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Experimental analysis of Turning Process in CNC Lathe using Nano Fluid as a Coolant

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Abstract-The latest development in the field of Nanotechnology is newly developed heat transfer fluids called as Nano fluids. Nano fluid is just the mixture of nano sized particles dispersed and stably suspended in the conventional heat transfer fluids. The various scientific experiments conducted in the past showed that when very small amount of nanoparticles suspended in the conventional fluid has the potential to enhance the thermo physical, transport and radiative properties of the conventional fluid to the maximum extent. Cutting fluid is the form of a liquid, are supplied to the chip removing zone in order to improve the better cutting conditions. The major role of cutting oil is maintain a perfect protective film in that place of the area between the tool tip and the work piece being cut where hydrodynamic conditions can exist. Such a film assists the chip in sliding readily over the tool. Besides reducing heat, proper lubrication lowers power requirements and reduces the rate of tool wear, particularly in machining tough, ductile metals. In This paper introducing nano fluid using as a coolant in CNC machine, it's increasing the machining condition and it is reducing the production time and considered the cutting condition and analyzed surface roughness of the material like high carbon high chromium.

Keywords- Nano materials; Nano fluids; Properties; Heat Transfer Enhancement.

I. INTRODUCTION

Most the machining operation is to be done by using the different raw materials in wide range of industries. Turning is the significant machining process for removal of materials from the workpiece by means of single point cutting tool. The important parameters that affect the machining parameters are spindle speed, feed rate, depth of cut, cutting conditions and constituents. The cutting fluid plays a vital role in removing heat occurs in between the workpiece and cutting tool. High Carbon High Chromium steel rods are recently used in many industries like automobiles, bearings and thread rolling dies. Number of researchers has dealt with the optimization of turning parameters in dry conditions. There are many combinations of coolant available to improve the surface quality of the machined specimen. The important significant of this experimental investigation is to forecast the temperature and surface roughness of the turned specimen on High Carbon High Chromium steel rods.

II. LITERATURE REVIEW

Normally variables considered for this experimental investigation are spindle speed, feed rate, depth of cut and percentage of nano particles of the test specimen. The literature assessment on the CNC turning process is crucial to study the effect of input process parameters on the test specimen.

Mehrdad. Kavosh (2016) studied the viscosity study of CuO nano fluid based on propylene glycol. Heat transfer performance of nano fluid depends on viscosity, thermal conductivity, specific heat and density. Viscosity affects the pressure and the pumping power of fluids. The authors concluded that the decrease in viscosity of propylene glycol-based nano fluids with increase in CuO nano particles concentration. Faiza M. Nasir and Aiman Y. Mohamad (2016) demonstrated the heat transfer of CuO-water based nano fluids in a compact heat exchanger. The authors investigate the effect of copper-oxide (CuO) nano particles volume concentration and the operating temperatures on the rate of nano fluids heat transfer in a compact heat exchanger. The authors indicated that nano fluids have the potential to enhance the heat transfer of a compact heat exchanger if properly designed. Vasudevan Nambeesan et al. (2015) demonstrated the Experimental study of heat transfer enhancement in automobile radiator using Al_2O_3/water-ethylene glycol nano fluid coolants. The experimental results shows that the heat transfer performance of the radiator reduced with the addition of Ethylene Glycol (EG) and increased with the addition of nano particles to the water–EG mixture. Mahendra Godley et al. (2015) explained the Investigation of Automobile Radiator using Nano fluid-CuO/Water Mixture as Coolant. The authors concluded that overall heat transfer coefficient & heat transfer rate increased different volume concentration by mixing CuO particle and flow rate range 2 -5 LPM respectively. Hafiz Muhammad Ali et al. (2015) investigated the heat transfer enhancement of car radiator using aqua based magnesium oxide nano fluids. The authors focused the application of water based MgO nano fluids for thermal management of a car radiator. The authors

concluded that, the MgO/water nano fluids showed good repeatability when experimentally tested after one week, however, there is a need to produce more stable nano fluids for long terms in order to be used in engineering applications. Khalid Faisal Sultan et al. (2015) investigated the experimental study of heat transfer enhancement in car radiator by using copper and aluminum nano fluids. The experimental result concluded that the Nusselt number increased with increasing of nano fluid inlet temperature, nano particle volume fraction and Reynolds number. Wadd et al. (2015) demonstrated the comparing performance of nano fluids of metal and nonmetal as coolant in automobile radiator. The authors suggested that, Cu nano fluid have high potential for flow and heat transfer enhancement and are highly appropriate to industrial and practical applications. Gadekar et al. (2015) investigated the Zno a Nano fluid in Radiator to increase thermal conductivity based on ethylene glycol. The thermal conductivity of nano fluids is experimentally measured with conventional method and the authors concluded that the thermal conductivity of nano fluids increase with the nano particle volume concentration and temperature.

Patel and Mavani (2014) studied the effect of nano fluids and mass flow rate of air on heat transfer rate in automobile radiator by CFD analysis. The authors concluded that CFD analysis is a good tool for avoiding costly and time consuming experimental work. Salma Halelfadl et al. (2014) investigated the Efficiency of carbon nano tubes water based nano fluids as coolants. The effect of low nano particle volume fraction, ranging from 0.0055% to 0.278%, on density, thermal conductivity and viscosity of nano fluids is investigated for temperature range of 20°C to 40°C. The authors concluded that the nano fluids investigated in this investigation can be beneficial in energy systems and heat exchangers involving fluid flow following the temperature of the set-up, the volume fraction in nano particles and the flow regimes. Senthilraja1 and Vijayakumar (2013) studied the Analysis of Heat Transfer Coefficient of CuO/Water Nano fluid using Double Pipe Heat Exchanger. CuO/water nano fluid with a nominal diameter of 27nm at different volume concentrations (0.1 &0.3 vol.%) at room temperature were used for this investigations. The authors concluded that the convective heat transfer coefficient increases with an increase in time also the Nusslet number increases with increasing the liquid flow rate. Vishnuprasad et al. (2013) studied the performance analysis of overall heat transfer coefficient using nano fluids on an automobile engine test rig. The authors focused on analysis of overall heat transfer coefficient in an automobile engine radiator with nano fluids (TiO_2). Sirisha and Vijaya Kumar (2013) investigated the Performance Enhancement of an Automotive Radiator using Ethylene Glycol and Al_2O_3 Nano fluid as a Coolant. The authors suggested that, significant increase in heat transfer was observed with the used different volume concentrations of nano particles mixed with water. The experimental results shows that the variation of the friction factor and Nusselt number of the ethylene glycol were highly depended on the volume concentration and Reynolds number. The friction factor decreases with increasing of volume flow rate and the inlet temperature of ethylene glycol. Navid Bozorgan et al. (2012) demonstrated the Numerical Study on Application of CuO-Water Nanofluid in Automotive Diesel Engine Radiator. The authors studied the effect of the automotive speed and Reynolds number of the nano fluid in the different volume concentrations on the radiator performance. The authors indicated that the overall heat transfer coefficient of nano fluid is greater than that of water alone and the total heat transfer area of the radiator can be reduced.

NOR AZWADI Che Sidik and NG Yen Cheong studied the Computational Analysis of Nano fluids in Car Radiator. In this investigation, two type of base fluids which are water and 50-50 mixture of Ethylene Glycol with water (EGW) are tested. The authors concluded that the Nano fluids in car radiator will increase heat transfer of the engine, reducing radiator size hence reducing fuel consumption and higher efficiency. On the other hand, water based nano fluids have better heat transfer compared to EGW based nano fluids. The experimental results shows that, higher concentration will have better heat transfer. Thermal conductivity of nano particles will directly affect the thermal conductivity of the nano fluids and it is proportional related.

Most of the researchers can carry out the trial and error based experimental analysis for conducting the research work. Based on the literature review, it is found that CNC lathe is one of the significant equipment for machining of various combinations of materials and this turning process provides enhanced strength and reduces the cost as well as time. The significant objective of the present investigation is to turn the material of High Carbon High Chromium steel rods using design of experiments concept and found that process parameters plays vital role in the strength and quality of the specimen.

III. EXPERIMENTAL WORKS

Normally turning is the important machining process to remove material from the workpiece by using the single point cutting tool. The turning process is performed on the CNC lathe Sinumerik (820D) and it shown in Figure 1. In this research work, High Carbon High Chromium steel rods have been selected and the test specimen was prepared from the raw materials having the dimensions of 80 mm length and 31 mm diameter. Before conducting the turning process, the test specimen was cleaned with emery sheet to remove unwanted impurities present in the faying surfaces. The chemical composition of the test specimen is presented in Table 1. Based on the machine specifications and customer requirements, the important process parameters that

influencing the surface quality are spindle speed, feed rate, depth of cut and percentage of nano particles as a coolant is presented in Table 2. The selection of input process parameters plays major crucial role for achieving the better surface finish. In this experimental investigation, spindle speed of 800 rpm, feed rate of 0.2 mm/rev and depth of cut of 0.5 mm is kept constant for attaining better surface quality. Figure 2 and 3 shows the test specimen before and after turning process is carried out on this experimental work. Figure 4 represents the actual metal removal process done in CNC lathe using coolant. The nano fluids like aluminium oxide and copper oxide used as a coolant to enhance the surface quality during the turning operations is shown in Figure 5.

Figure 1: CNC lathe Sinumerik (820D)

Table 1: Chemical composition of High Carbon High Chromium steel rods

Element	C	Mn	Si	Cr	V
%	1.65	0.3	0.3	11.5	0.4

Table 2: Turning process parameters

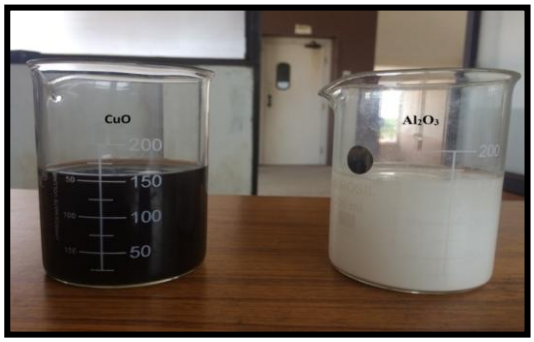
Spindle Speed	Feed Rate	Depth of Cut	Coolant used
rpm	mm/rev	mm	
800	0.2	0.5	Aluminium oxides & Copper oxides

Figure 2: Test specimen before machining process

Figure 3: Test specimen after machining process

Figure 4: Actual turning process using coolant

Figure 5: Nano fluids (Al_2O_3 and CuO)



IV. RESULTS AND DISCUSSION

Turning process plays most important role for machining of metals, non metals, plastics and composites. The important

process parameters for this experimental works are spindle speed, feed rate, depth of cut and percentage of nano particles. The CNC lathe Sinumerik (820D) is used for this experimental investigation. Based on the research, 10 experiments were conducted on High Carbon High Chromium Material with different nano fluids like aluminium oxides and copper oxides to predict the optimal level of process parameters are presented in Table 3 and Table 4.

Table 3: Experimental Results using Al_2O_3 as coolant

S. No.	% of Al_2O_3 Nano particle	Depth of cut	Feed rate	Spindle Speed	Surface roughness
		mm	mm/rev	Rpm	microns
1	1%	0.5	0.2	800	0.187
2	2%	0.5	0.2	800	0.179
3	3%	0.5	0.2	800	0.172
4	4%	0.5	0.2	800	0.165
5	5%	0.5	0.2	800	0.158
6	6%	0.5	0.2	800	0.149
7	7%	0.5	0.2	800	0.148
8	8%	0.5	0.2	800	0.1479
9	9%	0.5	0.2	800	0.1475
10	10%	0.5	0.2	800	0.1472

Based on the experimental results shows that after adding of aluminium oxides more than 6 %, the surface roughness values should be uniform throughout and it is shown in Figure 6.

Figure 6: Prediction of Results using Al_2O_3 as coolant

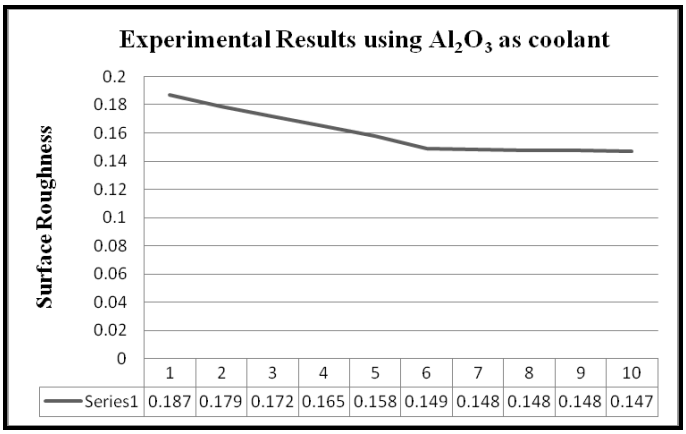
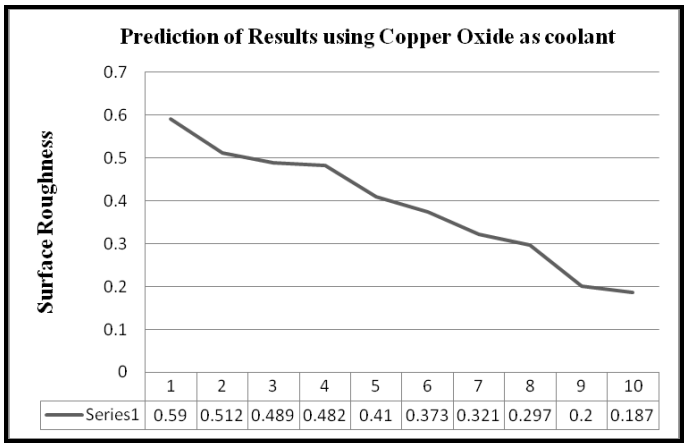


Table 4: Experimental Results using Al_2O_3 as coolant

S. No.	% of CuO Nano particle	Depth of cut	Feed rate	Spindle Speed	Surface roughness
		Mm	mm/rev	rpm	microns
1	1%	0.5	0.2	800	0.590
2	2%	0.5	0.2	800	0.512
3	3%	0.5	0.2	800	0.489
4	4%	0.5	0.2	800	0.482
5	5%	0.5	0.2	800	0.410
6	6%	0.5	0.2	800	0.373
7	7%	0.5	0.2	800	0.321
8	8%	0.5	0.2	800	0.297
9	9%	0.5	0.2	800	0.200
10	10%	0.5	0.2	800	0.187

Based on the experimental Results shows that there are no uniform results of surface roughness values by adding the copper oxide as nano fluid and it is shown in Figure 7.

Figure 7: Prediction of Results using CuO as coolant



V. CONCLUSION

The computer numerical control lathe (sinumerik) is used for conducting the experimental investigation to predict the optimal surface roughness of the High Carbon High Chromium Material. The surface roughness tester is used to evaluate the quality of the machined specimen. The authors reported the following significant conclusion based on the experimental results and analysis is listed below.

- Machining of High Carbon High Chromium Material presented enhanced mechanical properties.
- Production rate and quality of the surface roughness are improved.
- The effective optimal parameter for this experimental investigations are spindle speed of 800 rpm, feed rate of 0.2 mm/rev, depth of cut of 0.5 mm and 10% of aluminium oxide nano particles.
- Depth of cut plays more significant parameters for optimal machining parameters.

Based on the experimental investigation, it is found that surface roughness and production rate is improved on the optimal conditions. This investigation is helpful for the researchers to develop the knowledge on turning of High Carbon High Chromium Material.

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