cutting tool and work piece [1].A lubricant is the substance which reduces the friction between two surfaces which are sliding one over the other. Common solid lubricants are layered compound likegraphite, molybdenum disulphide (MoS_2) and tungsten disulphide (WS_2) [2]. Their layer slide apart each other to reduce friction, but layered compounds have drawbacks [3]. In this study, we prepared Al_2O_3 nano particles by solution combustion process and deposited over a mild steel rod during different machining conditions on lathe machine. The crystal size of Al_2O_3 nano particles are tested by using X-ray diffraction (XRD). The surface roughness of the samples is tested by using SJ-310 Portable Surface Roughness Tester. The hardness of the samples is tested by using Rockwell hardness before and after spraying of Al_2O_3 nano particles[4].After spraying of Al_2O_3 nano particles on mild steel, the thickness of the coated material is study by using coating thickness gauge [5]. At condition 835 rpm, the hardness decreases as the coating thickness increases because the deposition of Al_2O_3 nano particles is more on the specimen.

MATERIALS AND METHODS

Materials Used:
Composition of the base material as shown in the Table 1.

Table 1: Composition of the Mild steel

Iron (%)	Carbon (%)	Manganese (%)
99.3	0.25	0.45

- Work material: Mild Steel
- Material size: 50x10mm
- Tool material: High Speed Steel
- Solid lubricant: Al_2O_3 nanoparticle size of 28nm

Synthesis of Al_2O_3 nano particles
Aluminium oxide is prepared by Solution combustion process. Stoichiometric mixture of Aluminium Nitrate and Urea are taken into beaker and stirred it for 30 minutes on a magnetic stirrer and place it on a hot plate (~1000°c).

$$2[Al\ (NO_3)_3 9H_2O] + 5[NH_2CONH_2] \longrightarrow Al_2O_3 + 5CO_2 + 28\ H_2O + 8N_2$$

Heating rapidly the solution containing the redox mixture boils, frothing, smouldering, flaming, fumes and catches fire and burns with an in candescent flame to yield Al_2O_3 with evolution of large amount of gases like carbon dioxide, Hydrogen Oxide in the form of flames [6].

Parameters Selection in Machining Process: The following parameters and various conditions are selected during machining process as shown in Table 2.

Table 2: Parameters selected in the turning process

Speed	Carriage speed	Feed rate
305	22	0.3
500	36	0.5
835	63	0.7

Experimental Work
During turning process, a layer of material is removed with respect to the parameters as shown in Table 2. These samples were prepared according to standard dimensions for testing hardness and surface roughness. The Al_2O_3 nano particles of size 28 nm are deposited on mild steel during turning process for various conditions.

Surface Roughness
After machining the samples, at different speeds and feed rates the surface roughness of the base metals are tested by using SJ-310 Portable Surface Roughness Tester [7]. And after spraying Al_2O_3 nano particles on metals again the surface roughness of the metal is tested.

Rockwell Hardness
After machining the samples, at different speeds and feed rates the hardness of the base metals are tested by using Rockwell hardness. After spraying of Al_2O_3 nano particles on mild steel again the samples are tested for hardness.

Coating Thickness
After spraying of Al_2O_3 nano particles on mild steel, the thickness of the coated material is study by using coating thickness gauge. Due to temperature and speed difference the coating thickness varies. The following mechanical properties are tested under various conditions of the parameters as shown in Table 3.

Table 3: Mechanical properties are varied with respect parameters

S.No.	Speed	Carriage speed	Feed rate	Surface roughness (Base metal)	Surface roughness (After spraying)	Hardness (Base mental)	Hardness (After spraying)	Coating thickness (After spraying)
1	305	22	0.3	7.185	4.496	65.2	62.57	8.96
2	305	22	0.5	5.935	4.496	60.54	58.42	9.76
3	305	22	0.7	6.351	4.483	65.54	70.52	8.96
4	500	36	0.3	4.213	2.266	70.84	68.6	2.88
5	500	36	0.5	6.023	3.14	56.7	62.5	5.44
6	500	36	0.7	6.990	1.68	68.5	66.2	3.84
7	835	63	0.3	4.335	4.36	68.3	70.2	6.24
8	835	63	0.5	6.390	5.053	65.8	65.57	8.11
9	835	63	0.7	5.807	4.36	69.5	58.22	9.76

RESULTS AND DISCUSSION

X-ray diffraction analysis (XRD):

In the XRD pattern of the Al_2O_3 nano particles, the peaks are observed at 25.560°, 35.140°, 37.770°, 43.340°, 52.560°, 57.480° and 68.180°. The (h k l) values of the peaks are (0 1 2), (1 0 4), (1 1 0), (1 1 3), (0 2 4), (1 1 6) and (3 0 0) respectively. These results are coincided with JCPDS card number 77 – 2135, and it shows that the Al_2O_3Nano particles having the Rhombohedra structure. The average crystalline size is measured using the Debye-Scherer's formula.

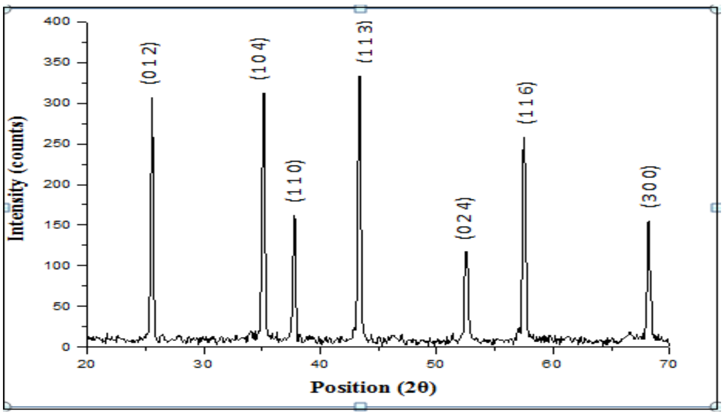

Fig.1. XRD Pattern of Al_2O_3 nano particles

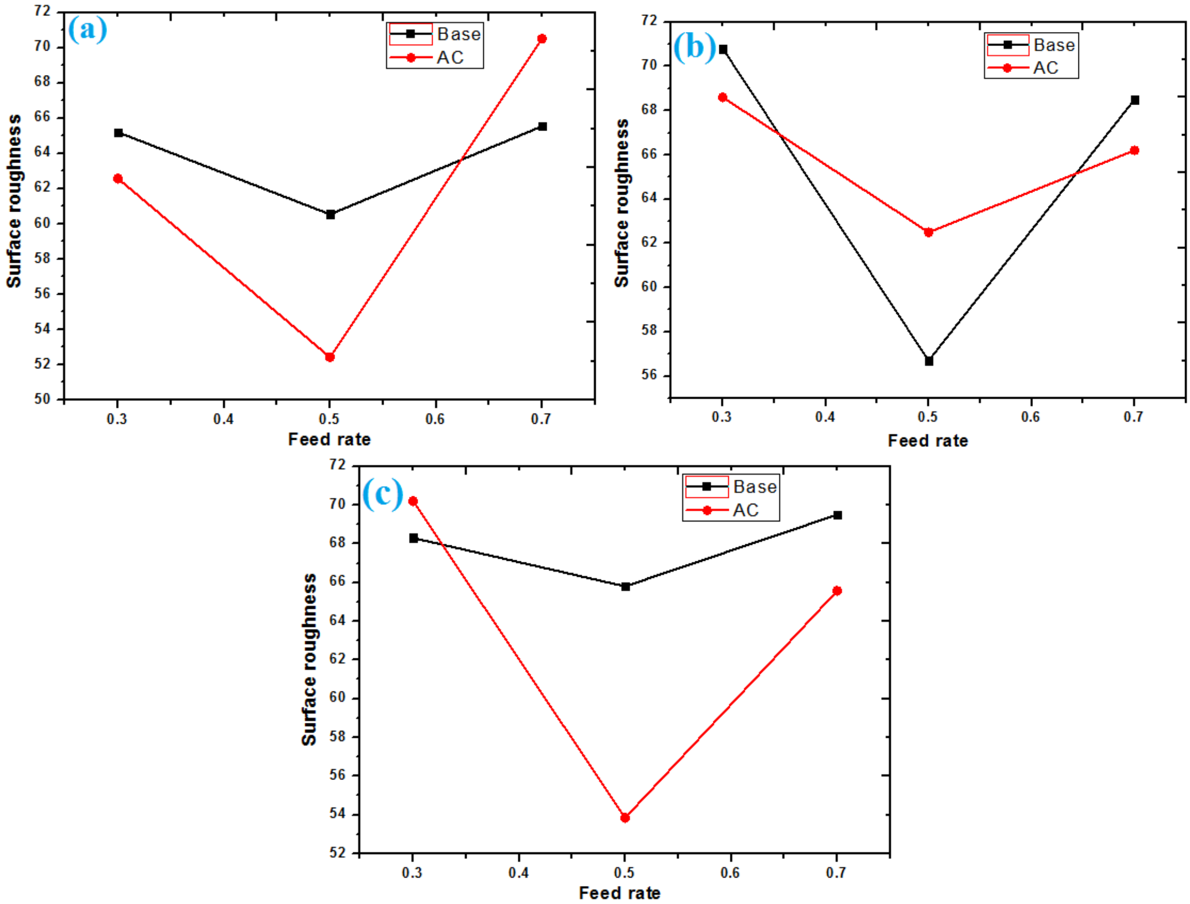

Fig.2. Surface roughness variation with feed rate at different speeds
(a) 305rpm (b) 500rpm (c) 835rpm

Surface Roughness

At rotational speed 305 rpm, initially the surface roughness of the base metal is high due to low speed. As the feed rate increases the surface roughness of the base metal varies correspondingly. After deposition of Al_2O_3 nano particles on mild steel, the surface roughness shows constant due to low rotational speed which results low friction at any feed rate. The surface roughness increases with increasing feed rate due to moderate rotational speed (i.e. 500 rpm) for base material. After coating, the surface roughness increases initially and then decreases with increasing feed rate due to temperature variation during turning process. But at higher rotational speed, the trend of the surface roughness increases with increasing feed rate both in base metal and coated metal due to temperature generated. Due to higher rotational speed, the nano particles are not spread properly on the surface as shown in Figure 2.

Rockwell Hardness

The behaviour of the hardness variation with increasing feed rate in both cases (i.e. before coating and after coating) is similar. Initially the hardness decreases then increases with increasing feed rate. The hardness is high at higher feed rate due to high friction generated which results good reaction betweenAl_2O_3 nano particles and mild steel. The same trend happened even at moderate rotational speed (i.e. 500 rpm). But at high rotational speed,the hardness decreases due to more deposition of Al_2O_3 nano particles on mild steel as the feed rate increases.

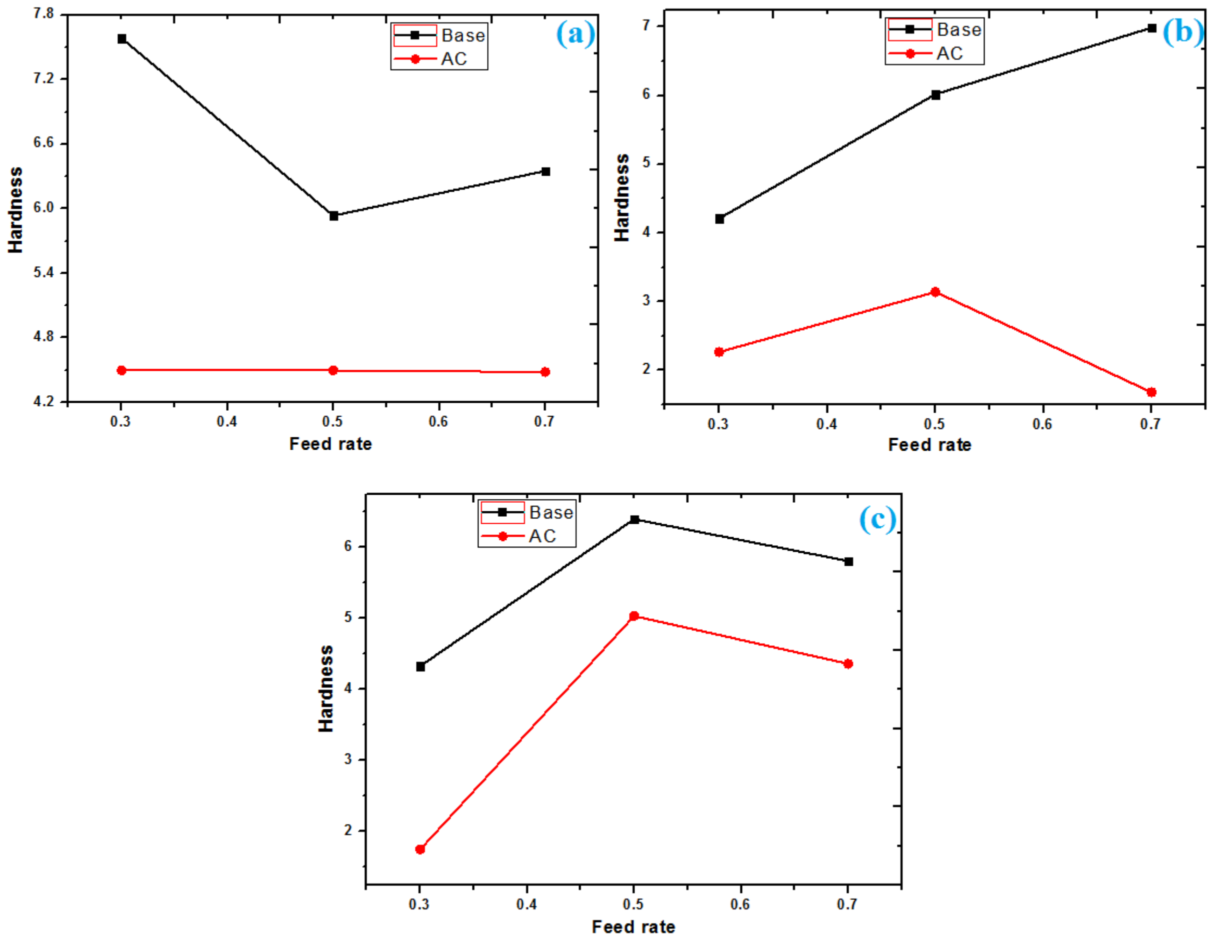

Fig.3. Hardness variation with feed rate at different speeds
(a) 305rpm (b) 500 rpm (c) 835 rpm

Coating Thickness

The coating thickness initially increases then decreases with increasing feed rate. The behaviour of coating thickness is similar in both cases (i.e. before coating and after coating) at lower and moderate rotational speed. But at higher rotational speed, the coating thickness increases with increasing feed rate due tomore deposition ofAl_2O_3 nano particles on mild steel.

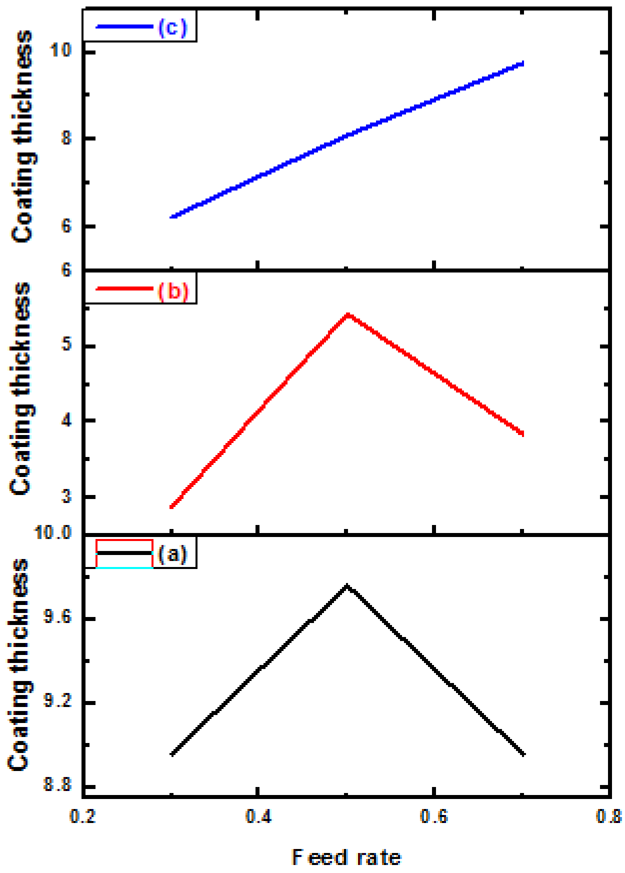

Figure 4: Coating thickness variation with feed rate at different speeds (a) 305rpm (b) 500 rpm (c) 835rpm

CONCLUSION

Spraying of nano Al_2O_3 particles on mild steel changed the surface roughness of the mild steel at constant speed 500 rpm and it prevents the destruction of mild steel structure during the friction process which might be one of the anti-wear mechanisms of nano Al_2O_3 particles.At high rotational speed, the hardness decreases which results more deposition of Al_2O_3 nano particles on mild steel as the feed rate increases. The deposition of Al_2O_3 nano particles is less at rotational speed (305 rpm) and more at high rotational speed (835 rpm).

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