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Experimentation of Surface Roughness of AISI-1080 in Turning Operation under Different Cooling Conditions

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Abstract- This paper presents the optimized method of machining process for improved surface finish of AISI 1080 steel which was turned under dry, wet and mist condition.In machining operation large amount of cutting fluids are used for cooling & lubrication purpose. There is necessity to use minimum amount of cutting fluid for machining operations. In this work, to achieve that aim, Minimum quantity lubrication (MQL) method was used to reduce the cutting fluid while machining. A mathematical model will also developed to determine the surface roughness in terms of machining time and cutting tool wear function in terms of the four independent variables: the cutting depth (d), the cutting feed (f), the cutting speed (Vc) and the cutting duration (t). The results application of MQL technique will significantly helps to obtain better performance in compare to dry condition. The purpose of cutting fluid in a machining operation is to cool the work piece, reduce friction, and wash away the chips. The cutting fluid contributes significantly toward machining cost and also possesses environmental threats.

Index Terms- Minimum Quantity lubrication(MQL),Original Equipment Manufacturer(OEM), High Speed Steel(HSS), Surface Roughness(Ra),

I. Introduction

The motive of this study is to obtain optimum cutting conditions for reduction in tool wear, surface roughness, material removal rate and components of cutting forces in turning of mild steel AISI 1080 with HSS tools. Mild steel have been around in the market for a long time now. However, their potential use in the area of air craft fittings, aerospace components such as shafts, valves, special screws, bushings, cryogenic vessels and components for chemical environments is beginning to be appreciated lately.Mild steel AISI 1080 unlike conventional metals are considered to be 'easy to machine' materials, due to their inherent properties. It has been estimated that about most of the mild steel structural components made for automotive industries require some form of machining. This high proportion of machining involved with steel parts in the aerospace and automotive industries. So manufacturer to improve the tool-life in machining of mild steel components used in their manufactured products. The manufactured parts supplier (will be referred as Original Equipment Manufacturer(OEM)) was experiencing productivity loss due to shorter tool-life on the machining station used to machine these mild steel components. Because of the shorter tool-life, the machine used to be down for longer periods of time, owing to frequent tool changes and quality checks after each tool change[1][3]. This problem was exacerbated due to the fact that the life of some tools was half that of the rest of the tools used to machine of mild steel materials[4][5]. This resulted in significant bottlenecking on the powder metal component machining stations. Hence, a need was felt tofundamentally study and analyze the machining operation and to develop a predictive model for increasing the life of the tools, surface finish, material removal rate and reducing the components of cutting force. In order to understand the behavior of the mild steel and HSS cutting tools during machining and that extensive experimental work was conducted with varying cutting conditions and response output data was collected. Then optimization technique was used to obtain optimum cutting conditions, which would produce maximum number of components.

II. Minimum Quantity Lubrication System

The conventional system of applying the coolant is flood coolant system, in which a large quantity of coolant is continuously impinged on the rake face of the tool[2]. This system is very inefficient. Firstly, a large quantity of the cutting fluid is required. Second, the cutting fluid is not able to reach the cutting zone due to obstruction from chips. A better method is the application of mist lubrication, in which a mixture of air and cutting called aerosol is produced and supplied in the cutting zone with a high pressure. The system uses an atomizer. The atomizer is an ejector where the compressed air is used to atomize the cutting oil. By the air in a low-pressure distribution system to the machining zone. As the compressed air flows through the venturi path, the narrow throat around the discharge nozzle creates a venturi effect in the mixing chamber, i.e., a zone where the static pressure is below the atmospheric pressure, it produces a spray of gaseous suspension called mist in the machining zone which works as cooling as well as lubricating medium[9].

III. Problem Statement

Cutting fluid used in machining industries has evolveissues like employee health and environmental pollution. The current trend in metal working industry is to completely eliminate or drastically reduce the cutting fluid use in most machining operations, which ispractically impossible. Also Metal cutting fluid changes the performance of machining operation because of their lubrication, cooling and chip flushing function. The growing demands for high productivity machining need use of high cutting speed and high feed rate. This produce high temperature which not only reduce the tool life but also impairs the product quality. Because of this some alternative has been sought to minimize or even avoid the use of cutting fluid in machining operations. One of the alternatives is MQL. The MQL can able to subsidize the heat generated. The saving in cutting fluid and other related costs would be very significant if minimum lubrication (MQL) is adopted. Machining with MQL is cost saving and environmental friendly option.

IV. Objective

The purpose of this research is to investigate and optimize the surface roughness in turning operation under different cooling conditions and also to investigate the effect of various cutting conditions for surface roughness.

V. Literature Review

The recent reviews and relevant published work in the area of mild steel AISI 1080 machining using HSS tool inserts. It has been noted that so much published work does not exists on machining of powder metals. The major variables that influence the machinability of mild steel AISI 1080 are Work material and properties, Cutting tool materials, Cutting conditions, Cutting tool geometry, Coolant application and type of machining operation.

In what follows, a brief review of these influencing variables and how they affect machining of mild steel AISI 1080 will be presented.

So many numbers of researchers have been used Taguchi method for design the experiment and also used to optimize the turning operation on the different alloys.

Several recent and novel approaches have been proposed and are examined. The experimental investigation is done on the role of MQL on cutting temperature, tool wear, surface roughness and dimensional deviation in turning of AISI-4340 steel at industrial speed-feed combinations by uncoated carbide insert. MQL under pulsed jet mode protects the operator's health and reduces the detrimental effects on the environment. MQL technique offer better results than by dry cutting in terms of surface roughness. The tool life was increased by 43.75 % by MQL than dry cutting[8][9][10]. The average chip-tool interface temperature increases with the increases in cutting velocity and feed rate for all three conditions.

VI. Experimental Setup

Turning Operation on Lathe Machine

A lathe is a machine tool which rotates the work piece on its axis to perform various operations such as cutting, sanding, knurling, drilling, or deformation, facing, turning, with tools that are applied to the work piece to create an object which has symmetry about an axis ofrotation.

Turning is a machining process in which a cutting tool, typically a non-rotary tool bit, describes a helical tool path by moving more or less linearly while the work piece rotates. The tool's axes of movement may be literally a straight line, or they may be along some set of curves or angles, but they are essentially linear.

Experimental procedure

For conducting the experiment Centre Lath was used. The work material for experiment was used mild steel AISI 1080 and HSS as the cutting tool.After each and every experiment the HSStool was removed and allows it to cool naturally.After each experiment work piece is also removed, the average surface roughness (Ra) of work piece was measured by using contact type surface roughness measurementinstrument. The measurement is repeated on three reference places on the cylindrical surface of the work piece. It is a contact type measuring instrument with a probe which is travelling in the work piece surface; probe has a diamond tip of having diameter 2 micro-meter. The range of the measuring instrument is 0.05-40 micro-meter.This procedure is repeated for each experiment with different-different cooling conditions.

Work Material AISI 1080

In turning, the raw form of the material is a piece of stock from which the work pieces are cut. This stock is available in a variety of shapes such as solid cylindrical bars and hollow tubes. Custom extrusions or existing parts such as castings or forgings are also sometimes used. Turning can be performed on a variety of materials, including most metals and plastics.The machinability of a material is difficult to quantify, but can be said to possess the following characteristics:
- Results in a good surface finish
- Promotes long tool life
- Requires low force and power to turn
- Provides easy collection of chips

AISI 1080 mild/low carbon steel has excellent weld ability and produces a uniform and harder case and it is considered as the best steel for carburized parts. AISI 1080 mild/low carbon steel offers a good balance of toughness, strength and ductility. Provided with higher mechanical properties, AISI 1080 hot rolled steel also includes improved machining characteristics and hardness.

- machining, threading and punching processes.
- It is used to prevent cracking in severe bends.

HSS Single Point Cutting Tool

On the basis of literature review HSS tools is selected for turning process. HSS is less expensive per unit than other typical tool materials, and it is more brittle, making it susceptible to chipping and breaking. This gives the benefit of using HSS at the cutting interface without the high cost and brittleness of making the entire tool out of HSS[6][7]. Most modern face mills use HSS tool, as well as many lathe tools and end mills. In recent decades, though, solid-HSS end mills have also become more commonly used.

Cutting Fluids used in Experiment

Water, Soluble oil (mixture of oil and water), Oils (mineral, animal, vegetable, compounded, and synthetic oils)[10]

Cutting environmental condition

Dry cutting, Wet cutting (flood cooling) ¡E Minimum quantity lubrication (MQL) machining

Selection of Input and Output Parameter

Turning Process Parameter

In turning, the speed and motion of the cutting tool is specified through several parameters. These parameters are selected for each operation based upon the work piece material, tool material, tool size, and more. [8]Turning parameter that can affect the process are:

1) Cutting speed, 2) Spindle speed, 3) Feed rate, 4) Axial depth of cut, 5) Radial depth of cut, 6)Type of cutting fluid.

A cutting speed for mild steel of 30 meters/min is the same whether it is the speed of the cutter passing over the work piece, such as in a turning operation, or the speed of the (rotating) cutter moving past a (stationary) work piece such as in a milling operation. For a given material there will be an optimum cutting speed for a certain set of machining conditions, and from this speed the spindle speed (RPM) can be calculated. Feed rate is the velocity at which the cutting tool is fed, that is, advanced against the work piece. It is expressed in units of distance per revolution for turning and boring (typically inches per revolution [rpm] or millimeters per revolution). The thickness of the material that is removed by one pass of the cutting tool over the work piece. Cutting speed and feed rate come together with depth of cut to determine the material removal rate, which is the volume of work piece material (metal) that can be removed per time unit.

Response Output

Surface roughness of machined parts is the output on which the complete focus is put on. It is measured in decibel and a complete smooth surface has 0 value of surface roughness.

VII. Surface Roughness Measurement

The quality of surface is a factor of importance in the evaluation of machine tool productivity. Hence it is important to achieve a consistent surface finish and tolerance.

The effects of cutting parameters, which also contribute to the variation in the tool's modal parameters, are more useful for controlling tool vibration. This study focuses on the collection and analysis of cutting-force, tool-vibration and tool- modal-parameter data generated by lathe dry turning of steel samples at different speeds, feeds, depths of cut, tool nose radii, tool lengths and work piece lengths. This analysis investigated the effect of each cutting parameter on tool stiffness and damping, and yielded an empirical model for predicting the behavior of the tool stiffness variation.

Figure 3.7: Portable Surface Roughness Measuring Device

Experimental Parameters table

Parameters used in the experiments are:

S.No FEED DOC CUTTING SPEED C.C

1. 0.251.5mm 31.68 m/min Dry
2. 0.251.0mm20.966 m/min Wet
3. 0.25 0.5mm13.0609 m/min Mist

Combination of parameters for optimal Surface Roughness:

s.no.	Feed (mm/rev)	D.O.C (mm)	Cutting speed (m/min)	Cooling cond.
1	0.25	1.5	31.68	Dry
2	0.25	1	20.966	Dry
3	0.25	0.5	13.0609	Dry
4	0.25	1.5	31.68	Wet
5	0.25	1	20.966	Wet
6	0.25	0.5	130609	Wet
7	0.25	1.5	31.68	Mist
8	0.25	1	20.966	Mist
9	0.25	0.5	130609	Mist

VIII. Conclusion

To find out which input parameter is influencing the average surface roughness, tool flank wear, material removal rate and cutting forces components by using the statistical technique such as ANOVA. After the analysis by ANOVA the most significant factor which were influencing is obtained in the term of % contribution.

From ANOVA it was found that cutting speed has greater contribution on average surface roughness 37.365%, along with 37.38% and 25.31% respectively as depth of cut and cutting condition.During the analysis it was observed that cutting fluid also have considerable effect on the surface roughness.

The study determined appropriate cutting parameters to optimal performance measures. The Taguchi optimization method was successfully applied in the study[11]. Machining parameter surface roughness was maximized for the considered mild steel AISI 1080; process performance was enhanced and product quality was improved.

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