

PROCESS PARAMETER OPTIMIZATION ON MQL WITH VEGETABLE GRADE CUTTING OIL-A REVIEW

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ABSTRACT

Machining with conventional flood lubrication system is a traditional practice in manufacturing industries. Recently, the application of cutting fluids has gained much attention in the machining of any super alloys due their good lubricating/cooling properties including thermal conductivity, viscosity etc. Increasing demand of production, Industrialist increase the speed, feed so produces high temperature, which reduce tool life. There have been continues efforts in developing metal working fluids to replace the conventional mineral oil based MWF Lubricant with other advance cooling process. This paper reviews studies of different MWF formulation including the application of dry machining, wet machining, MQL Process and Cryogenic cooling process. The result of surface roughness obtained during turning and milling of different alloy material with minimum quantity lubrication of both traditional oil and vegetable oil are compared with each other and it observed that the surface roughness of non edible oil i.e. Vegetable give better surface finish. The Engraving machine gives better result to other machine as regards accuracy and better surface finish. Taguchi methodology is widely used for statistical analysis. ANOVA analysis is also used to determine which parameters is the most significant affect on the selected quality parameters.

Keyword: - Milling/Engraving Machine, Dry, Wet, MQL Machining, Process parameters, Taguchi etc.

1. INTRODUCTION

CNC Engraving/Milling machine is one of the most commonly used in industry and machine shops today for machining parts to putting the design onto the hard flat surface by engraving or milling onto it and machining slot, gear manufacturing result may be decorated piece or quality piece itself. The basic function of metalworking fluid is cooling, lubricating, and decrease the temperature of the chip tool interface. An alternative to Dry or Flooding cutting fluid application, the minimum quantity lubrication (MQL) process is introduced as an environmentally friendly and economically beneficial method. The advantages of MQL machining include non pollution of the atmosphere, reduced disposal and lowering costs, no danger to operator and safety as well as cost reduction in machining. (Bankar N. D. et al. 2019) Dry machining also gives better results but this cooling technique required coated tool and which is costly. Different types of engraving processes of the most vital metal cutting operations used for machining parts because of its capability to remove materials at faster rate compare to lathe with a reasonably good surface quality Also, it is capable of producing a variety of shapes using Engraving cutter. In recent times, computer numerically controlled (CNC) machine tools have been used to make the engraving process fully automated and It delivers greater enhancements in productivity, increases the quality of the machined parts and minimizes the production cost. The process parameters for required quality the surface roughness, material removal

rate, machining time, power consumption, tool life, chips flushing are some of the quality parameters which required optimizing for the selected process parameters. Minimum quantity lubrication (MQL) is introduced as an environmentally friendly and economically beneficial method. This cooling technique is sometimes referred to as near dry lubrication or micro lubrication or micro machining. The major benefits of MQL are reduction of consumption of cutting fluid, cost saving and obtained better quality and the cutting fluids used in MQL should be biodegradable. The principal of MQL is that it applies a fine mist of air fluid mixture containing only a few amount of cutting fluid to the cutting zone through the nozzle of the machine tool. The diameter of nozzle used in MQL application is about 0.5 to 1mm and the pressure applied is around 2 to 4 bar along with flow rates 30 ml/h to 500 ml/h. In traditional flood cooling 10 lit/hour to 50 lit/hour oil used.

2. EXPERIMENTAL METHOD

The performance of vegetable grade cutting oil by using MQL on Micromachining is carried out on CNC Engraving machine gives better Surface finish and material removal rate. In recent times, modern industries are trying to achieve high quality products in a very short period of time with less input. For that purpose, the computer numerically controlled (CNC) machine tools with automated and flexible manufacturing systems have been implemented. In the manufacturing industries, various machine tools are used to remove the material from the work piece over the bed. Out of these, milling machine is the first most common method for metal cutting because of its ability to remove materials faster with a reasonably good surface quality as well as to make decorative design Engraving machine is used to engrave material on the surface. In actual practice, there are many factors that affect responding parameters, like cutting conditions, tool variables, work piece variables, manual variation, and cooling process. Cutting conditions include spindle speed, feed rate and depth of cut, tool variables include tool material, flute angle, rake angle, peripheral 2nd relief angle whereas in workpiece variable include material hardness and other mechanical properties, in manual variation, variation of person to person, shift to shift and in the cooling process include dry, wet and MQL Machining, etc. However, it is very difficult to control all the parameters at a time. All authors used different experimental methods in which the MQL cooling method gives the best performance. In an Engraving machine, it is a vital task to select the control parameters properly to achieve high quality performance as well as decorative design, etc. While designing the experiment select machine, process parameter, and anyone cooling method find out the result.

3. LITERATURE REVIEW

Binayak Sen et al.(2021) Explain the concept of Eco-Friendly Cutting Fluids in Minimum Quantity Lubrication Assisted Machining: A Review on the Perception of Sustainable Manufacturing. Considering the recent trend, this review paper presents a summary of the previously published research articles on minimum quantity lubrication (MQL) assisted machining. The requirement to stir towards sustainability motivated the researchers to revise the effects of substitute lubrication methods on the machining. Conventional lubri-cooling agents are still extensively employed when machining of engineering alloys, but the majority of the recent papers have depicted that the utilization of vegetable oil, nanofluids, and nanoplatelets in MQL system confers superior machining performances as compared to conventional lubrication technology.[1]

Munish Kumar Gupta et al.(2019) Explain the concept of Performance Evaluation of Vegetable Oil-Based Nano-Cutting Fluids in Environmentally Friendly Machining on Inconel-800 Alloy. In this study, a set of turning experiments on new nickel-based alloy i.e., Inconel-800 alloy, was performed to explore the characteristics of different nano-cutting fluids (aluminum oxide (Al₂O₃), molybdenum disulfide (MoS₂), and graphite) under minimum quantity lubrication (MQL) conditions. The performance of each nano-cutting fluid was deliberated in terms of machining characteristics such as surface roughness, cutting forces, and tool wear. Further, the data generated through experiments were statistically examined through Box Cox transformation, normal probability plots, and analysis of variance (ANOVA) tests. Then, an in-depth analysis of each process parameter was conducted through line plots and the results were compared with the existing literature.[2]

Turgay Kivak et al.(2017) Optimization of MQL parameters using the Taguchi method in milling of nickel based waspaloy. This study aimed to investigate the effect of the minimum quantity lubrication (MQL) parameters such as cutting oil type, flow rate, milling method, pulverization distance and nozzle type on average surface roughness (Ra) in milling of nickel based Waspaloy super alloy. During milling experiments, constant cutting speed (45 m/min), feed rate (0.1 mm/rev) and depth of cut (0.5 mm) were selected as machining parameters. Four different types of oil (vegetable, synthetic, mineral and mineral-synthetic), four different flow rates (25, 50, 75 and 100

ml/h), two different milling methods (down milling and up milling) two pulverization distances (25 and 50 mm) and two different nozzle types were chosen as MQL parameters. The results were analyzed using 3D surface graphs, signal-to-noise ratio (S/N) and main effect graphs of means. Optimal MQL parameters were determined using the S/N ratio. Mathematical models have been created for surface roughness.[3]

Shahrookh Shakeel et al. (2016) had studied A Review on Study the Methods and Applications of MQL using Natural Oils in which the metal industries using the cutting fluid has become more problematic in terms of employees health and environmental pollution. Micro lubrication are also known as minimum quantity lubrication (MQL) serves as an alternative to fluid cooling by reducing the volume of cutting fluid used in the machining process; but not significant health concerns. MQL machining was performed much superior in cutting zone temperature enabling favorable chip formation and tool wear, with enhanced the tool life and surface finish. This review paper presents the effects of minimum quantity lubrication(MQL) by vegetable oils based on the lathe performance of low alloy steel as compared to completely dry and wet machining in terms of tool wear, surface finish and surface roughness.[4]

Bankar N D et al. (2019) explain the concept of Experimental Investigation of Aluminum 7075 using Dry, Wet and MQL Condition. There have been continuous efforts in developing technology in metal cutting and cutting fluids due to increasing demands for high productivity so increasing cutting speed and feed rate. Due to increasing speed and feed rate temperature near the cutting zone will increases and tool life will be decreases. Conventional cutting and lubrication process is general practices in manufacturing industry for reducing temperature and friction in between tool and work piece. The use of vegetable cutting fluid in machining process has economic benefit and minimizes environmental impact and safety to employees. These paper reports on the effect of different lubricant method apply when AL7075 alloy is machined. The effect of dry, flooded and minimum quantity lubricant (MQL) machining was analyzed with respect to the surface roughness and temperature near the cutting zone. The three types of coolant environment are compared. It is found that MQL Condition will be very good alternative compared to dry and flooded method. It is Eco-friendly and easily biodegradable. MQL gives minimum amount of Ra Value and Temp as compare to Dry and Wet Machining.[5]

Sachin Agrawal et al. (2018) in this research study process parameters input like spindle speed, depth of cut, feed rate to investigate to show their Impact on surface finish. Main objective of this paper he takes experiment on aloe-vera oil as MQL system and analysis various parameters such as speed, feed and depth of cut. They found the optimal setting for selected process parameters and optimal value of surface finish which is lower by 6.7% Surface roughness Ra value using aloe-vera oil as compared to conventional cutting fluid. Tool wear rate using aloe-vera oil is lower by 0.14% as compared to conventional cutting fluid.[6]

Fernando W. L. R et al. (2018) The cutting fluids play very important functions during machining operations and has a considerable effect on the machining performances. The vegetable oil based MWFs are elegant potential substitutes for mineral oil based MWFs due less environmental and health issues. The MQL can be considered as alternative to conventional cooling methods and having great improvement in performances. The vegetable oil based MWF in MQL had given better machining performances in terms of surface roughness, tool wear, cutting force, chip formation and temperature of tool-chip interface than conventional cooling techniques. Further it can be regarded as an environment friendly substitute for mineral based MWFs.[7]

Gunjal and Patil (2018) have concluded in the experimental study, canola oil as cutting oil gives better performance it improve surface roughness. At higher cutting speed, use of traditional oil with MQL shows longer tool life than vegetable-based cutting fluids. Varying cutting speed did not show any significant impact on surface roughness, as feed rate was constant throughout the experiment. Tool wear is observed after every machining cut by virtue of average flank wear. [8]

Krolczyk et al. (2019), have conclude on the Dry cutting, Minimum Quantity Lubrication/Minimum Quantity Cooling Lubrication; Cryogenic Cooling; High-Pressure Coolant and Vegetable grade Oils. The research work focuses on the improvement of surface roughness with a balanced attention on the reduction of pollution generated by coolants and emulsions. The study presented in the paper will help the next generation to find recent advances as well as future avenues of research on ecological aspects of machining for sustainability.[9]

4. RESEARCH FINDINGS AND GAP

The objectives of this research paper are to review vegetable grade cutting oil with a Minimum quantity lubrication system, which is used for quality and productivity improvement using CNC machining. The main objective is to obtain a better surface finish while increasing the material removal rate and productivity. The above papers and literature review of researchers, the concentration is on a single response of surface roughness i.e. Ra value. Out of overall production cost 16% cost required for cutting fluid, it can minimize 4 to 8% by using vegetable grade oil and MQL process. . It is reported that 80% skin disease of operator due to skin contact of traditional fluids. According to a European Union report, only Europe consumed 3,18,000 tons of cutting fluids per year. According to a Health report, one liter of cutting fluids can pollute 1 million of drinking water. Metal Working Fluids may cause irritation or allergy particularly in so need of new generation environmental and operator friendly cutting fluid like vegetable oils. All government agencies forcing industrialists to reduce the use of harmful cutting fluids because this fluid damages the ecosystem. Vegetable grade oil is a Non edible category like Jatropa oil, a mineral oil based fluid and a synthetic fluid, etc. This oil can reduce the cutting temperature by 5 to 20% by using the MQL process compared to Dry machining process. It also reduces cutting force by 5 to 15% compared to the dry machining process. All authors studied the concept of dry, wet, MQL, cryogenic cooling system, Hybrid system over the different materials. All companies require better quality of surface finish with minimum input to improve productivity. It is required the development of new materials, in the wet machining MQL cooling process and new coatings for the cutting tools for the dry process. MQL is one of the best cooling methods to obtain a better surface finish. But the industry has no awareness about the MQL process and its benefits.

4. CONCLUSIONS

The cutting fluids play a very important role in machining to improve the surface finish. This paper reviews the effect of the cutting parameters on surface roughness. The vegetable based cutting oil with MQL process gives the best result with Experimental results is obtained from the best combination of input and output process parameters. The process parameter and the final work piece can be improved through the application of the MQL Process. Dry machining has a cooling capacity less to achieve the best result because heat is generated near the cutting zone for the best improvement tool required special coating material which increases the cost. Cryogenic machining is superior in many regards, but the cost is very high. By using different materials researcher obtained the best result using the MQL process with vegetable oil as compared to dry machining and wet machining. Every industry shift to use vegetable oil for cutting fluids. Vegetable oil like Jatropa oil, a mineral oil based fluid, and a synthetic fluid can reduce cutting temperature using the MQL process and reduce cutting force compared to the dry machining process. By using MQL cutting chips can flush easily and chip size is thinner than dry machining. Because of MQL Process near the cutting zone temperature will decreases and by nozzle spray chip easily be flushed.MQL performance is better as well as achieves both environmental and ecological benefits. On the other hand, wet machining though expensive but have good lubricating properties and poses less threat to the environment. Based on the study of literature reviewed, It was found that MQL machining gives better results than dry and wet lubricants with minimum cost.

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