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MINIMUM QUANTITY LUBRICATION IN MACHINING A REVIEW

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Abstract
Minimum quantity lubrication (MQL) serves as an alternative to conventional cooling by reducing the volume of cutting fluid used in the machining process. The environment is also protected and possible health hazard for the machine operator. With MQL the machining cost can be minimize significantly. Conventional cutting fluid is especially used to cool and lubricate the cutting tool and work piece interface during machining process. The adverse health effects caused by the use of coolants. Minimum quantity lubrication (MQL) is a method between dry and flood cooling to ensure cooling lubrication effects. The objective of this paper is to review the state of the art in MQL with particular focus on turning, milling machining operation. At the end it is concluded that minimum quantity lubrication has better performance than dry machining in terms of surface roughness, tool life, tool wear, chip removal in the cutting zone.

Keywords: Minimum quantity lubrication, cutting fluid, dry machining, surface roughness, tool wear

1. Introduction

Machining is the most important process in manufacturing industry. In various machining process like turning, milling, drilling, grinding cutting tool is used to remove material from the workpiece in the form of chips. In chip formation process heat generated at the tool chip interface in the cutting zone. The purpose of cutting fluids in machining processes to reduce the cutting temperature and provides lubrication to tool and workpiece as a result increase in surface finish and tool life also chip removal from the cutting zone (1-2). However conventional cutting fluid found environmental and health hazardous issues (3). Minimum Quantity Lubrication (MQL) incorporates the use of minimum quantity and high quality lubricants. Minimum quantity lubrication also called as near dry cutting method (4). MQL reduces the machining cost of the products because very small amount of lubricant used during the machining process. In minimum quantity lubrication a synthetic ester, vegetable oil, nanofluid is used as coolant. In minimum quantity lubrication Vegetable oils is one of the most usual cutting fluids due to its superior and high pressure performance. Nanofluid is a combination of base oil and particles of nano-metre size. Selection of cutting fluid depends upon various factors like workpiece material, cutting tool, machining process, cutting parameters. MQL techniques consists in atomizing a very small amount of lubricant in an airflow directed towards the cutting zone. The aerosol can be sprayed by means of an external supply system, via one or more nozzles. It was used in machining various workpiece materials, including steels, aluminium alloys, and Inconel, using carbide tools. The purpose of this review is to provide readers with a clear understanding of the usefulness of MQL as a alternate for conventional flood cooling.

2. Minimum Quantity Lubrication

Minimum quantity lubrication techniques consists in atomizing a very small amount of lubricant in an airflow directed towards the cutting zone at high pressure.

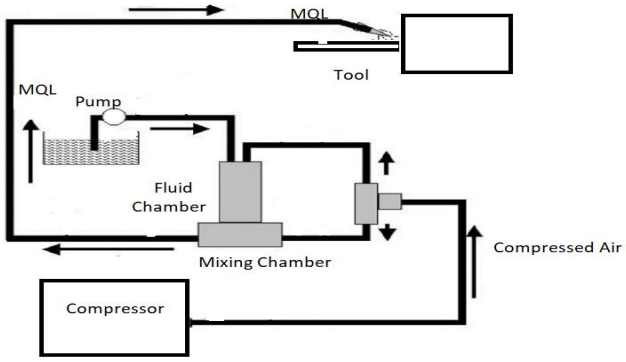

Fig. 1: Minimum quantity lubrication system [5]

In minimum quantity lubrication system, for high pressure air supply the compressor is used. Then this compressed air enters into fluid chamber and mixing chamber at specific pressures. The fluid chamber is connected with the mixing chamber. The air and the oil are mixed in the mixing chamber so that the mixture of oil and air impinged at a high velocity through the nozzle at the contact point of tool and workpiece. The stream of minimum quantity lubrication can be applied at the tip of the cutting tool. Consequently, the coolant reaches as close to the contact point of tool and workpiece. Thus very small quantity of lubricant used in minimum quantity lubrication system.

3. Machining of Materials Using MQL

Effect of minimum quantity lubrication (MQL) have been studied by various researcher on various material with the use of various lubricants assisted with minimum quantity lubrication in various machining processes like turning, drilling, milling, grinding. They have studied effect of MQL on surface roughness of workpiece, tool life, machining cost, cutting force, cutting temperature, chip thickness and chip contact length.

3.1. Machining Using MQL in Turning

Turning is one of the machining process in which a cutting tool, typically a non-revolving tool, describes a helical tool path by moving more or less linearly while the work piece rotates.

Oleksandr Gutnichenko et al. (1) reported that in MQL assisted turning of Alloy 718 with rapeseed oil with graphite nanoadditives (GnP) as lubricant increment in surface finish and tool life.

Mohamed Handawi Saad Elmunafi et al. (2) studied that use of castor oil as cutting fluid in turning of Hardened AISI 420 stainless steel (hardness of 46-48 HRC) under dry and MQL using coated carbide cutting tools at different cutting speed and feed up to 170 m/min and 0.24 mm/rev respectively, using small amount of lubricant of 50 ml/h, results in longer tool life as compared to dry machining. Surface roughness and cutting forces enhanced slightly.

E. A. Rahim et al. (3) observed that in orthogonal cutting of AISI 1045, with minimum quantity lubrication techniques synthetic ester as the cutting fluid, 10%-30% decrease in temperature in the cutting zone approximately, cutting force was decreased approximately by 5% to 28%, tool-chip contact length was decreased 12%, chip thickness were 3% to 9% thinner compared to the dry condition.

Ahmad Nabil Mohd Khalil et al. (4) investigated the effect of minimum quantity lubrication with aluminium oxide nanoparticles in soluble cutting oil, on cutting force and tool wear during turning of nickel titanium alloy of ASTM F2063 grade on the Chevalier FCL-608 CNC turning machine there is 6-10% and 4.2-34.5% reduction in cutting force and tool wear respectively.

Rabin Kumar Das et al. (6) noted that lesser wear at flank surface and better surface finish of workpiece than dry cutting condition during turning of AISI 4340 heat treated hardened steel on CNC lathe, iron aluminium oil LRT 30 as lubricant mixed with air having 50 ml/hr flow rate with minimum quantity lubrication.

Sachin M. Agrawal and Nilesh G. Patil (7) used mixture of aloe vera gel and cotton seed oil as cutting fluid while turning of M2 steel (molybdenum high speed steel) with carbide cutting tool inserts on CNC lathe, reported that lower values of surface roughness by 6.7% and tool wear 0.14% than conventional fluid in MQL.

Kamal Kishore Joshi et al. (8) studied the outcome of MQL in turning Incoloy 800 with uncoated tungsten carbide tool and sunflower seed oil lubricant result in improvement in tool life and surface finish as compared to conventional and flood cooling conditions.

Shrikant U Gunjal and Nilesh G. Patil (9) examined effect of vegetable based cutting fluid under MQL on turning of hardened AISI 4340 steel on CNC lathe with PVD AlTiN coated carbide inserts, shows that use of synthetic oil shows best result at higher cutting speed, canola oil as a cutting fluid shows better results for tool life, tool wear and surface roughness as compared to coconut oil and soybean oil.

Mohd Asyraf Mahboob Ali et al. (10) studied the effect of dry, chilled air and minimum quantity aluminium oxide nanolubricant on turning of Inconel 718 with coated carbide tool shows a marginal difference in specific cutting energy generated with dry, chilled air and minimum quantity aluminium oxide nanolubricant. However, MQL nanolubricants shows better performance.

Uma Maheshwera Reddy Paturia et al. (11) examined the effect of micron sized tungsten disulfide (WS2) solid lubricant powder particles were dispersed in emulsifier oil based cutting fluid assisted minimum quantity lubrication in turning of Inconel 718 on the surface quality.WS2 solid lubricant assisted MQL machining showed a much improvement on the finish quality of work material by on average about 35% when compared to MQL machining.

3.2. Machining Using MQL in Milling

Milling is metal cutting process with the help of rotating multipoint cutter which is fitted on arbor of the milling machine.

Alper Uysal et al. (12) studied milling of AISI 420 martensitic stainless steel with uncoated tungsten carbide (WC) cutting tool on CNC milling machine and minimum quantity lubrication (MQL) method was applied by using commercial vegetable cutting fluid and 1%wt. of nano MoS2 (Molybdenum Disulphide) particles with flow rates of 20 ml/h and 40 ml/h, wear reductions as 16.8% and

19.9% respectively, decrease in surface roughness were observed as 36,3% and 39,2% respectively compared with the dry milling.

K. Aslantas and A. Cicek (13) found minimum tool wear and better surface finish during micro-milling of Inconel 718 superalloy using TiCN coated micro-end mills in minimum quantity lubrication.

Mahmood Al Bashir et al. (14) performed the experiment on hardened AISI 4140 steel (40 HRC). The result shows comparison of MQL with dry machining to ensure that the cutting fluid can be applied in different timed pulses and quantities at critical zone. The MQL was impinged into the form of pulse jet. MQL gives better performance. MQL in high speed milling to increase tool life, reduce tool wear, reduce cutting force and better surface finish.

S. Thamizhmanii and Rosli S. Hasan (15) conducted the experiment on the milling of Inconel 718 with the conditions being vegetable based MQL and dry milling with super hard cobalt tool. It was concluded that the cutting tool travelled longer under the condition of MQL with flow rate of 37.5 ml/hr providing the optimum surface roughness and flank wear of the material. Moreover the reduction in the flank wear led to a tool life increase of 43.75% compared dry milling.

Conclusion

Minimum quantity lubrication gives some meaningful advantages in the machining process. From the result obtained from various researcher it is noticed that minimum quantity lubrication gives better result on surface finish, tool wear, tool life as compared to dry and flood cooling during various machining process like turning and milling process. Also MQL system reduces the cost of lubrication. Now day's minimum quantity lubrication is one of the most important method to achieve sustainable machining efforts.

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