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ANALYSIS OF MINIMUM QUANTITY LUBRICATION

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***ABSTRACT*- The main purpose of the study of minimum quantity lubrication (MQL) is to use appropriate and minimum use of lubricants to the contact points of the tools and machines. It is important for cost of machining and for ecology as well. For single-purpose machines, e.g. broaching, sawing and shaping, simple, manually controllable MQL devices with internal and external feeds with different functional modes are normally used. They are usually systems with pressure tanks and metering pumps. This helps in easy recycling of the nearly dry chips due to less oil soiling. This methodology replaces the existing "Near Dry Machining" method and is a step ahead of it. Surface finishes also improved mainly due to reduction of temperature and damage at the tool tip by the application of MQL. Analysis shows that turning with MQL is a good alternative for conventional lubrication. Future research will be performed in area of low cost technologies, high productive and hybrid machining processes.**

***Key Words:*Lubrication, Machining, MWFs, NDM, Turning, Broaching, Sawing**

I. INTRODUCTION

Minimum Quantity Lubrication (MQL) as name indicates is a method of reducing use of oil or lubricant in machines. It has been referred to as "Minimal Quantity Lubrication", "Near-Dry Machining" , "Microlubrification", "Micro-Dosing" and sometimes even gets incorrectly referred to as "mist coolant." Minimum Quantity Lubrication (MQL) is an alternative to the use of traditional metal working fluids (MWFs) in machining. You may have heard MQL referred to as "Near Dry Machining" (NDM), "Micro-Lubrification" or "Micro-lubrication", "Micro-dosing", or even, some what incorrectly, referred to as "mist coolant" [01].

The historical, widespread use of coolants as MWF's has over shadowed MQL and kept it as a marginal technology [02] [A. D. J.et.al, 2009]. It has been observed that many machinists don't know or clearly understand the concepts behind MQL and so are not able to use it beneficially. In an industry where production efficiency is mazor pupose, the unknowns of a new technology pose the potential threat of complications and downtime [03] [A. Devilez et.al, 2007]. The fear of the unknown may be the greatest challenge to MQL, and the fact that a large percentage of metal working equipment comes already equipped with flood coolant systems is surely no help either [04] [B. K. A. Ngoi et.al, 2000].The present study was conducted to study the minimum quantity lubrication (MQL) is to use appropriate and minimum use of lubricants to the contact points of the tools and machines.

II. METHODOLOGY

The study was carried out on the research lab of Department of mechanical engineering, S.I.T.M. Barabanki U.P, India.The enormous reduction in the quantity of lubricant compared to the circulated quantities of conventional metalworking fluid systems is the key feature of MQL. In contrast to conventional flood lubrication, minimum quantity lubrication uses only a few millilitres (ml) of lubrication per hour for the machining process [40] [Minitab Statistical Software Features, 2011.

Minimum quantity lubrication today uses such precise metering that the lubricant is nearly completely used up. Typical dosage quantities range from 5 ml to 50 ml per process hour (tool cutting time).The extreme reduction in lubricant quantities results in nearly dry work pieces and chips. Losses due to evaporation and wastage, which may be considerable with emulsion lubrication (depending on the work piece being processed), are inconsequential with MQL. This greatly reduces health hazards due to emissions of metalworking fluids on the skin and in the breathed-in air of employees at their workplaces [42] [N. Fazli et.al, 2007]. The cost-inflating factors of conventional flood lubrication are done away with when MQL is used. Lubricant is supplied by means of a minimum quantity lubrication system (MQL system). Application of a targeted supply of lubricant directly at the point of use lubricates the contact surfaces between tool, work piece and chip [41] [N. Saravanakumar et.al, 2014]. The lubricant is either applied from outside as an aerosol using compressed air or it is "shot" at the tool in the form of droplets.

In comparison to conventional flood lubrication, minimum quantity lubrication uses only a few millilitres (ml) of lubrication per hour for the machining process [43] [P.H. Lee et.al, 2010]. Minimum quantity lubrication today uses such precise metering that the lubricant is nearly completely used up. Typical dosage quantities range from 5 ml to 40 ml per process hour (tool cutting time). The extreme reduction in lubricant quantities results in nearly dry work pieces and chips [44] [P. Vamsi Krishna et.al, 2010]. Losses due to evaporation and wastage, which may be considerable with emulsion lubrication (depending on the work piece being processed), are inconsequential with MQL. This greatly reduces health hazards due to emissions of metalworking fluids on the skin and in the breathed-in air of employees at their workplaces.Lubricant is supplied by means of a minimum quantity lubrication system (MQL system) [45] [P. J. Ross, 2005]. The lubricant is either applied from outside as an aerosol using compressed air or it is "shot" at the tool in the form of droplets [46] [R. Autret et.al, 2003]. Cutting fluids can be divided into two categories first is the water based fluidsincluding straight oils and soluble oils and second oil based fluidsincluding synthetics and semi-synthetics**.** The main functions of cutting fluid are Cooling,Lubrication, Removing chips and metal fines from the tool/work piece interface, Flushing, Prevention of corrosion.

A. BLOCK DIAGRAM OF LATHE MACHINE

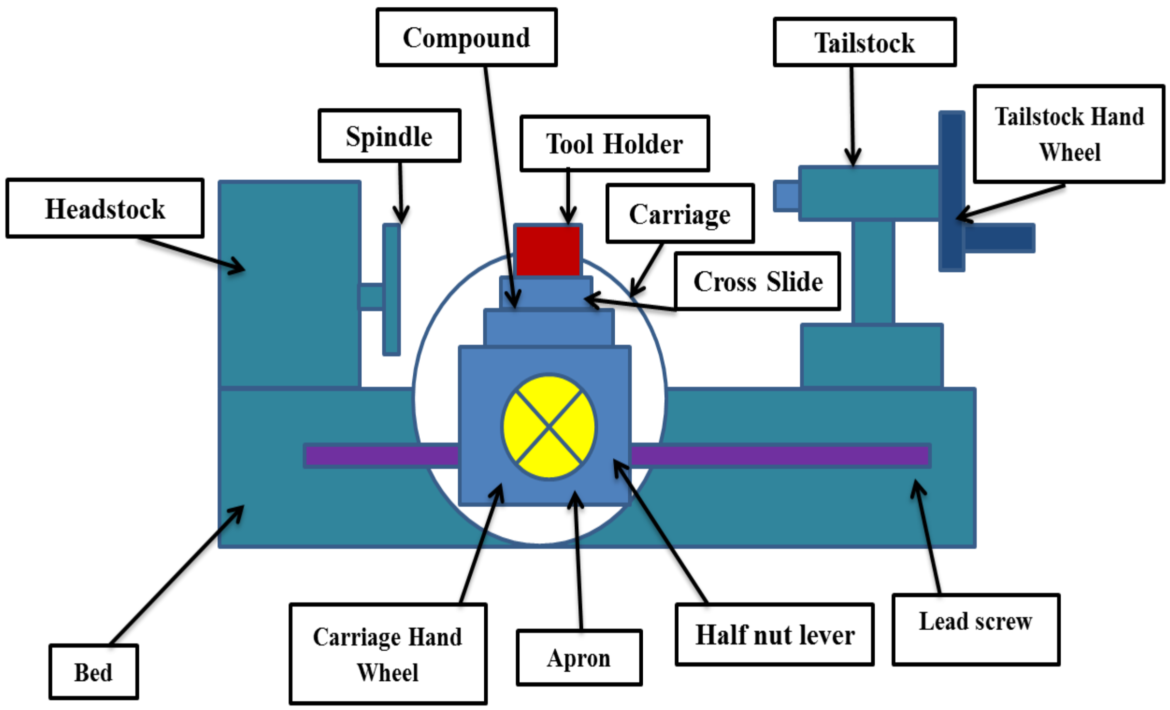

Fig. 1: A view of Lathe Machine diagram

B. TYPES OF MQL SYSTEM

There are two basic types of MQL delivery systems

1. External feed
2. Internal feed.

C. MINIMUM QUANTITY LUBRICATION SYSTEMS FOR EXTERNAL FEED

Devices for external feed transport the lubricant and the separate atomisation air to near the contact point. This takes place in a coaxial or parallel pipework packet. At the end of the pipes, the lubricant is atomised with a spray nozzle and fed to the tool as an aerosol from outside.Low cost, simple retrofitting and the option of deploying conventional tools are the key advantages of these systems.

However, all of these systems have disadvantages that limit their use owing to the principle involved. The nozzles have to be manually adjusted or adjusted via supplementary positioning axes to the tool; there are also losses due to dispersion and shadowing effects.

The most important areas of application use machine tools with a low level of flexibility and involve sawing, milling, broaching, shaping, drilling and threading processes.

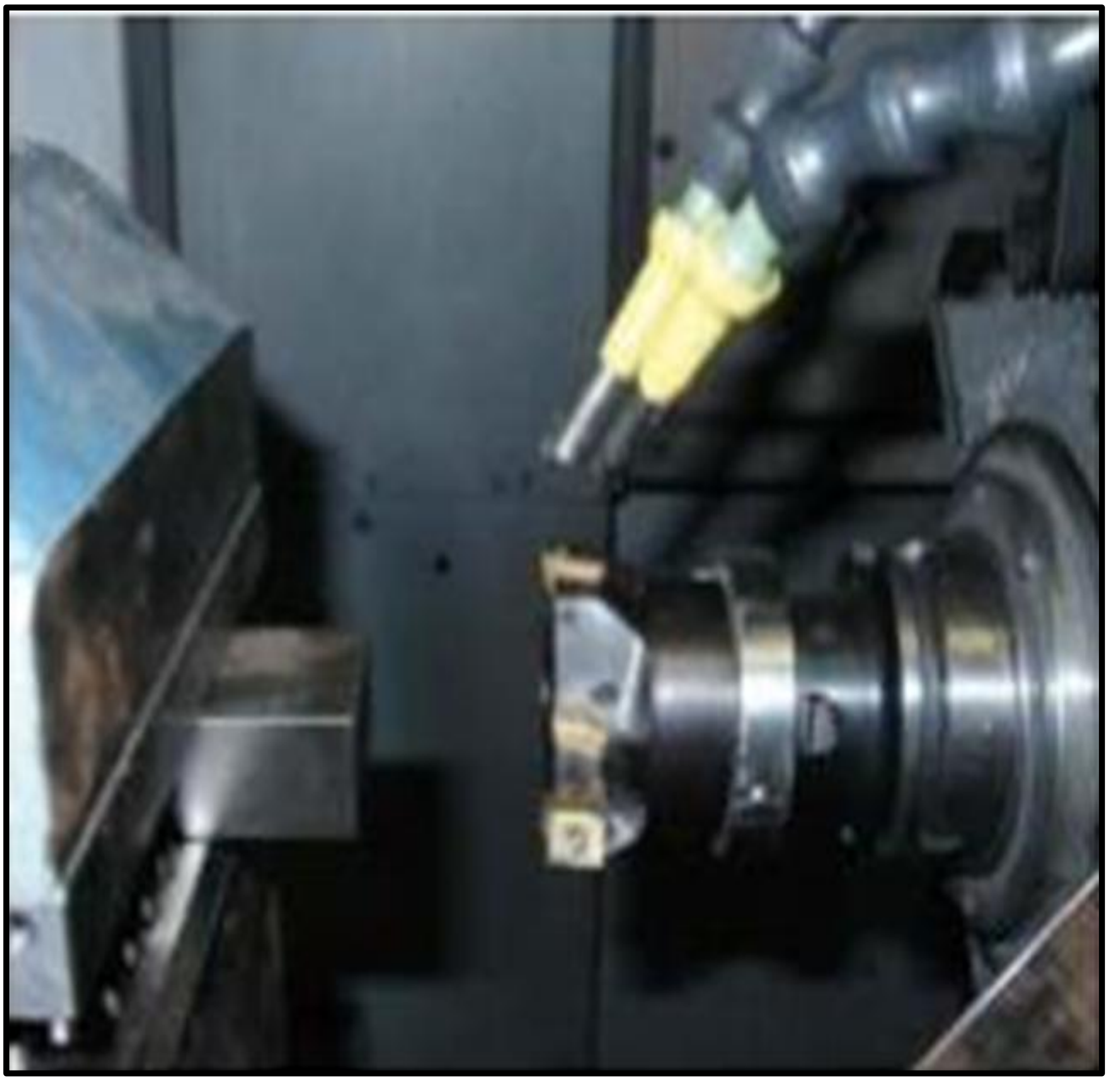

Fig. 2: A view of external feed via nozzles

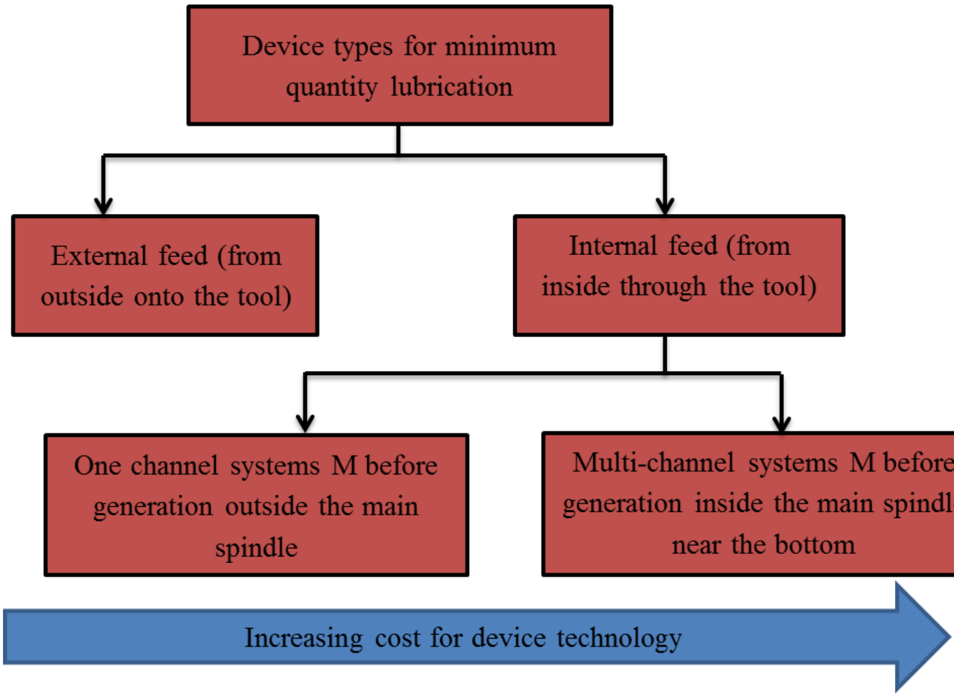

Fig.3: Flow chart of devices types of minimum quantity lubricant system

D. EXPERIMENTAL WORK

Work piece, cutting tool, machine for turning, vegetable based cutting fluid, selection of cutting parameters and machining conditions can be selected for the experimentation. To record the input and output parameters suitable orthogonal array can be used. For the analysis and to study response variables taguchi methods, Signal to noise ratio and Annova can be used. Following steps can be followed for experimentation. Fig. 4 shows turning by using natural oil.

Fig. 4: Aview of turning by using natural oil

E. DESIGN OF EXPERIMENT

Experiments were conducted on plain turning a 31 mm diameter and 150 mm long rod of mild steel which are commonly used in a powerful and rigid lathe (15hp) at different cutting velocities and feeds under dry and MQL by vegetable oil conditions. These experimental investigations were conducted with a view to explore the role of MQL on the machinability characteristics of that work material mainly in terms of cutting temperature, material removal rate. The ranges of the cutting velocity (V_c) and Depth of cut (D_p) were selected based on the tool manufacturer‟s recommendation and industrial practices. Feed rate was kept to vary only, which would adequately serve the present purpose. Machining ferrous metals by carbides is a major activity in the machining industries.

Fig. 5: A view of turning by synthetic oil

Figure 5. shows the turning operation by using the synthetic oil, and the ranges of the cutting velocity (V_c) and feed rate (S_0) were selected based on the tool manufacturer‟s recommendation and industrial practices. Depth of cut is vary, which would adequately serve the present purpose. Machining ferrousmetals by carbides is a major activity in the machining industries. Machining of steels involves more heat generation for their ductility and production of metal removal rate having more intimate and wide tool contact. Again, the cutting temperature increases further with the increase in strength and hardness of the steels for more specific energy requirement. Keeping these facts in view, the commonly used mild steel AISI 1006 was considered in this experimental research.

III. RESULTS

A. GRAPH AND RANK OF NATURAL OIL BY USING TAGUCHI METHOD

Table.1: Shows rank obtain from taguchi method

Level	Cutting Velocity	Depth of cut
1	58.99	56.23
2	59.11	59.49
3	60.30	62.68
Delta	1.31	6.46
Rank	2	1

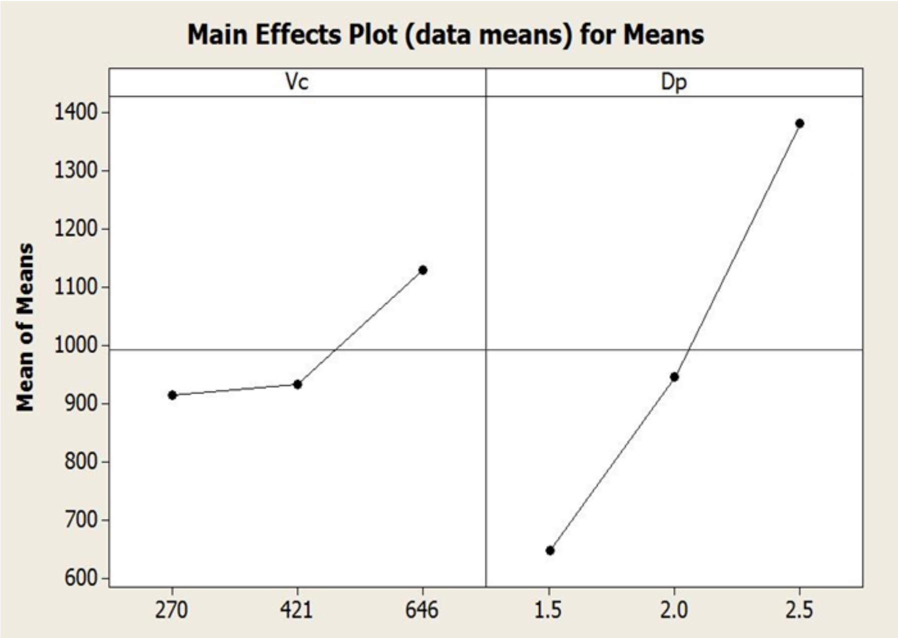

Figure 6: Shows Graph b/w V_c, $D_p$to MRR

B. ANALYSIS OF VARIANCE FOR MRR, USING ADJUSTED SS FOR TESTS TO NATURAL OIL

Table.2: Shows analysis of variance for MRR

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Vc	2	85707	85707	42854	1.38	0.351
Dp	2	820691	820691	410345	13.18	0.017
Error	4	124548	124548	31137		
Total	8	1030946				

C. ANALYSIS OF VARIANCE BY USING NATURAL OIL

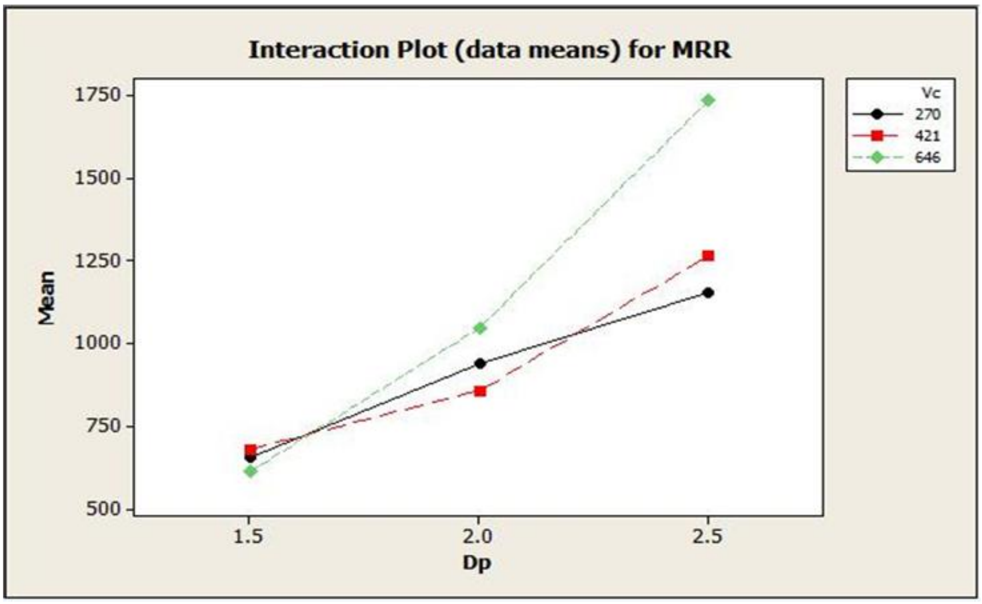

Fig.7: Shows interaction plot for MRR

D. GRAPH BETWEEN CUTTING VELOCITY AND TEMPERATURE

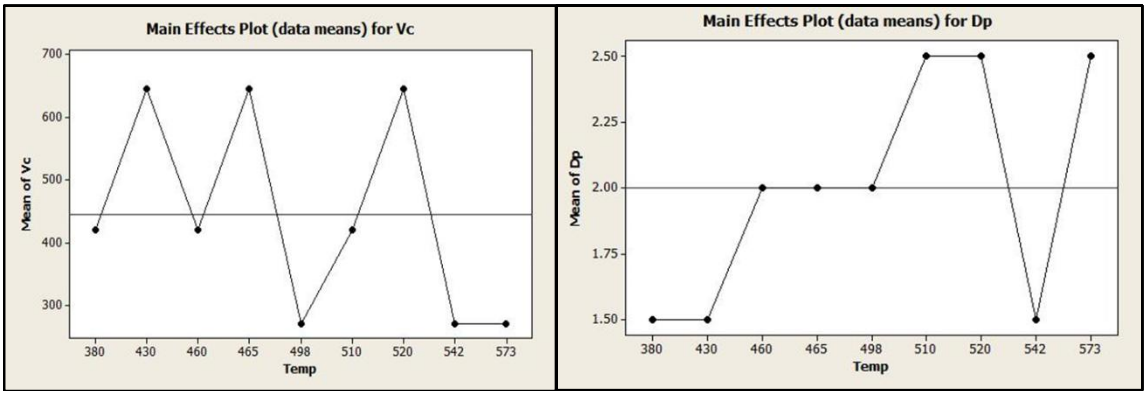

Fig. 8: A view of graph between V_c& T, D_p& T

This results in: Reduction of metalworking fluid quantities in use, Decrease in the work required for monitoring and metalworking fluid maintenance, No need to prepare and dispose of used metalworking fluids, Decrease in the work required for cleaning the processed pieces, Easy recycling of the nearly dry chips due to less oil soiling.

IV. CONCLUSIONS

This experimental study described the optimization of conventional machining parameters in Lathe machine of Mild steel using L9 orthogonal array of Taguchi method. Factors like cutting velocity (V_c) and depth of cut (D_p) and their interactions have been found to play significant role in Lathe operation for maximization of MRR.Based on above work following conclusions are made:

- The Material Removal Rate (MRR) increases with increase in Cutting velocity and depth of cut and the most influential factor was the depth of cut.
- The confirmation experiments are revealed that Taguchi‟s robust design methodology is successfully verified with the optimum process parameters. The predicted model is adequate at 95% confidence level with confirmation experiment chosen for optimum quality characteristics.
- Synthetic oil is much better than natural oil because the machining time of this process is less over the natural oil.
- Synthetic oil is also better than natural oil because of cost comparison the synthetic oil is cheap over the natural oil.
- Surface finishes also improved mainly due to reduction of temperature and damage at the tooltip by the application of MQL.
- Analysis shows that turning with MQL is a good alternative for conventional lubrication. It is important for cost of machining and for ecology as well.
- It is observed that the cutting temperature in turning of AISI 1006 is less as compared to natural wet and synthetic wet turning. It gives decreases in cutting temperature. The MQL shows lower range of temperature which helps to improve tool life.

V. FUTURE SCOPE

In practice, demanding production processes (HSC machining) for large-scale mass production have been implemented using process-reliable MQL. For this to be the case it is important that the elements are optimally adjusted to each other. A key objective for the user is to keep the MQL process “easy” to use and initiate. The selected NC program contains all information (optimal interface parameterslubricant quantity and feed, tool etc.) for the smooth running of the process.

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