Effect of Nano fluid in High Speed Machining of Metals: A Review

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Abstract— High speed machining is widely used in industry to obtain well surface finished products. It is important that to improve the surface finish of Ni based alloys because they are used in the aerospace industry. In machining lubricant plays very important role in reducing the tool-workpiece interface temperature. In this study, the role of nanofluid in different machining processes has been explained. The different cutting parameters such as surface roughness workpiece-tool interface were influenced by application of nanofluid. Furthermore, the concentration of nanoparticle in base fluid also affects the surface roughness of the Ni based alloys. Effect of nanofluid for different machining processes such as turning, milling, grinding and drillig are also demonstrated in this study. This clearly indicates that nanofluid improves the surface roughness and reduce the cutting temperature of the Ni based alloys.

Key words: Nanofluids, High Speed Machining

I. INTRODUCTION

In recent days, the increasing attention to the environmental and health impacts of industry activities by governmental regulation and by growing awareness in society is forcing manufacturers to reduce the consumption of lubricating oil for machining purpose. In the machining of aerospace alloys such as Inconel 718, RR100 which are difficult to machine materials so that these materials are widely used in aerospace industry. It was found that the combination nanofluids and MQL gives better surface finish with good heat dissipation in the cutting zone when compared with other cutting environments [1]. In microdrilling process the use of nanofluid significantly reduces microdrilling force and that leads to decrease in cutting temperature [2].If the size of nanoparticle is decreased then burrs and surface roughness effectively decreased in the case of Ti-6Al-4V alloy. When the size of nanoparticle is larger it could affect the surface roughness due to their inefficient penetration to the cutting zone and subsequent indentation and abrasion [3]. Hybrid nanoparticles are used as nanolubrication in the grinding process. They have better lubrication performance than pure nanoparticle. A hybrid nanofluid is consisting of MoS2 nanoparticles with good lubrication effect and CNTs with high heat conductivity coefficient [4]. Dispersion of solid particles was found to play an important role, especially when a slurry layer was formed. The slurry layer generated a higher Grinding ratio (less wheel wear), smaller grinding forces, and better surface finish. MQL grinding shows that reduction in grinding temperature as compared to dry grinding but no significant reduction in the grinding temperature when nanofluid is used as coolant[5].

II. LITERATURE REVIEW

D. Dudzinski et.al.(2004) had given critical review on the machining of Inconel 718.The attention is focused on Inconel 718 and recent work and advances concerning machining of this material are presented. Huang et.al. (2015) presented a novel nanofluid/minimum quantity lubrication (MQL) technology for a 7075-T6 aluminum alloy micro-drilling. D. Kim et.al. (2014) studied that the characteristics of micro end milling process of titanium alloy (Ti- 6AL-4V) using nanofluid minimum quantity lubrication (MQL). R. Saidur et.al. (2011) has been identified few barriers and challenges in this review must be addressed carefully before it can be fully implemented in the industrial applications.

III. MACHINING PROCESSES

A. *Turning:*

Turning process is widely used for manufacturing cylindrical components such as shafts, rods, some complex cylindrical components. Surface roughness, temperature, cutting force, and tool wear can be reduced significantly by turning Inconel 600 alloy under the condition of MQL with (6 vol. % of Al2O3 particle) nanofluids than dry and MQL[6].

B. *Milling:*

When the milling of difficult cut machine materials are introduced the cutting fluids are used to reduce the temperature of cutting zone. With the application of cutting fluid surface quality and tool life of workpiece can be increased. They also reduce the cutting forces and prevent metal from corrosion. In this context, the continuous usage of these cutting fluids can cause the health problems to workers and it also affects the environment [7].

C. *Grinding:*

Grinding is widely used as the finishing machining process for components that require smooth surfaces and precise tolerances. A large volume of grinding fluid is most commonly used to flood the grinding zone, hoping to achieve tangible productivity targets while often neglecting the seemingly less tangible environmental and safety hazards. In grinding, G ratio is defined as the volume of work material removed divided by volume of wheel wear [5].

D. *Drilling:*

Drilling seems to be a simple machining operation that usually use a spiral fluted tool with two or more symmetrical cutting edges together with the simplest machine tool. In this operation, material is removed by a circular motion and transports the chips out of the hole by spiral flutes [9]. nanodiamond concentration is the most important factor affecting the micro-drilling forces, followed by the distance of the nozzle, while air pressure is of minimal influence [2].

IV. MECHANISM OF NANOPARTICLE FUNCTIONING

A variety of mechanisms have been explored to explain the improvement in lubricity of nanofluids including formation of tribo-film, ball bearing effect, mending effect and polishing effect. Nano sized spherical particles are more

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likely to roll between the two surfaces and flip the sliding friction into combination of rolling and sliding friction; these nano-sized particles have a tendency to interact with friction pairs to develop a surface protective film; these nano-sized particles are deposited on the contact surface to form a physical tribo-film that compensates for the loss of mass, which is known as "mending effect"; compressive stress concentrations due to high contact pressure can be decreased by number of nanoparticles which uniformly bear the compressive force [8]. These different mechanisms are shown in figure1

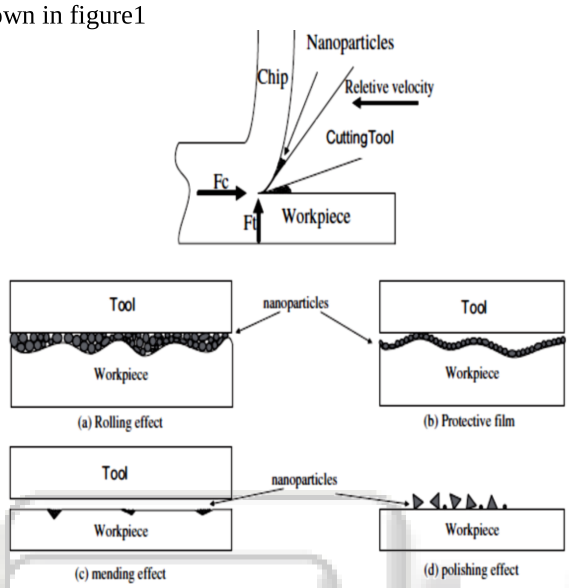

Fig. 1: Mechanism of Nanoparticle Functioning [11]

V. EFFECT OF NANOFLUID ON DIFFERENT MACHINING PARAMETERS:

A. *Effect on Cutting Forces:*

From results [9] of turning, the application nanofluid shows the reduction in main cutting forces as compared to dry, wet and conventional cutting fluid under MQL. This reduction may be due to reduced coefficient of friction between tool and workpiece because of rolling action of nanoparticles and lubricating effect of vegetable oil. This reduction is as shown in figure 2

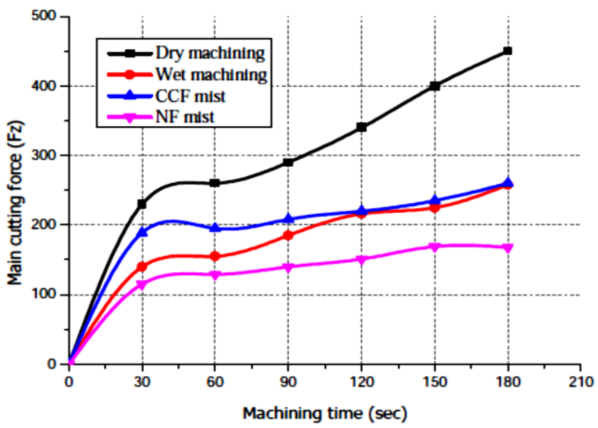

Fig. 2: Main Cutting Force verses machining time [9]

B. *Effect on Machining Temperature:*

Nanofluids are considered to be potential heat transfer fluids because of their superior thermal and tribological properties [10]. If the cutting speed increases slightly then mean shear zone temperature increases slightly and tends to become constant [11]. From the Figure it is observed that at each experiment the value of surface roughness when used with Al2O3 Nanofluids is comparatively low as compared with Vegetable oil. The smooth surface finish were obtained while using Al2O3 nanofluids with MQL [12].

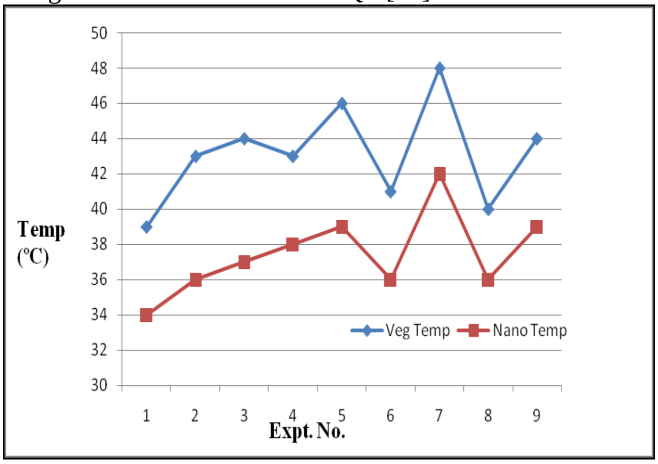

Fig. 3: Comparison graph for Temperature[12]

C. *Effect on Surface Roughness:*

When the nanofluid is applied during machining of metal it gives the better surface finish as compared to dry and wet machining due to reduction cutting forces cutting temperature[5]. Nanofluid significantly improves the lubricating properties rake and flank region. This effect leads to better heat dissipation and therefore surface roughness achieved in by using nanocutting fluid is better than as compared to other cutting environments[13]. The result is as shown in figure 3

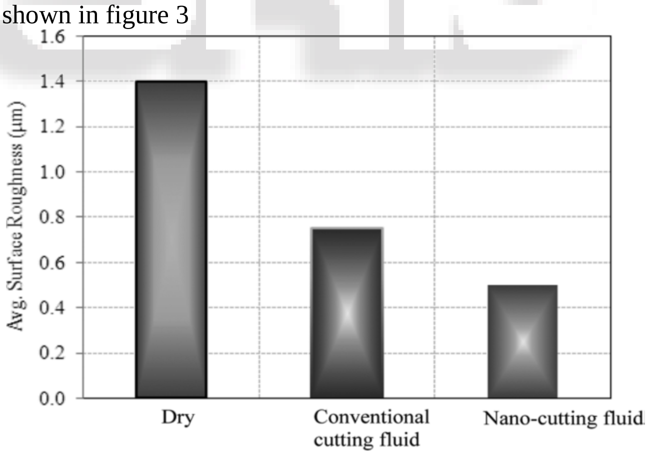

Fig. 4: Variation of Average surface roughness while dry machining and machining with conventional and nano-cutting fluid[13]

D. *Effect on Tool Wear:*

The results of turning of Inconel 600 shows that significant changes in the tool wear. Flank wear caused due to continuous rubbing of cutting edge of workpiece material. The wear is dependent upon the factors like as hardness, operating parameters and coolant which used during machining. Figure 5 indicates that reduction of tool wear in MQL + 6% Al2O3 nanofluid condition as compared to dry, MQL, and MQL + 4% Al2O3 nanofluids. The tool life was increased by 45 per cent by MQL + 6% Al2O3 nanofluids as coolant than dry cutting. This is because at high cutting

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temperature coolant may not have the time to remove the heat from cutting zone[7].

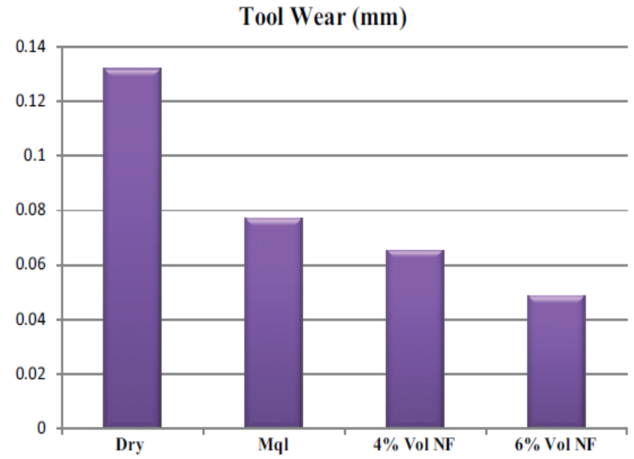

Fig. 5: Tool Wear Verses Different Cutting Conditions[6]

VI. Challenges for Application of Nanofluid

Preparation of homogeneous suspension remains a challenge for researchers due to strong van der Waals force of attraction. To overcome this disadvantage surfactant is added to the nanofluid suspension. Higher cost of nanofluid is major challenge to implement as a cutting fluid in industry. Previous efforts to manufacture nanofluids have often employed either a single step that simultaneously makes and disperses the nanoparticles into base fluids, or a two-step approach that involves generating nanoparticles and subsequently dispersing them into a base fluid. Using either of these two approaches, nanoparticles are inherently produced from processes that involve reduction reactions or ion exchange. Furthermore, the base fluids contain other ions and reaction products that are difficult or impossible to separate from the fluids [14].

VII. Conclusion

In present study, various nanofluids are employed to machining processes. The cutting parameters such as cutting speed, feed rate, depth of cut, surface roughness, tool-workpiece interface, tool wear and environmental aspects with the implementation of nanofluid were reviewed. In the mechanism of nanoparticle functioning different effects like as rolling effect, mending effect and polishing effect which leads to improve the surface finish. Different physical aspects of nanofluid such as nanoparticle size, concentration of nanoparticle, base fluid and type of nanoparticle affects the tool wear, cutting temperature, cutting forces and surface roughness. Homogeneous suspension of nanoparticle in base fluid, high cost of production are major challenges for application of nanofluid in machining.

References

[1] D.Dudzinski, A.Devillez, A.Moufki, D.Larraouquere, V.Zerrouki, J. Vigneau, "A Review of Developments towards dry and high speed machining of Inconel 718", , International Journal of Machine Tools & Manufacture 44, Page No.439-456, 2004

[2] Wei-Tai Huang , Der-Ho Wu , Jian-Ting Chen, "Robust design of using nanofluid/MQL in micro-drilling", Springer-Verlag London 2015

[3] Dae Hoon Kim, Pil-Ho Lee, Jung Sub Kim, "Experimental Study on Micro end Milling Process of Ti-6Al-4V Using Minimum Quantity Lubrication (MQL)", Proceedings of the ASME 2014 International Manufacturing Science and Engineering Conference, MSEC, 2014

[4] Yanbin Zhang, Changhe Li, Dongzhou Jia, Dongkun Zhang, Xiaowei Zhang, "Experimental evaluation of the lubrication performance of MoS2/CNT nanofluid for minimal quantity lubrication in Ni-based alloy grinding", International Journal of Machine Tools & Manufacture 99, Page No.19–33 2015

[5] Bin Shen, Albert J. Shih, Simon C. Tung, "Application of Nanofluids in Minimum Quantity Lubrication Grinding", Society of Tribologists and Lubrication Engineers, Page No. 730-737,2008

[6] V Vasu , G Pradeep Kumar Reddy, " Effect of minimum quantity lubrication with Al2O3 nanoparticles on surface roughness, tool wear and temperature dissipation in machining of Inconel 600 alloy", Proc. IMechE Vol. 225 Part N: J. Nanoengineering and Nanosystems, 2011

[7] Y.Shokoohi, E. Shekarian, Appliation of Nanofluid in Machining Process- A Review, Jouranal of Nanoscience & Technology 2(1),Page No.59-63, (2016).

[8] Bizhan Rahmati , Ahmed A.D. Sarhan , M. Sayuti, "Morphology of surface generated by end milling AL6061-T6 using molybdenum disulfide (MoS2) nanolubrication in end milling machining", Journal of Cleaner Production, Page No. 1-7 , 2013

[9] Anuj Kumar Sharma, Arun Kumar Tiwari, Rabesh Kumar Singh, Amit Rai Dixit, "Tribological Investigation of TiO_2 Nanoparticle based Cutting Fluid in Machining Under MQL", Materials Today: Proceedings 3, Page No.2155–2162, 2016

[10] Anuj Kumar Sharma, Arun Kumar Tiwari, Amit Rai Dixit, "Mechanism of Nanoparticles functioning and Effects in Machining Processes: A Review", Materials Today: Proceedings 2, Page No.3539 – 3544, 2015

[11] Boothroyd, Knight, Fundamentals of Machining & Machine Tool, Third Edition, Taylors & Francis Publication.

[12] Shrikant Borade, M.S.Kadam, "Comparison Of Main Effect Of Vegetable Oil And Al2o3 Nanofluids Used With Mql On Surface Roughness And Temperature", International Journal of Mechanical Engineering and Technology (IJMET) Volume 7, Issue 1, Page No. 203-213, 2016.

[13] S. Khandekar, M. Ravi Sankar, V. Agnihotri, and J. Ramkumar, Nano-Cutting Fluid for Enhancement of Metal Cutting Performance, Materials and Manufacturing Processes, 27 Taylor & Francis Group , LLC, Page No.963–967, 2012

[14] R. Saidur, K.Y. Leong, H.A. Mohammad, "A review on application challenges of Nanofluid", Renewable and Sustainable Energy Reviews 15 , Page No. 1646-1668,2011

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