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Influence of Zinc Ferrite and Copper Ferrite nanoparticulate oil based lubricants in turning of AISI 1040 Steel using Minimum Quantity Lubrication

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Abstract

Lubricants play a significant role in enhancing machine performance and machine life by reducing wear and friction. They also prevent machines from getting damaged. During machining, friction between the tool and work piece results in high temperatures. The friction lubricants play a significant role in machine performance and machine life reducing wear and friction; and thereby increasing the life span of the component/machine. To improve the lubricating efficiency, nanoparticles of metallic ferrites can be added to the base oils. In this research, four types of nano lubricating oils are used. The base engine oils used are SAE40 and SAE50. The nano lubricating oils are SAE40 with Zinc Ferrite nanoparticles, SAE50 with Zinc Ferrite nanoparticles, SAE40 with Copper Ferrite and SAE50 with Copper Ferrite nanoparticles. This study deals with the investigation of the relative influence of Zinc Ferrite and Copper Ferrite nanoparticulate lubricants with regard to the variations in the main cutting force, tool temperature and surface roughness.

Key Words: *Turning, SAE40, Zinc Ferrite and Copper Ferrite, MQL, Temperature, Surface Finish*

1. Introduction

Today, we see a variety of advanced lubrication technologies across the globe. The technology involved in lubrication by nanoparticles is a rapidly developing scientific area and one that has been watched with interest for the past one decade. Nanolubrication offers a solution to many problems associated with machining using traditional lubricants. The use of energy-conserving and emission-reducing automotive engine oil additives would have a great impact on energy conversation and environment protection.

The use of metal working fluids in machining process has caused some problems such as high cost, environmental pollution and health hazards to the operators. Minimum Quantity Lubrication (MQL) helps to resolve these problems in an efficient manner. MQL reduces the usage of cutting fluids to one-third or one-fourth in quantity as compared to the fluids used in

flood cooling. Many investigations are in progress to develop new solid based lubricant systems to take up machining operations in a more scientific way.

2. Literature Review

Krishna et al. [1], conducted experiments to investigate the performance of nanoboric acid suspensions in the coconut oil and SAE-40 oil during turning of AISI 1040 steel. The effect of nano solid suspensions in lubricant is studied in terms of surface finish, tool wear and cutting tool temperatures at variation of cutting parameters. Relatively low temperatures were observed with coconut oil than SAE oil under similar conditions. The tool temperatures were most effected by feed rate than other cutting parameters. There has been improvement in the Surface finish with coconut oil than that of SAE oil. They also concluded that flank wear, surface roughness and tool temperatures were minimum with addition of nano particle suspensions in cutting oil than with pure coconut oil and SAE oil.

With the advancement in tribology, the use of solid lubricants in machining has been observed during the past few years. It is found that solid lubricants could effectively control the temperature at the machining zone. Experiments also revealed the reduction in surface roughness value due to the use of solid lubricants [2]. Several studies and researches related to the lubrication properties of Graphite have been carried out over the past few decades and investigated its use as a lubricating medium in various machining operations [3]. Shaji et al. and Venu Gopal et al. have used graphite as lubricant in grinding operations to reduce the heat generated at the grinding zone and found that graphite as lubricant proved to be better than conventional flood coolant in terms of decreased cutting forces, temperature and surface roughness values [4], [5]. A number of research articles have reported that the addition of nanoparticles to the lubricant proved to be more effective in reducing the wear and friction [6], [7]. In fact, the friction-reduction and anti-wear behaviour are dependent on the characteristics of nanoparticles, such as their size, shape, and concentration. Nano fluids have emerged as promising coolants and lubricants in many industries because of their specific properties [8]. Putra et. al. reported that the heat transfer rates depend on the inclusion level of the nano particles in the fluids [9]. Many cutting fluids were introduced and used by the machining industry. Recently, industries realized the cost, environmental and health issues in the use of these cutting fluids [10], [11]. It has been reported by Debnath et.al. that the industry expects a cutting fluid with minimal cost, more output and best quality [12].

3. About the Present Work

The present work is to experimentally investigate the effect of Zinc Ferrite and Copper Ferrite nanoparticles along with SAE40 oil used as cutting fluids applied under MQL technique in turning AISI1040 steel by uncoated carbide tool inserts. For different weight percentages of nanoparticles mixed with SAE40 oil, the machining properties have been studied for different cutting parameters. The resulting performance was evaluated in terms of main cutting force, tool tip temperature and surface finish. The results in both cases were studied and compared to find out the best weight percentage of nanoparticulate lubricant.

4. Experimental procedure

The first step in the experiment is the preparation of nanolubricant. Nanoparticles of Zinc Ferrite and Copper Ferrite with the weight percentages of 0.1%, 0.2%, 0.4%, 0.6% and 0.8% were separately added to 100 ml of SAE40 oil. Nanoparticles were dispersed in base fuel as it facilitates possible agglomerate nanoparticles back to nanometer range. To find the effect of Zinc Ferrite and Copper Ferrite nanoparticles in SAE40 oil as lubricant during turning test, experiments were conducted on AISI 1040 steel using uncoated carbide inserts. These experiments aimed at finding out the best weight percentage of nanoparticles added to the base oil. The cutting forces were measured using a calibrated strain gauge dynamometer and temperatures were measured using a thermocouple. The temperature measure by the thermocouple is only a representative value for the purpose of comparison, as this does not measure the cutting zone temperature. Surface roughness tester was used to measure the average surface roughness. The experimental setup consists of a reservoir attached with stirrer. Nanolubricant oil was poured in the reservoir. The stirrer was switched on at the time of machining to overcome agglomeration. This total setup has been attached to the lathe machine. The flow rate of oil is kept at 20ml/min during experimentation.

5. Specifications of equipment used

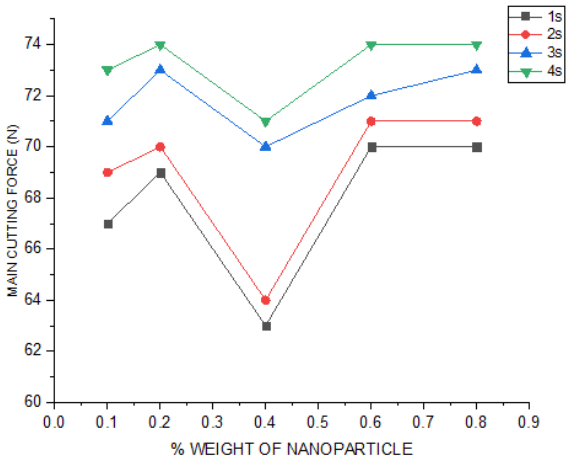
K-type	Turn Master – (PSG Make)
Tally surf	P4 Uncoated tool
Lathe tool dynamo meter	Make Techno lab Associates, India, strain gauge (0-300 kg)
Thermocouple	K-type
Surface roughness tester	Tally surf

6. Results and discussion

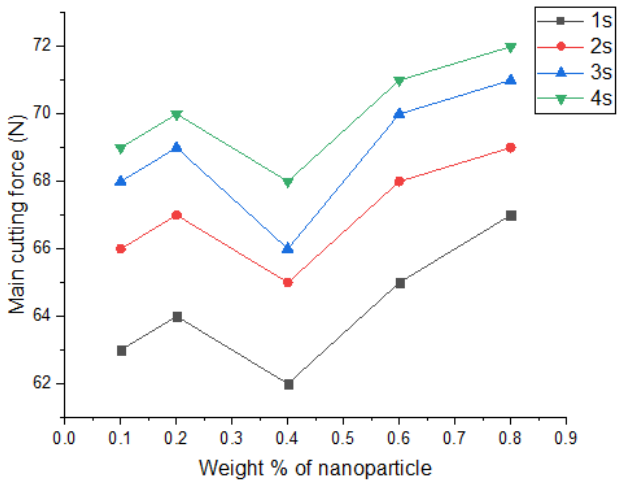
At first experiment was conducted in dry machining conditions and then with SAE40 oil. Initial experimentation was conducted with machining conditions as, cutting velocity 70m/min, depth of cut 0.25mm, feed rate 0.14 mm/rev. For dry machining temperature at the tool tip is 150°C and with SAE40 oil, the temperature is 137°C. Cutting forces are 119N and 98N for dry machining and machining with SAE40 oil respectively. Surface finish is 6.4 and 6.0 respectively.

Following are the results of variation of main cutting force and weight percentage of nanolubricants with SAE40 oil as lubricant.

Copper Ferrite nanolubricants with SAE40oil showed less main cutting forces as compared to Zinc Ferrite nanoparticles in SAE40 oil.

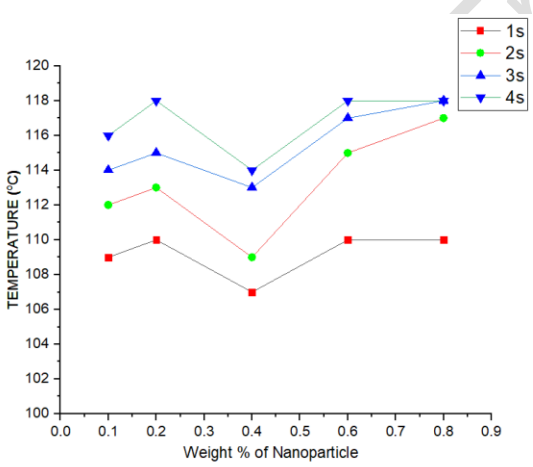


Variation of Main cutting Force with respect to weight percentage of Zinc ferrite nanoparticles
Fig1(a)

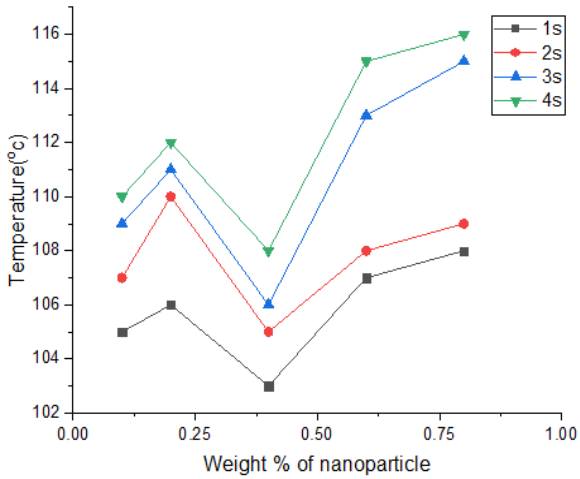


Variation of Main cutting Force with respect to weight percentage of Copper ferrite nanoparticles
Fig1(b)

Figures 2(a) and 2(b) show the variation of temperature with respect to weight percentage of the nanoparticles. For 0.1% and 0.2% weight percentages of nanoparticles, there is some increase in temperature. For 0.4% weight percentage of nanoparticles, there is decrease in temperature. Further, it has been noticed that for 0.6% and 0.8% weight percentages, there is increase in teperature. Copper Ferrite nanoparticles showed less temperature as compared to Zinc Ferrite nanoparticles.



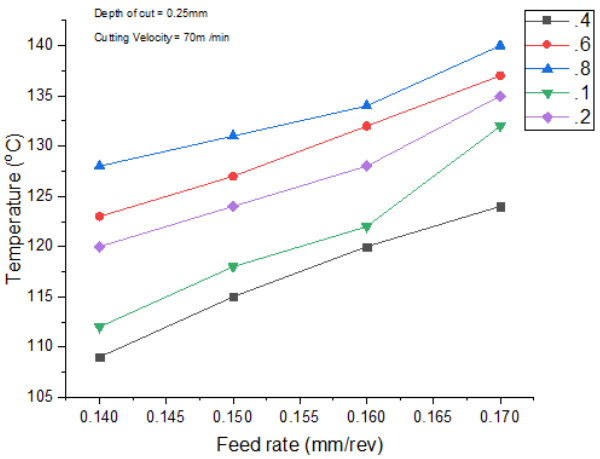
Zinc Ferrite nanoparticle
Fig 2(a)



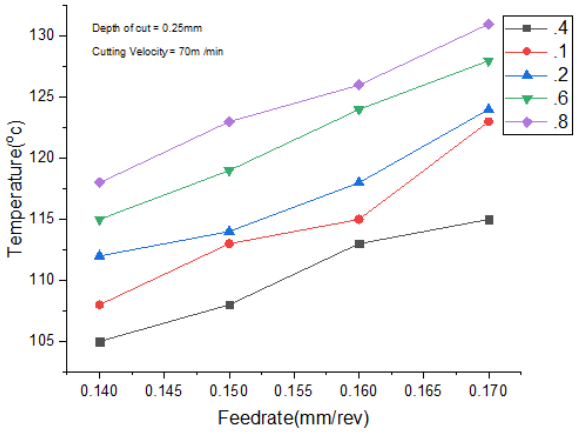
Copper Ferrite nanoparticle
Fig 2(b)

Following figures 3(a), 3(b) and 3(c) show the variation of temperature with respect to feed rate at constant depth of cut and at different cutting velocities. As the cutting velocity increases, temperature increases. It is observed that Copper Ferrite nanoparticulate lubricant shows less temperatures as compared to Zinc Ferrite nanoparticulate lubricant. In each case

0.4 weight percentage of nanoparticles shows fewer temperatures as compared to the other weight percentages of nanoparticles in the lubricant.

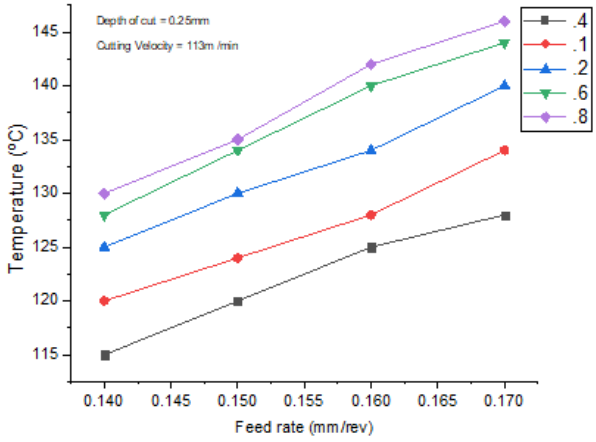


Zinc Ferrite nanoparticles

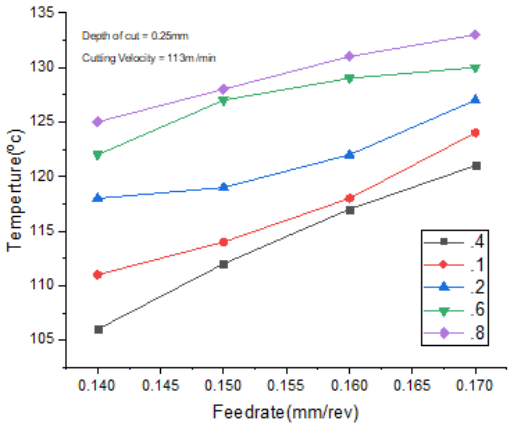


Copper Ferrite nanoparticles

Fig 3(a)

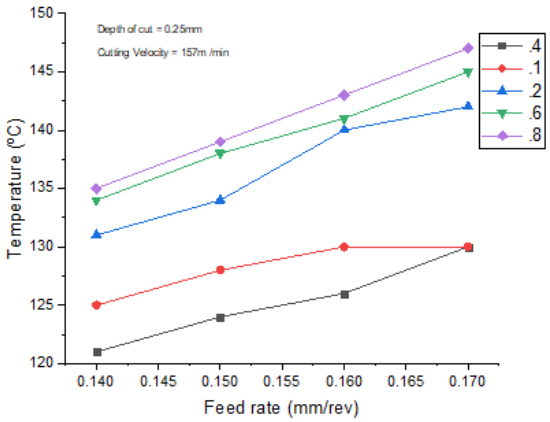


Zinc Ferrite nanoparticles

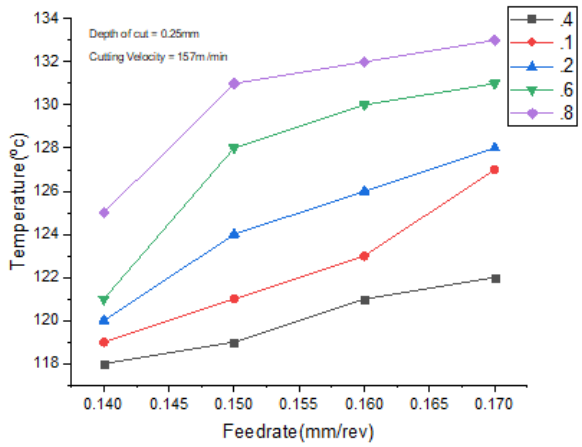


Copperferrite nanoparticles

Fig 3(b)



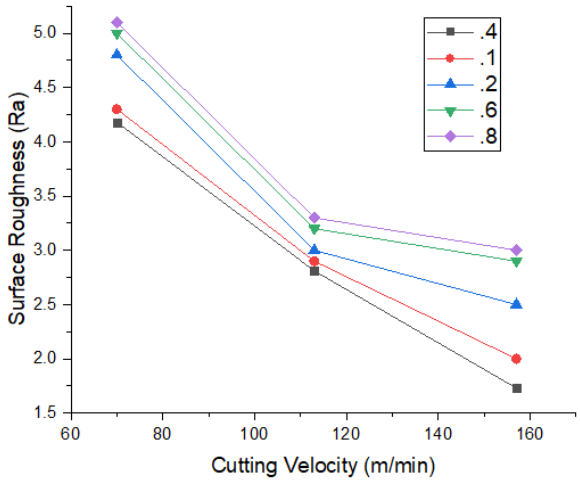
Zinc Ferrite nanoparticles



Copper Ferrite nanoparticles

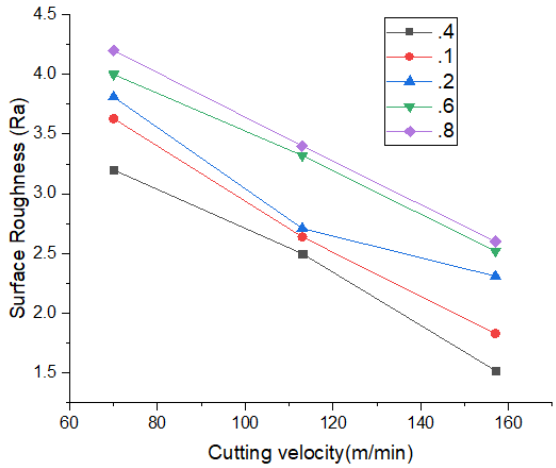
Fig 3(c)

Following figures 4(a) and 4(b) show change in cutting velocity with respect to surface roughness. As the cutting velocity increases, surface roughness decreases. For 0.4 weight percentage of nanoparticles, surface roughness is low as compared to the other weight percentages of nanoparticles.



Zinc Ferrite nanoparticles

Fig 4(a)



Copper Ferrite nanoparticles

Fig 4(b)

7. Conclusions

The following conclusions are drawn from the present experimental investigation.

1) The temperature at the tool tip increased by increasing anyone or the two cutting parameters - cutting speed and feed rate, keeping other parameters constant.
2) The cutting temperature and surface roughness is minimum at 0.4 weight percentage of nanoparticulate Zinc Ferrite and Copper Ferrite lubricants.
3) The surface finish is improved with the increase in the cutting velocity.
4) For Copper Ferrite nanoparticulate lubricant, the main cutting force and temperature are less as compared to Zinc Ferrite nanolubricant.
5) Surface roughness is also less for Copper Ferrite nanolubricant oil when compared to Zinc Ferrite nanoparticulate lubricant.

8. References

1 . P. Vamsi Krishna, R.R. Srikant, D. Nageswara Rao, "Experimental investigation on the performance of nanoboric acid suspensions in SAE-40 and coconut oil during turning of AISI 1040 steel", Int. J. Mach. Tool Manuf. 50 (2010) 911–916.

2. Mukhopadhyay Deep, Banerjee Sankha and Suresh Kumar Reddy N., Investigation to Study the Applicability of Solid Lubricant in Turning AISI 1040 steel, Transactions of the ASME, Volume129,2007, pp. 520526

3. Venu Gopal Anne and Venkateswara Rao P., Selection of optimum conditions for maximum material Removal rate with surface finish and damage as constraints in SiC grinding, International Journal of MachineTools & Manufacture, Volume 43,2003, pp. 1327-1336.

4. Shaji S. and Radhakrishnan V., An investigation on surface grinding using graphite as lubricant, International Journal of Machine Tools & Manufacture, Volume 42, 2002, pp. 733-740.

5. Shaji S. and Radhakrishnan V., Analysis of process parameters in surface grinding with graphite as lubricant based on the Taguchi method, Journal of Materials Processing Technology, Volume 14, Number 1, 2003, pp. 51–59.

6. Rao D. N. and Krishna P. V., The influence of solid lubricant particle size on machining parameters in turning, International Journal of Machine Tools & Manufacturing, Volume 48, 2008, pp. 107-1110.

7. Shaji S. and Radhakrishnan V., An investigation on surface grinding using graphite as lubricant, International Journal of Machine Tools & Manufacture, Volume 42, 2002, pp. 733-740.

8. Sarit K. Das, Stephen U. Choi, Wenhua Yu and T. Pradeep "Nanofluids: Science andTechnology", Wiley-Interscience, USA, 2008.

9. Nandy Putra, Wilfried Roetzel, Sarit K. Das, "Natural convection of nano-fluids", Heat and Mass Transfer 39 (2003) 775–784.

10. F. Klocke, G. Eisenblatter, "Dry Cutting", CIRP Annals, Vol. 46, No. 2, pp. 519-526, 1997

11. U. Heisel, M. Lutz, D. Spath, R. Wassmer, U. Walter, "Application of Minimum Quantity Cooling Lubrication Technology", in: Production Engineering Vol. II, Universities of Stuttgart and Karlsruhe, Institute for Machine Tools I Institute for Machine Tools and Production Science Processes, pp. 4954, 1998.

12. S. Debnath, M. M. Reddy, Q. S. Yi, "Environmental friendly cutting fluids and cooling techniques in machining: a review", Journal of Cleaner Production, Vol. 83, pp. 33-47, 2014.