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STUDY OF MUSTARD OIL AS COOLANT IN TURNING H13 STEEL USING MINIMUM QUANTITY LUBRICATION (MQL)

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Abstract— **In most of the metal machining process cutting fluid are more problematic in terms of both employee and environmental pollution, generally cutting fluid causes economy of tool and it become easier to keep tight tolerance and maintain the workpiece surface properties without damages. Due to this some alternatives has been sought out to minimize or even to avoid the use of cutting fluid in machining process. Some of the alternatives are dry machining and machining with minimum quantity lubrication (MQL).The aim of the present project is to investigate the machining parameter on surface roughness (R_a), chip removal and tool wear rate onworkpiece H13 steel in turning process. The approach was based on minimum quantity lubrication (MQL) technique. MQL uses a spray of small oil droplets in a compressed air jet. The lubrication is sprayed directly into the cutting zone, since the air jet carries the oil droplets directly in the cutting area to provide efficient lubrication.**

***Keywords*— MQL, H13 steel, cutting inserts-Tungsten carbide, Titanium nitride, Silicon carbide.**

Nomenclature

CC	Conventional Coolant
MQL	Minimum Quantity Lubrication
R_a	Surface roughness
Wc	Tungsten carbide
TiN	Titanium nitride
Sic	Silicon carbide

I. INTRODUCTION

The manufacturing process is to get specific shapes and properties of the raw material. This manufacturing process is 0f 3 types, namely, constant-mass process like forging, casting, extrusion,rolling, wire-drawing, etc., material addition process which is also called as bottom up approach likerapid-prototyping, riveting,welding, keying, bolting, etc., finally metal removal process which is refer as top down approach like finishing, etc., in machining process shape is obtained by relative motion of shape of tool and path traverses, relative motion is obtained by combining rotatory and translatory movements of either tool or workpiece or both. The tool used in lathe is known as a single point cutting tool, it has one cutting edge. The lathe tool shears the metal rather than cut it. The use of cutting fluids is fundamental in a machining processes, mainly during high heat generations. So, lubrication and cooling provided by thecutting fluids will improve the final quality of the workpiece. Anyhow, cutting fluid usage provide some drawbacks regarding environmental conditions, prices and health problem. Therefore, new methods for the application and minimization of cutting fluids are being researched aiming to reduce the amount of cutting fluid used, and also the minimization of cutting fluids hazards. The present study analyses the behaviour of a recently proposed optimization method, up to now only tested in turning, which consists of adding mustard oil to minimum quantity lubrication (MQL). Here for turning process H13 tool steel is as a raw material and for coolant mustard oil is used for the lubrication process, and Taguchi Method of eighteen standard orthogonal arrays is adopted to find the surface roughness (R_a), tool wear rate and chip removal on workpiece H13 tool steel in turning process.

II. EXPERIMENTATION

A. *Selection of workpiece and cutting tool*

Chromium hot-work tool steels are classified as group H steels by the AISI classification system. This series of steels start from H1 toH19. H13 chromium hot-work steel is widely used in hot and cold work tooling applications. Due to its excellent combination of high toughness and fatigue resistance H13 is used more than any other tool steel in tooling applications. For the experiments H13 tool steel of 36mm diameter and 90mm length is taken.

TABLE 1The chemical compositions of H13 tool steel

Element	**Content (%)**
Chromium, Cr	4.75-5.50
Molybdenum, Mo	1.10-1.75
Silicon, Si	0.80-1.20
Vanadium, V	0.80-1.20
Carbon, C	0.32-0.45
Nickel, Ni	0.3
Copper, Cu	0.25
Manganese, Mn	0.20-0.50
Phosphorus, P	0.03
Sulfur, S	0.03

Three different types of cutting tools of 55˚ were used for this experiment they are Tungsten-Carbide, Titanium- Nitride and Silicon-Carbide.

B. *Selection of cutting parameters*

For this experiments cutting tool, cutting speed and depth of cut were selected as cutting parameter for turning H13 tool steel with two different types coolants, namely conventional coolant and MQL method.

C. *selection of cutting fluid*

Conventional fluid and Mustard oil are used as the cutting fluid for turning H13 tool steel in MQL method in this experiments. The properties of mustard oil are tabulated below.

TABLE2Properties of Mustard Oil

Parameter	**Value**
Relative Density (g/cm3; 20˚C/water at 20˚C)	0.914 - 0.917
Refractive Index (nD 40˚C)	1.465 - 1.467
Crismer Value	67 – 70
Viscosity (Kinematic at 20˚C, mm2/sec)	78.2
Cold Test (15 Hrs at 4˚C)	Passed
Smoke Point (˚C)	220 – 230
Flash Point, Open cup (˚C)	275 – 290
Specific Heat (J/g at 20˚C)	1.910 - 1.916
Thermal Conductivity (W/m˚K)	0.179 - 0.188

D. Design of experiment

18 experiments were conducted according to Taguchi Method of eighteen standard orthogonal arrays.As per the Taguchi method L18 orthogonal array by taking following factors for the experiment.

TABLE 3 Experiment's parameter and level

PARAMETER	LEVELS		
	1	*2*	*3*
Coolant	Conventional coolant	Minimum Quantity Lubrication	-
Cutting speed *(m/min)*	41.84	62.76	80.86
Depth of cut *(mm)*	0.4	0.6	0.8
Cutting tool	Tungsten carbide	Titanium nitride	Silicon carbide

Here L18 orthogonal array was adopted because the array L_{18} $(2^1 3^7)$ has 18 row, one “2 level” column; and seven “3 level” columns. Thus, there are eight columns in the array L_{18}. The number of rows of an orthogonal arrayrepresents the requisite number of experiments. The number of columns of an array represents the maximum number of factors that can be studied using that array. The table below shows the list of experiments conducted according to the Taguchi Method for turning H13 tool steel work piece.

TABLE 4.1L18 orthogonal array table of the experiments conducted

Exp.no	Coolant	Cutting speed *(m/min)*	Depth of cut *(mm)*	CuttingTool	Surface Roughness *(µm)*
1	CC	41.84	0.4	Wc	6.04
2	CC	41.84	0.6	TiN	2.64
3	CC	41.84	0.8	Sic	1.25
4	CC	62.76	0.4	Wc	7.35
5	CC	62.76	0.6	TiN	0.64
6	CC	62.76	0.8	Sic	3.79
7	CC	80.86	0.4	TiN	5.04
8	CC	80.86	0.6	Sic	0.93
9	CC	80.86	0.8	Wc	2.01
10	MQL	41.84	0.4	Sic	1.42
11	MQL	41.84	0.6	Wc	1.48
12	MQL	41.84	0.8	TiN	1.56
13	MQL	62.76	0.4	TiN	0.78
14	MQL	62.76	0.6	Sic	0.99
15	MQL	62.76	0.8	Wc	1.31

16	MQL	80.86	0.4	Sic	1.48
17	MQL	80.86	0.6	Wc	5.69
18	MQL	80.86	0.8	TiN	0.92

III. RESULTS AND DISCUSSIONS

By comparing the surface roughness value of both conventional method and MQL method for this 18 experiments, its noted that good surface finish is gained mostly in MQL method, ofcourse good surface finish is gained in conventional method only in one or two experiments. In most of the experiments surface finish of conventional method is noted as poor.

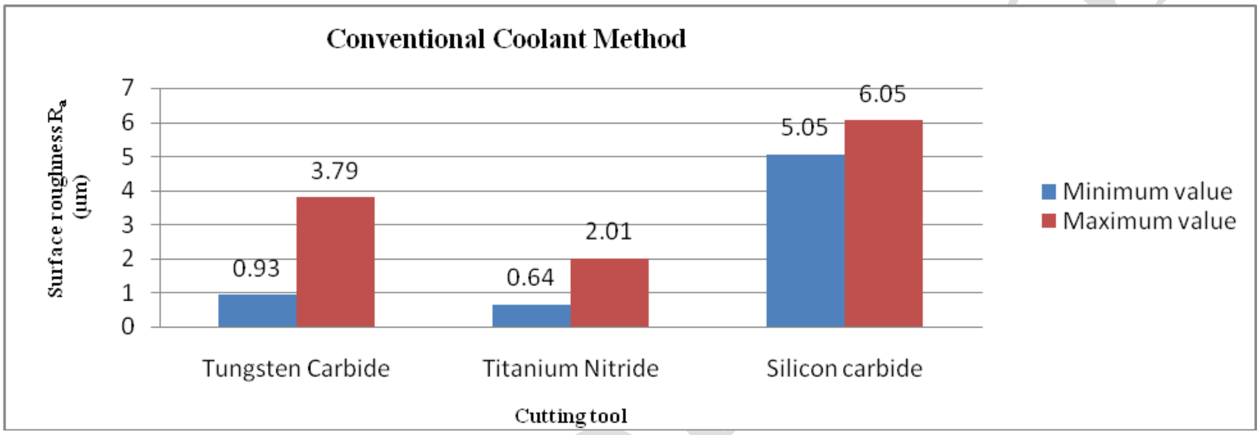

Fig 1 Surface roughness of conventional coolant method

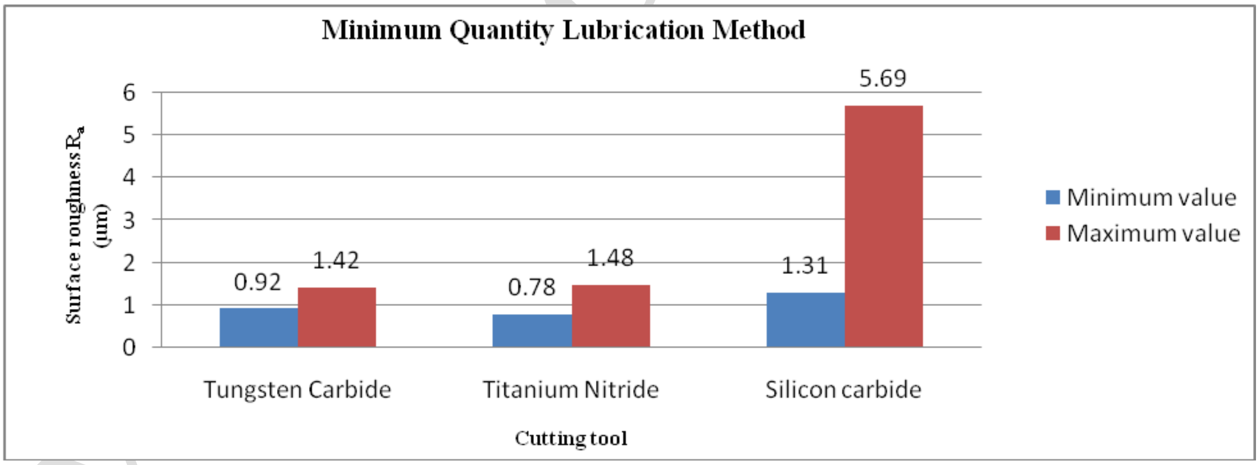

Fig 2 surface roughness of Minimum Quantity Lubrication method

IV. CONCLUSIONS

In the study of mustard oil as coolant in turning H13 steel using minimum quantity lubrication method following conclusions were drawn below:

- Most of MQL method gained good surface finish of turning H13 tool steel.
- Minimized the usage of cutting fluid of large quantity.

- Minimized the hazards of harmful aerosols.
- Mustard oil does not pollute the environments.

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