EXPERIMENTAL INVESTIGATION ON TURNING OF TURBINE BLADE MATERIAL AISI 420 SS (X20 CR13 ALLOY) UNDER DIFFERENT CUTTING FLUID CONDITIONS

Madan Mohan Reddy Nune[1], Vemula Adithya[2], Phaneendra Kiran Chaganti[3]
[1]Research Scholar, BITS Pilani, Hyd
[2]Assistant Professor, Anurag Group of Institutions, Hyd
[3]Assistant Professor, BITS Pilani, Hyd

Abstract
A different variety of cutting fluids are available in the market for various machining operations. Of them mineral and synthetic cutting fluids are commonly used in industries. Although, these cutting fluids are beneficia.l in the industries, they are harmful to health and environment. In the recent times the use of vegetable based cutting fluids came into existence. As the vegetable based cutting fluids are prepared from the naturally available resources they overcome the negative effects associated with the other fluids which are commercially in use. This paper has focused on environmental conscious machining such as dry cutting, machining with minimum quantity lubricant and especially vegetable based cutting fluids.
Index Terms: vegetable based cutting fluids; semi-synthetic; environment, lubricant.

I. INTRODUCTION

The environmental impact of lubricants is a key issue towards sustainable manufacturing. Even if dry cutting can be identified as the ultimate goal to achieve, lubrication is still a hardly surmountable industrial standard when machining difficult-to-cut alloys. Moreover, the flow rate and the type of cutting fluid are variables significantly affecting the process performance [1].

Use of cutting fluids in machining processes can reduce the cutting temperature and provides lubrication to tool and work piece. These translate to longer tool life and improved surface quality. Due to the issues of using fluids in machining related to environment, health, and manufacturing cost that need to be solved, options to reduce their use[2].

The purpose of cutting fluids in metal cutting process is to provide cooling and reduce the friction between tool and work piece at the shear zone. In dry cutting, the work piece is machined under dry conditions. The air surrounding the work piece acts as the cooling agent. Since air has low thermal conductivity it acts as a poor coolant. High temperatures at tool-work piece interface causes failure of cutting tools, formation of micro cracks and surface roughness of work piece is compromised. In wet cutting, the work piece is machined under wet conditions. Most cutting fluids constitute ninety five percent of water and five percent of cutting oil. Usage of cutting fluids have shown significant changes in thermal properties, tool wear, surface roughness and cutting forces on tool and work piece respectively. A study by few American institutes states that 60% companies are spending 20% more amount on their coolants/lubricants in a cutting operation than on cutting tool being used for machining. Uncontrolled microbial contamination of metal working fluids represents both economic and health risk [3].

When machining difficult-to-cut materials, the high temperature in the cutting area is one of the dominating phenomena affecting tool wear and process capability. Hence cutting fluids are profusely used for cooling and lubrication purposes, in order to obtain satisfactorily process performances. The use of conventional fluids creates several problems, such as the environmental pollution due to chemical disassociation at high cutting temperatures, water pollution, soil contamination during disposal, and biological problems to operators. The implementation of green machining strategies to accomplish the increasing pressures for sustainability is therefore an open challenge for manufacturers and researchers [4].

During machining operation, a huge amount of heat is generated and affects the tool life, surface roughness and dimensional sensitivity of work piece. In the case it is necessary to remove the heat from the tool and work piece. There are different methods have been used to protect tool and work piece during machining operations. One method is selection of coated cutting tools but it is expensive process and also it is mostly suitable for some materials such as titanium alloys, heat resistance alloys etc.

Another method is to apply cutting fluids in machining operation. They are used to provide lubrication and cooling effects between tool and work piece during machining operation. Cutting fluids are not only performing cooling and lubrication but also flushing the metal particles from machining region.

II. DEVELOPMENT OF SEMI-SYNTHETIC CUTTING FLUID

COMPOSITION OF A CUTTING FLUID

Every cutting fluid contains base oil + emulsifier + other additives such as corrosion inhibiter, antibacterial agent and PH controller. Base oils used for cutting fluids are of two types, they are mineral oils and vegetable oils. Mineral oils are petroleum based oils, these are effect to atmosphere after disposal into atmosphere and also they are costly than other oils due to this we refer vegetable based oils in the place of petroleum based oils as base oil.

Table 1: Characteristics of Petroleum oil and Vegetable oil

Characteristics	**Petroleum oil**	**Vegetable oil**
Lubricity	Low	High
Oxidative Stability	300	50
Viscosity Index (VI)	100	200
Hydrolytic Stability	High	High
Polarity	Low Polar	High Polar
Saturation	Saturated	Unsaturated
Flash Point	200	450
Pour Point (0F)	-35	-35

Advantages of vegetable oil based CF:
1. High biodegradability.
2. Low pollution of the environment.
3. Compatibility with additives.
4. Low production cost.
5. Wide production.
6. High flash points.

The final formulation of cutting fluid is given below

Table 2: Formulation of cutting fluid

Component	**%**
Oil	18
Surfactant	57
Co-surfactant	24.68
Anti-corrosive and pH controller	0.2
Anti-bacterial agent	0.3

The basic mixture was added to anti-corrosive and anti-bacterial to increase the life span and efficiency of the cutting fluid, this final mixture is mixed with water at 1:20 ratio (1molecule of mixture to 20 molecules of water) then the final product is stirred thoroughly, thus the final mixture is prepared.

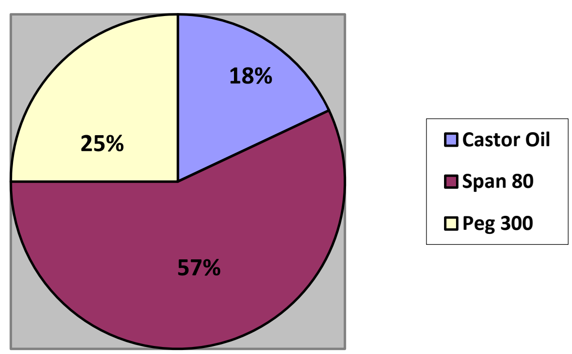


Fig 1: Composition of cutting fluid

III. EXPERIMENTATION OF CUTTING FLUID ON LATHE DURING TURNING OPERATION

The cutting fluid developed is tested on lathe machine during turning operation with specific cutting speeds, depth of cut and feed rate on a particular work piece using a tool. Three operations are performed on lathe with three different conditions like without cutting fluid (dry machining), with servo cut s oil as cutting fluid, with developed cutting fluid. The characteristics are compared for three conditions and the best one is suggested for future.

WORK PIECE (SS 420)

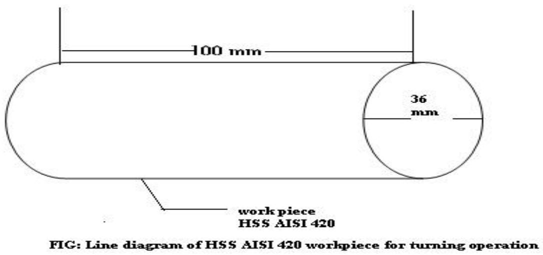


Fig 2: Line diagram of HSS AISI 420 workpiece

For machining purpose we are going to use SS STEEL 420 as work piece this type of steel is very tough, 420 is a martensitic stainless steel that provides corrosion resistance similar to Type 410 plus increased strength and hardness. It is magnetic in both the annealed and hardened conditions. Maximum corrosion resistance is attained only in the fully hardened or fully hardened and stress relieved condition. It is never used in the annealed condition. Applications requiring good corrosion resistance and high hardness are ideal for this alloy. Typical uses include cutlery, surgical and dental instruments, scissors, tapes and straight edges. The alloy is not normally used at temperatures exceeding 800°F (427°C) due to rapid softening and loss of corrosion resistance.

Table 3: Composition of stainless steel 420

COMPOSITION	**%**
Carbon	0.15 min.
Manganese	1. 00 max.
Phosphorus	0.040 max.
Silicon	0.030 max.
Chromium	12.00-14.00

This particular alloy is generally considered to have poorer weld ability than the most common alloy of this stainless class, Type 410. A major difference is higher carbon content for this alloy which requires both preheat and post-weld heat treatment. When weld filler is needed, AWS E/ER 420, 410 Ni Mo and 309L are most often specified. Type 420 is well known in reference literature and more information can be obtained in this way.

Table 4: Operating conditions

PARAMETERS	**VALUES**
Cutting speed	399 rpm
Feed	30 mm/rev
Depth of cut	0.2mm

Dry machining:

Dry machining means that no cutting fluid is used during machining process. For economical and environmental reasons machining process is carried by without cutting fluid but dry machining has some disadvantages. During dry machining process, the temperature of cutting tool is very high and this induces excessive tool wear and tool life. Also the chips generated during machining cannot wash away and these chips caused deterioration on machined surface.

In our experimentation, we perform turning operation with a length of 40 mm on work piece with a single point cutting tool by without using any coolant and cutting fluid for determine the generated temperature in cutting tool and surface roughness in work piece during operation.

Fig 3: Turning operation with no cutting fluid (dry machining)

After machining the resulted temperature and surface roughness are

Table 5: Dry machining values

Operation	**Max. temp of cutting tool in degree centigrade**	**Surface roughness of work piece in microns**
Turning	296	2.81

Machining with servo cut oil:

In this operation, we perform turning operation with servo cut oil used as cutting fluid for determining the maximum temperature of tool and surface roughness of work piece during operation.

We prepare cutting fluid by diluting the 500ml of servo cut oil with 10litres of water as per mixing concentration 1:20 ratio. This fluid is placed in the sump of lathe machine for continuous supplying of fluid during operation. A pump is used to supply the cutting fluid from sump to machining area.

Fig 4: Turning operation with servo cut oil

After machining the resulted temperature and surface roughness are

Table 6: Servo cut s machining values

Operation	Max. temp of cutting tool in degree centigrade	Surface roughness of work piece in microns
Turning	201	2.28

Machining with developed cutting oil:

In this operation, we perform turning operation with our developed cutting oil used as cutting fluid for determining the max temperature of tool and surface roughness of work piece during operation.

We prepare cutting fluid by diluting the 500ml of our developed cutting oil with 10litres of water as per mixing concentration 1:20 ratio. This fluid is placed in the sump of lathe machine for continuous supplying of fluid during operation. A pump is used to supply the cutting fluid from sump to machining area.

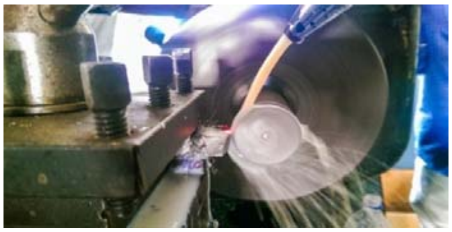


Fig 5: Turning operation with developed cutting oil

After machining the resulted temperature and surface roughness are

Table 7: Developed cutting fluid machining values

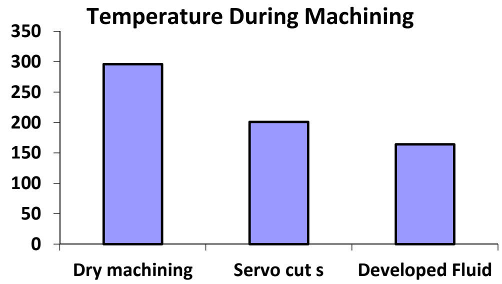
Operation	Max. temp of cutting tool in degree centigrade	Surface roughness of work piece in microns
Turning	164	1.65

The surface finish values are average of all values obtained for specific machining conditions. The surface finish obtained for dry machining is higher than other conditions. The surface finish obtained for servo cut s oil is 15% less than that obtained for dry machining. The surface finish obtained for developed cutting fluid is 30% less than that of dry machining.

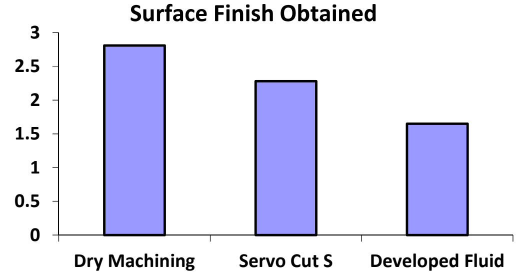
The developed cutting fluid has obtained better surface finish and the reduction of temperature during machining. The cutting fluid has good properties of reducing temperatures and providing better surface finish.

IV. RESULTS AND DISCUSSIONS

The temperatures obtained during machining at different conditions are represented below:



The surface finish obtained during the different conditions of machining are represented below:



V. CONCLUSION

The machining properties of a work piece are observed with three different conditions. The different conditions are dry machining, with servo cut s oil as cutting fluid, and with the semi synthetic cutting fluid which we developed.

The cutting fluid developed has obtained better surface finish and the temperature obtained during the machining operation has less than the other machining conditions. The surface finish obtained during machining using cutting fluid is 30% less than the dry machining.

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