Investigation of Performance of Application of vortex tube for tool tip cooling and Minimum quantity Lubrication in turning of EN24 material

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ABSTRACT

Conventionally the flood lubrication system is used for cooling the tool and work interface to attain maximum surface finish , close dimensional tolerance and better tool life. This method has disadvantages that the chips get mixed with the coolant , more over coolant has minimum shelf life and hence has to be replaced frequently and flood lubrication has tendency to wet the workplace area making it dirty slippery and unsafe for working hence the conventional process needs to be replaced by new one which is minimum quantity lubrication. The tool point cooling can be achieved if the air used in MQL system for atomization of the oil particles is at lower temperature hence the application of vortex tube is done which lowers the temperature of the oil air mixture which effectively reduces tool tip temperature and thus reduced tool wear and improves the surface finish

Project work has been carried out to apply the MQL system in solitary manner during turning of steel EN24where in the coolant has been applied to the tool -work interface as a air-lubricant (cutting oil) mist . Here machine parameters like speed , feed and depth of cut have been varied and measured parameters will be dimensional value of work piece , machining time have been done. Taguchi method has been used for Design of experiment to determine the optimized parameters of speed feed and depth of cut for optimized value of surface finish for wok piece along with tool life. The test were also carried out after addition the vortex tube to the coolant circuit and similar results were poltted. Comparative analysis and recommendations are made for both cases ie, MQL with and without Vortex tube in machining of EN24..

Keyword : - *MQL, Vortex tube, Design of Experiment , Taguchi Method , Surface finish , Tool wear.*

1. Introduction

Minimum quantity lubrication (MQL) has increasingly found its way into the area of metal cutting machining and, in many areas, has already been established as an alternative to conventional wet processing. In contrast to flood lubrication, minimum quantity lubrication uses only a few drops of lubrication (approx. 5 ml to 50 ml per hour) in machining. Today, the enormous cost-saving potential resulting from doing almost entirely without metalworking fluids in machining production is recognized and implemented by many companies, primarily in the automotive industry. While in the early 1990s small applications (sawing, drilling) were done “dry”, today we are able to produce cylinder heads, crankcases, camshafts and numerous other components made of common materials – such as steel, cast iron and aluminium – using MQL in the framework of highly automated large volume production.

The advantages of this new technology are clear. With respect to occupational safety, MQL offers numerous advantages over water-mixed metalworking fluids. A major advantage is the substantially better compatibility concerning skin care. Minimum quantity lubrication is a total-loss lubrication method rather than the circulated lubrication method used with emulsions. This means using new, clean lubricants that are fatty-alcohol or ester based. Additives against pollution, e.g. biocides and fungicides, are not necessary at all, since microbial growth is possible only in an aqueous phase. The extreme reduction of lubrication quantities results in nearly dry work pieces and chips. This greatly reduces health hazards caused by emissions of metalworking fluids in breathed-in air and on the skin of employees at their workplaces. Metalworking fluids do not spread throughout the area around the machine, thus making for a cleaner workplace. Costs generated by conventional flood lubrication (e.g. maintenance, inspection, preparation and disposal of metalworking fluids) are no longer an issue with minimum quantity lubrication

2. Literature review :

1. Machining Using Minimum Quantity Lubrication: A Technology for Sustainability

Nourredine Boubekri, Ph.D. , Vasim Shaikh, International Journal of Applied Science and Technology Vol. 2 No. 1; January 2012

The purpose of this article is to review the relevant literature in machining using minimum quantity lubrication particularly as it pertains to environmental, and health issues , and outline future potential research in this technology. The results indicate that the process of mist particles generation and their physical characteristics are yet to be determined for a whole class of machining processes and machining conditions. The resulting impact of the findings as related to machine and work place design is yet to be determined.

2. Effect of Minimum Quantity Lubrication (MQL) on Tool Wear, Surface Roughness and Dimensional Deviation in Turning AISI-4340 Steel

Nikhil Ranjan Dhara,*, Sumaiya Islama, Mohammad Kamruzzamanb

In all machining processes, tool wear is a natural phenomenon and it leads to tool failure. The growing demands for high productivity of machining need use of high cutting velocity and feed rate. Such machining inherently produces high cutting temperature, which not only reduces tool life but also impairs the product quality. Metal cutting fluids changes the performance of machining operations because of their lubrication, cooling, and chip flushing functions but the use of cutting fluid has become more problematic in terms of both employee health and environmental pollution. The use of cutting fluid generally causes economy of tools and it becomes easier to keep tight tolerances and to maintain workpiece surface properties without damages. Due to these problems, some alternatives has been sought to minimize or even avoid the use of cutting fluid in machining operations. Some of these alternatives are dry machining and machining with minimum quantity lubrication (MQL).

3. Effects of minimum quantity lubrication on turning AISI 9310 alloy steel using vegetable oil-based cutting fluid

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2.1 Literature Gap

After careful study of literature, it is found that though various methods of MQL have been applied and various cutting fluids have been used .Major researchers have focussed their work on proposal of MQL for different materials but special study has been observed for steel EN24. More over no specific study was found as to study effect of variation in cutting parameters on surface finish , machining time and dimension on tolerance achieved on application of MQL system .

Hence the study is proposed to study the effect of variation in cutting parameters on the output parameters of dimensional accuracy or tolerance , surface finish and machining time for work piece material of EN8k . So also for specific Surface finish optimization technique using Taguchi method has been adopted to find the optimal parameters for the same. The most significant part of the gap being that no researcher has applied the vortex tube as a means of temperature reduction in their earlier researches.

As there is scope of improvement in surface finish , reduction in tip temperatures and subsequent increase in tool life , the project work studies this in a critical manner.

Problem Statement

Flood lubrication system is the general system used for coolant supply during the turning process , where in the water soluble coolant is mixed with water and then applied to the tool and workpiece interface. This system is difficult to handle due to the simple reason that the chips get mixed with the coolant and the coolant were to be reused then the chips have to remove by a suitable process which is costly and time consuming. Second difficulty being that the coolant gets decomposed as it is organic material and hence has a very small shelf life.

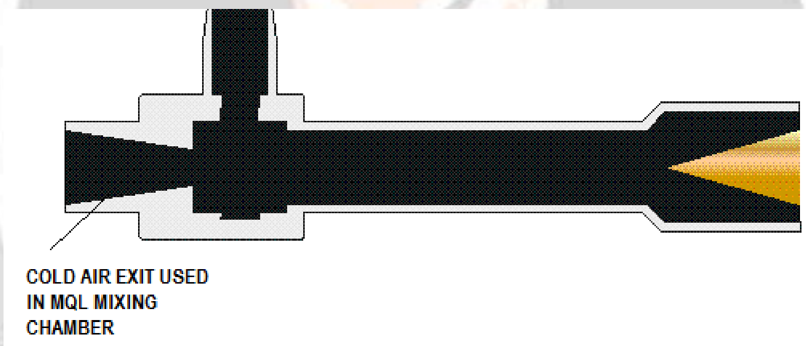
Thirdly the work are gets wet due to splling of the coolant which makes the floor slippery and accident prone. Hence the conventional process of coolant application by flood lubrication needs to be replaced by another system that will judiciuosly use the coolant and so also keep the work area clean and dry.

2.2 Objectives

- Design and Development of Minimum quantity lubrication system
- Carrying out test with plain MQL application and measurement of machining time and surface finish along with dimension tolerance .
- Carrying out test with MQL + additive application and measurement of machining time and surface finish along with dimension tolerance .

VORTEX TUBE :

Compressed air, normally 80-100 PSlG (5.5 - 6.9 BAR), is ejected tangentially through a generator into the **vortex spin chamber.** At up to 1,000,000 RPM, this air stream revolves toward the hot end where some escapes through the **control valve.** The remaining air, still spinning, is forced back through the center of this outer vortex. The inner stream gives off kinetic energy in the form of heat to the outer stream and exits the vortex tube as **cold air.** The outer stream exits the opposite end as **hot air.**

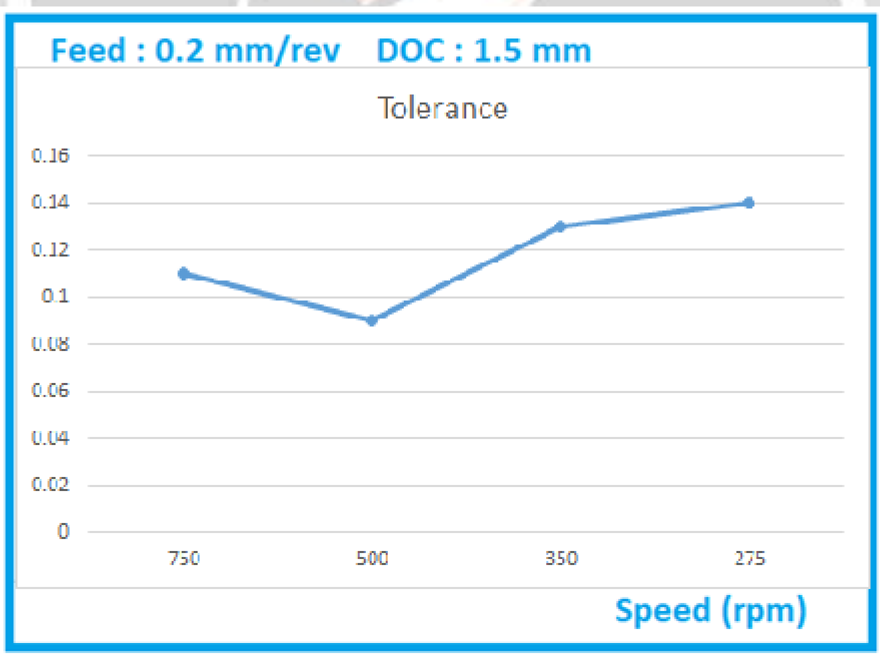


The vortex tube will be connected to the mixing chamber of the MQL system and this old air will mix with the lubricating oil and then this cold mixture will be directed towards the cutting area to carry out the cooling of the cutting tool tip.

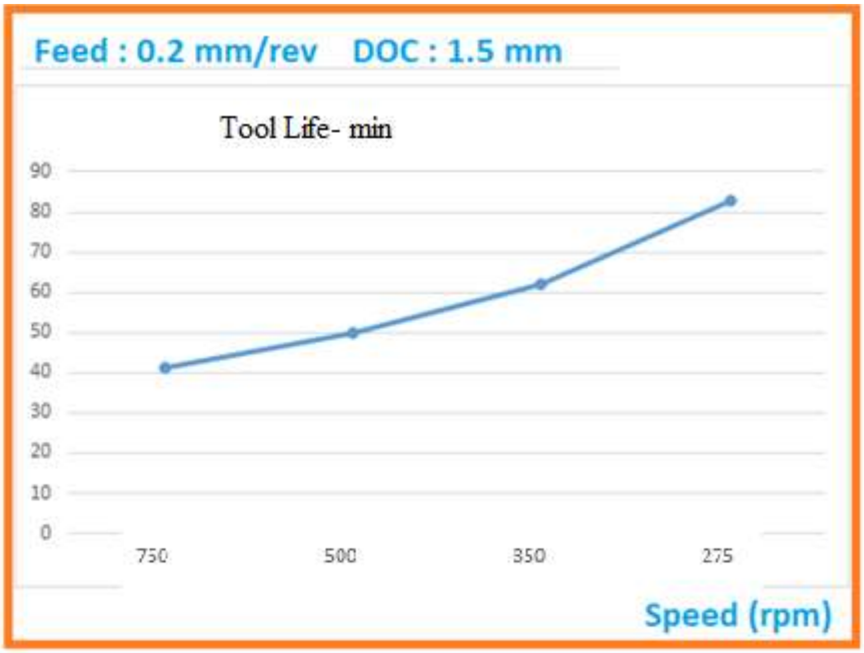
Vortex tube and the MQL set up during experimentation

Observations for Plain MQL – Tolerance and Tool life (min)

Sr no.	Speed	Feed	DoC	Tolerance	Tool Life (min)
1.	750	0.2	1.5	0.11	41
2.	500	0.2	1.5	0.09	50
3.	350	0.2	1.5	0.13	62
4.	275	0.2	1.5	0.14	83



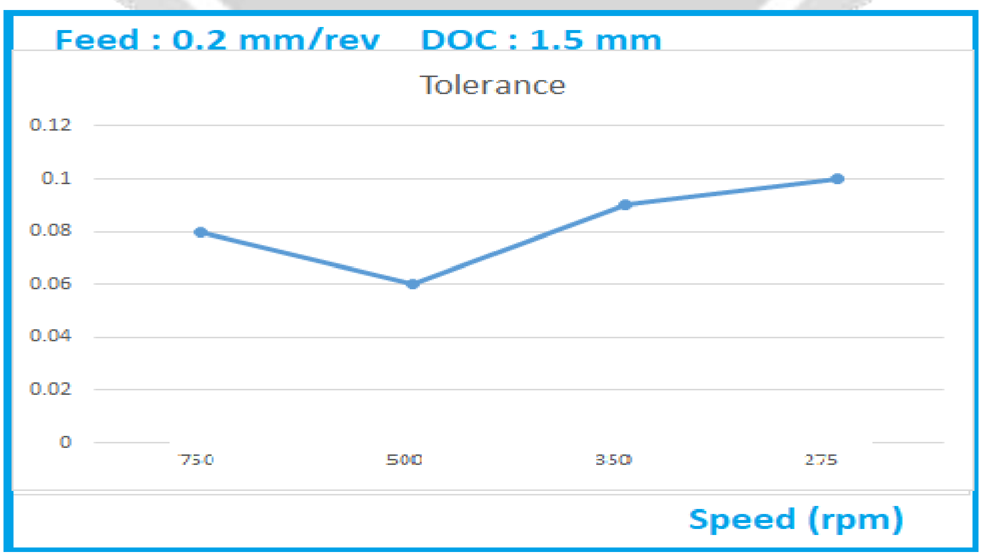
The graph of tolerance zone Vs Speed for maximum feed and maximum depth of cut , it is observed that the speeds of 750 rpm and 500 rpm are in the optimal range and the recommended speed for better precision is 500 rpm



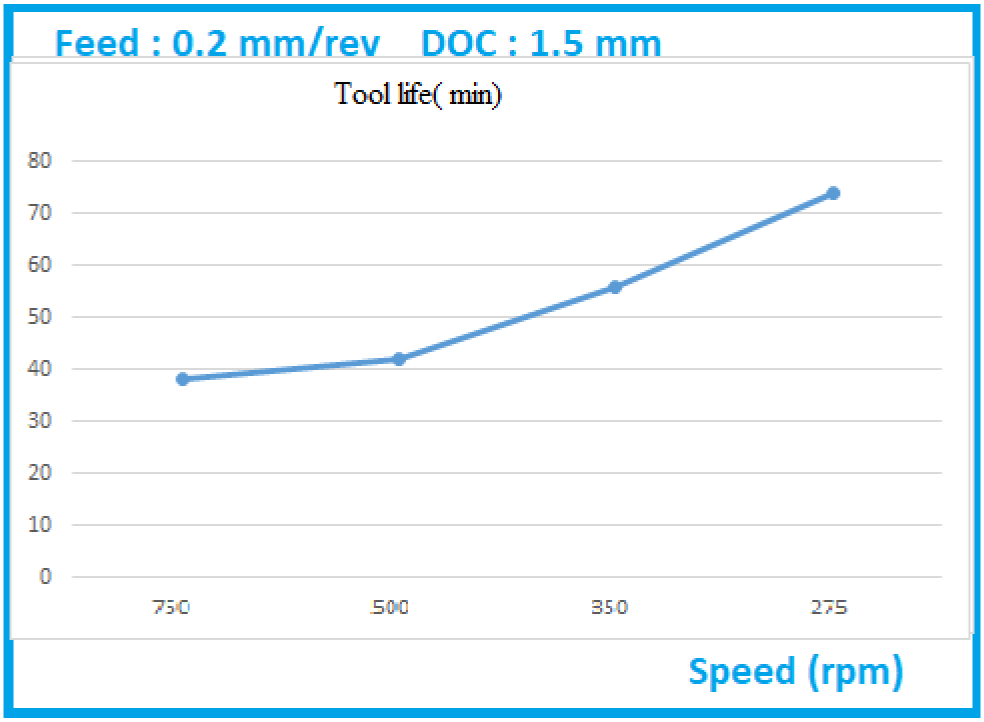
The graph Tool life Vs Speed for maximum feed and maximum depth of cut , it is observed that the speeds of 750rpm and 500 rpm are in the optimal range and the recommended speed for better production rate is 750 rpm

Observations for MQL – Tolarance and Tool Life (With Vortex tube)

Sr no.	Speed	Feed	DoC	Tolerance	Machining time (sec)
1.	750	0.2	1.5	0.08	38
2.	500	0.2	1.5	0.06	42
3.	350	0.2	1.5	0.09	56
4.	275	0.2	1.5	0.10	74

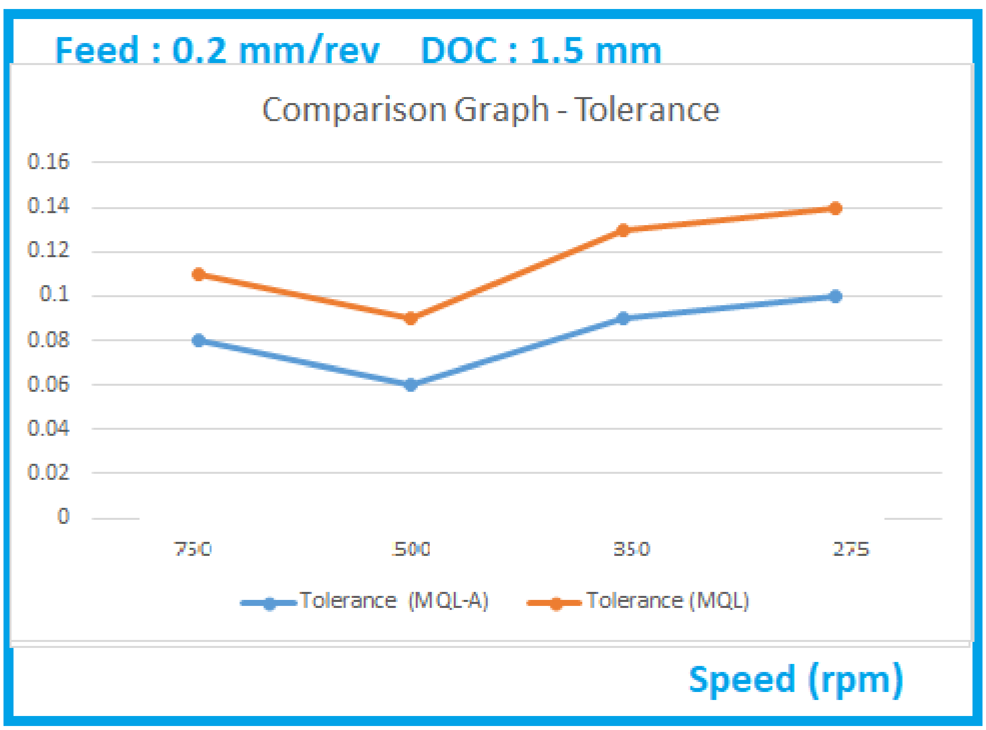


The graph of tolerance zone Vs Speed for maximum feed and maximum depth of cut , it is observed that the speeds of 500 rpm and 750 rpm are in the optimal range and the recommended speed for better precision is 500 rpm

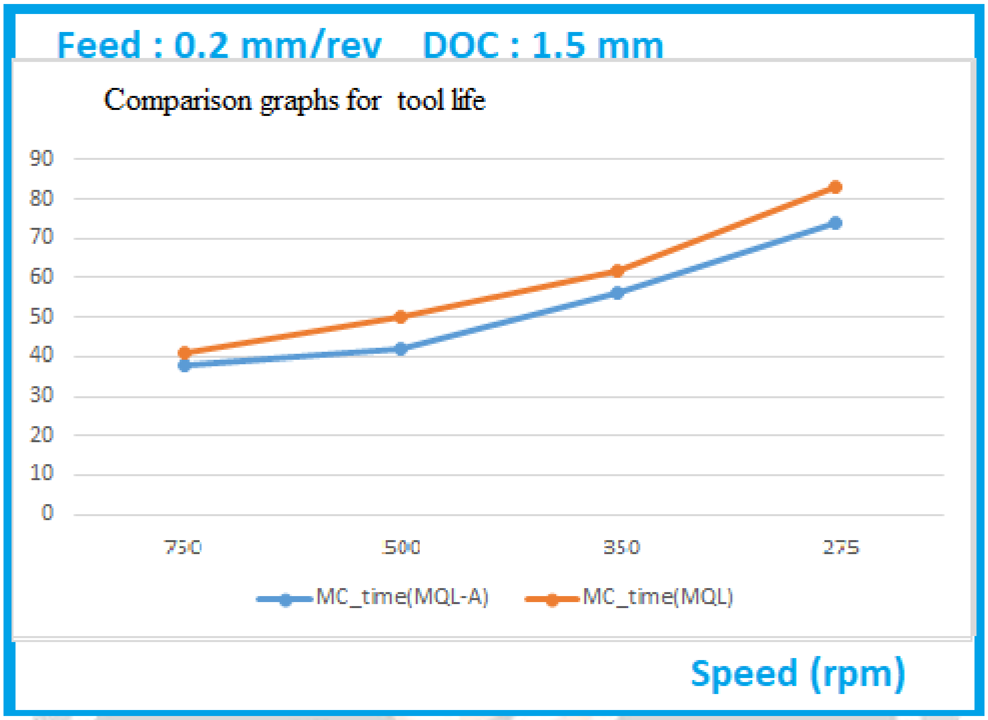


The graph Tool life Vs Speed for maximum feed and maximum depth of cut , it is observed that the speeds of 500 rpm and 750 rpm are in the optimal range and the recommended speed for better production rate is 750 rpm

<u>Comparison Graph for Tolerance zone Plain MQL & MQL-Vortex tube :</u>



The comparison graph of tolerance zone Vs Speed for maximum feed and maximum depth of cut , it is observed that the speeds of 1000 rpm and 1200 rpm are in the optimal range and the recommended speed for better precision is 1000 rpm in either cases but the MQL + vortex tube shows a better tolerance zone as compared to the Plain MQL so much as to say that all speeds are recommendable when the vortex tube is used.



The graph Machine time Vs Speed for maximum feed and maximum depth of cut , it is observed that the speeds of 1000 rpm and 1200 rpm are in the optimal range and the recommended speed for better production rate is 1200 rpm , but a slightly reduced machining time is observed with the MQL + vortex arrangement.

Conclusions :

1. The MQL system was designed and fabricated to apply the MQL as a stand alone system and as well as with the additive.
2. Design of Experiment using Taguchi method was done to optimize the parameters for best surface finish
3. The Surface finish is observed to improve with application of Vortex Tube with MQL System.
4. The optimal level of parameters are as follows for Plain MQL to obtain optimal surface finish Speed (750), Feed (0.14 mm/rev), DOC (1.2mm) for MQL plain
5. The optimal level of parameters are as follows for MQL- Additive SPEED (750), THIRD level of FEED (0.14 mm/rev), third level of DOC (1.2mm for MQL –Vortex tube
6. The comparison graph of tolerance zone Vs Speed for maximum feed and maximum depth of cut , it is observed that the speeds of 1000 rpm and 1200 rpm are in the optimal range and the recommended speed for better precision is 1000 rpm in either cases but the MQL + Vortex tube shows a better tolerance zone as compared to the Plain MQL so much as to say that all speeds are recommendable when the additive is used
7. The graph Tool life Vs Speed for maximum feed and maximum depth of cut , it is observed that the speeds of 1000 rpm and 1200 rpm are in the optimal range and the recommended speed for better production rate is 1200 rpm , but a slightly reduced machining time is observed with the MQL + Vortex tube arrangement.
8. The MQL System with additive addition shows better overall results and it is recommended for use .
9. Speed of 1200 rpm and 1000 rpm are found to be effective and optimal for best results of Surface finish ,

3. ACKNOWLEDGEMENT

In the due course of project with the valuable guidance of Guide Dr, G K Jadhav. the project was completed as per schedule and desirable results were achieved.

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