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# MQL: Sustainable Cooling Process for Taper Turning of En31 Steel

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**Abstract** — *Due to climate change today, "going green" is essential for manufacturing industries. Industrial cutting fluid affects the environmental pollution and also to the employee health. This research paper concerning on reducing use of cutting fluid by implementing Minimum Quantity Lubrication (MQL). MQL system uses only 5ml to 50ml/hr of lubricant in machining, where in flood this quantity is very much high. This paper also concentrate on better surface finish and reducing cutting fluid cost and investigation of tapper turning operation on EN- 31 material, for optimization of surface roughness, material removal rate in dry, flood and MQL system by considering three controllable input parameters that are cutting speed, feed rate, depth of cut.*

***Keywords***- *Minimum quantity lubrication (MQL), Flood, dry, cutting fluid, lubricant, EN-31, Taguchi*

## I. INTRODUCTION

In industries higher productivity of product is main motive and hence most of industries use flood cooling resulting in high cutting fluid cost and environmental problems. In dry cutting it generate high temperature and friction in work piece and cutting tool, in flood method it only reduced the temperature and not friction between tool and work piece. The cost and negative effects of dry and flood cooling set the platform for MQL system and it is more effective. Minimum quantity lubrication is an alternative solution, instead of using huge amount of oil and water in the metal removal process. The purpose of the lubricant is to reduce friction and wear; heat generated between work piece and tool is also removed by lubricant to a great extent and thus avoiding deformation of work pieces and producing close dimensional tolerances. It increases the metal removal rate and improves surface finish of product in machining.

In conventional flood cooling, according to the manufacturing statistics the cost of cutting fluid is 8% to 20% (approximately 15%) and 4% of tooling of total production cost and it is also depends upon the material of work piece used for production. If coolant and tool cost reduce it is more affordable to consumer and also to the industry as well.

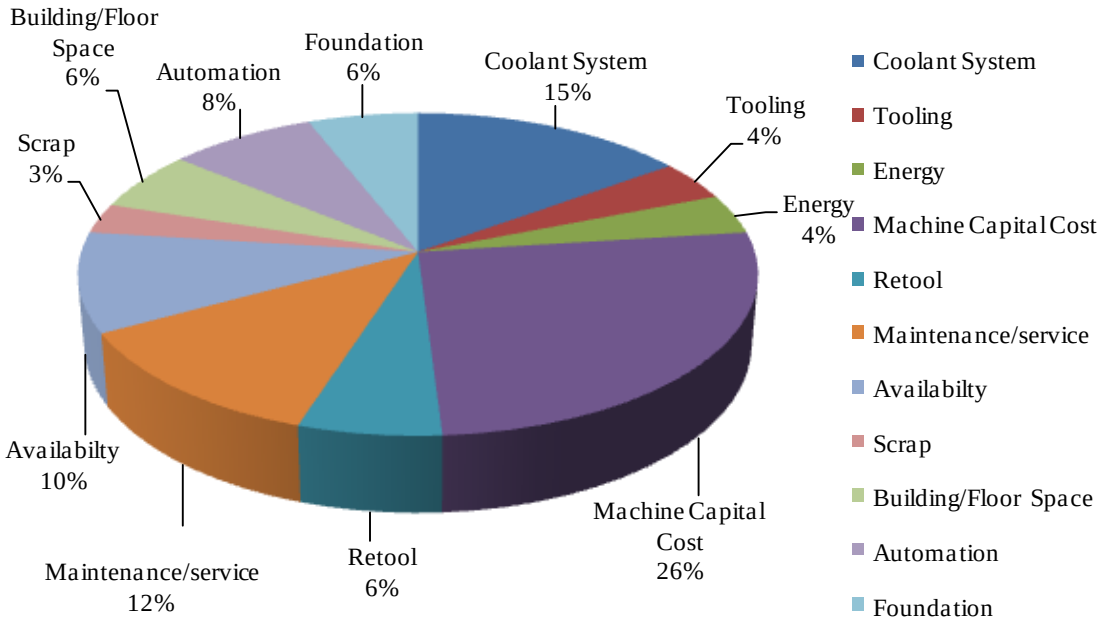


***Figure 1. Distribution of manufacturing costs for flood***

 

## II. MATERIAL DETAILS

The work piece material is EN-31 l in the form of round bars having diameters 25mm and length 85mm will use for performing experimental work in dry, flood and MQL conditions. The EN-31 high carbon alloy steel by its character which is subjected to severe abrasion, wear and high surface loading. The material is very widely used in automotive sectors for manufacturing of axels, gears, camshafts, driving pinion and it is also used in manufacturing of ball bearing, roller bearing, spinning tools, beading roll, punches and dies.

***Table 1. Composition of EN-31***

| Sample Identity | C | Si | Mn | P | S | Cr | Ni | Mo | Al | Cu | V | Nb | Ti |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Composition (in %) | 1.021 | 0.26 | 0.497 | 0.04 | 0.042 | 1.215 | 0.072 | 0.028 | 0.018 | 0.043 | 0.009 | 0.011 | 0.005 |

## III. TAPER TURNING OPERATION

Taper turning is the uniform increase or decrease in diameter, from one part of a cylindrical work piece to another part and create a conical shape. A taper is a uniform change in a cylinder's diameter when measured along its axis. A taper portion gives an accurate way to align parts and holding tool. For example, machine tool spindles have internal tapers that provide firm and reliable replacement of tool holders and work holders.

## IV. MQL SYSTEM METHODOLOGY

In MQL system the lubricant is supplied at high pressure and at a high speed between the cutting tool and work piece contact portion. This lubricant can be supplied externally or by internal channels of tool. A compressor is used to store and supply high pressure air. This high pressure air is supplied to the mixing chamber and fluid chamber at a different preselected pressure. The fluid chamber and mixing chamber is connected via a very small diameter flexible tube. The tube is passed through a roller type flow controller to permit the little amount of fluid to flow under high pressure. The compressed air entering to the inlet port creates pressure to flow the fluid continuously to the mixing chamber through controller at a constant rate. The oil and air mixed in the mixing chamber so that the mixture of oil and air flow at a high velocity through the nozzle and strikes between the tool and work piece contact place. This mixture of air and oil is in the form of an aerosol. Cutting fluid typically mixed with a small amount of compressed air right at the nozzle tip to disperse the fluid and propel it to the cutting tool. This layer reduces the friction between tool and work piece. In MQL system when the chip is shear the majority of heat is carried away by chip. The ability to precisely control both the cutting fluid and air is the key to maximizing productivity.

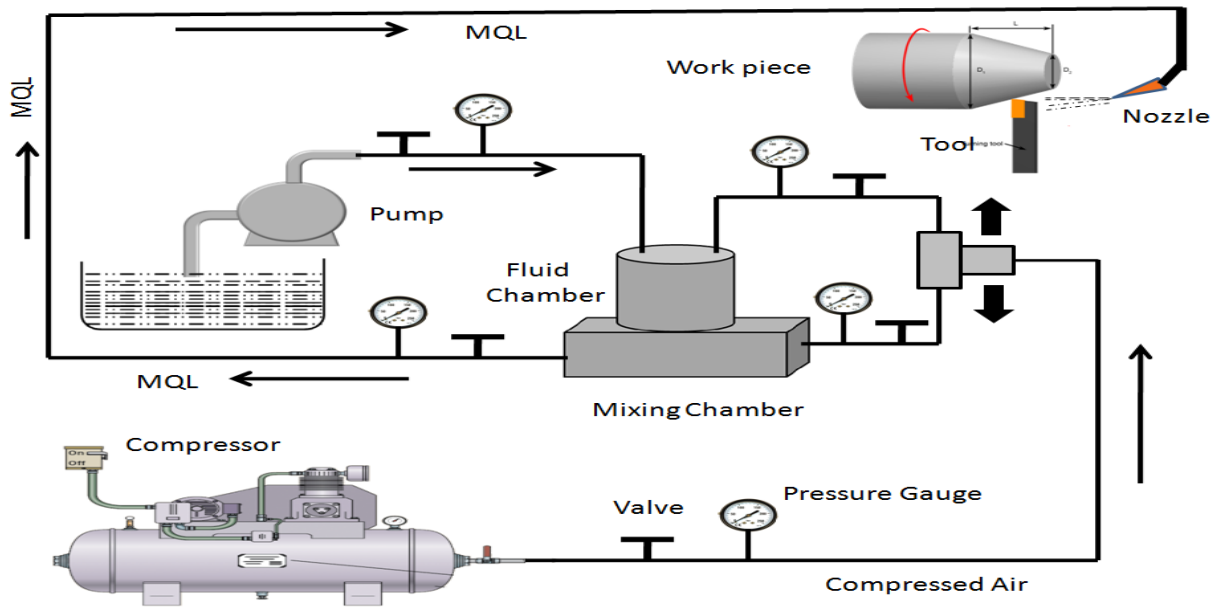


***Figure 2. Working of MQL system***

 

## V. TAGUCHI METHOD

The Taguchi method of quality control is an approach to engineering that emphasizes the roles of research and development, product design and product development in reducing the occurrence of defects and failures in products. The Taguchi method considers design to be more important than the manufacturing process in quality control and tries to eliminate variances in production before they can occur. The method is applicable over a wide range of engineering fields that include processes that manufacture raw materials, sub systems, products for professional and consumer markets. In fact, the method can be applied to any process be it engineering fabrication, computer-aided-design, banking and service sectors etc. Taguchi method is useful for 'tuning' a given process for 'best' results.

Taguchi method includes following steps:

1. Perform the verification experiment and plan the future action.
2. Identify the main function, side effects and failure mode.
3. Identify the noise factor, testing conditions and quality characteristics.
4. Identify the objective functions to be optimized.
5. Identify the control factors and their levels.
6. Select the orthogonal array matrix experiment.
7. Conduct the matrix experiment.
8. Analyze the data; predict the optimum levels and performance.

## VI. CONCLUSION

In this study, it concludes that MQL system is comprehensively way better than the dry and flood cutting.

- Application of MQL machining is much more acceptable from an environmental point of view.
- MQL system reduces the consumption of lubricant during the material removal operation.
- It reduces the friction between the cutting tool and work piece.
- It carried away the majority of heat generated during chip shear.
- It improves the surface finish, reduce production cost of a product and increase the cutting tool life.

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