THE STUDY ON THE EFFECTS OF WATER COMPOSITION IN COOLANT TO THE SURFACE CONDITION OF WORKPIECE

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This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Process) with Honours.

by

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DECLARATION

I hereby, declared this report entitled "The effect of water composition in coolant to the surface condition of workpiece" is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Process) with Honours. The member of the supervisory committee is as follow:

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Date	:	22nd May 2009
Official Stamp	:	

ABSTRACT

In this study, an attempt has been made to investigate the effect of water composition in coolant to the surface condition in turning of low carbon steel using coated carbide cutting tool. The machining experiment is conducted on computer numerical control lathe machine and using water miscible cutting fluid as coolant. Three cutting parameters, cutting speed, feed rate and depth of cut are fixed at 107 mm/min, 0.05 mm/rev and 0.2 mm respectively. The composition of water in coolant is varied from 92%, 94%, 96% and 98%. The turning operation is done using the above-mentioned parameters and the result obtained is analyzed using surface profilometer for surface roughness and stereo microscope for rust formation. It is found that water composition in coolant is not giving any significant result to the surface roughness of a workpiece. The chip produced after every machining process is influenced by the machining condition and the rust formation area is increased with the respect to the time and it is also not influenced by the water composition in coolant.

ABSTRAK

Dalam kajian ini, percubaan telah dilakukan untuk menentukan kesan komposisi air dalam kepekatan cecair pemotong terhadap keadaan permukaan keluli berkandungan karbon rendah menggunakan alat pemotong jenis karbaid tidak bersalut. Eksperimen pemesinan telah dilakukan di atas mesin larik kawalan komputer bernombor dan menggunakan cecair pemotong larut air sebagai penyejuk. Tiga parameter pemotongan, halaju memotong, kadar pemotongan dan kedalaman potongan telah ditetapkan pada 107 mm/min, 0.05 mm/putaran dan 0.2 mm. Operasi pemusingan dilakukan dengan menggunakan parameter yang dinyatakan di atas dan keputusan yang diperoleh dianalisis menggunakan profilometer untuk kekasaran permukaan dan mikroskop stereo untuk kawasan kemunculan karat. Komposisi air dalam penyejuk didapati tidak memberi sebarang keputusan bermakna terhadap kekasaran permukaan bahan kerja. Serpihan yang dihasilkan selepas setiap proses pemesinan dipengaruhi oleh keadaan pemesinan dan kemunculan karat adalah meningkat mengikut masa dan ia juga tidak dipengaruhi oleh komposisi air di dalam cecair pemotong.

DEDICATION

To my beloved parents:

Encik Abdullah Musa & *Puan Faridah Hussein*

&

To my supportive siblings:

Roslina

Mohd Fazlie

Rosmalina

Mohd Faiz Faizal

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LIST OF ABBREVIATION

AISI	-	American Iron and Steel Institute
BUE	-	Built-up Edge
C	-	Continuous
CNC	-	Computerizes numerically controlled
d	-	Depth of cut
DC	-	Discontinuous
f	-	Feed rate
HSS	-	High speed steel
ISO	-	International Organization for Standardization
LED	-	Light emitting diode
m/min	-	meter/minutes
mm	-	millimeter
mm/rev	-	millimeter/revolution
MRR	-	Material Removal Rate
R_a	-	Average surface roughness
RPM	-	Revolution per minute
SEM	-	Scanning electron microscope
TiAlN	-	Titanium aluminum nitride
TiC	-	Titanium carbide
TiCN	-	Titanium carbon nitride
TiN	-	Titanium nitride
v	-	Cutting speed
WC	-	Tungsten carbide
WP	-	Workpiece

CHAPTER 1
INTRODUCTION

1.1 Background

Machining is a process to cut, shape, or finish by machine. In cutting, the process may include drilling, forming, or grinding of a workpiece. Machining is also a group of processes that consist of the removal of material and modification of the surfaces of workpiece after it has been produced by various methods. Machining involves secondary and finishing operations. This study will discuss about one of three major types of material-removing processes which involving single-point and multi-point cutting tools that is turning operation.

A system of machining consists of workpiece, cutting tool, machine tool, and production personnel (Kalpakjian, 2006). The factors or variables that influenced machining can be divided into independent and dependent variables. The independent variables in cutting process are: tool material and coatings, tool shape, surface finish, and sharpness, workpiece material and conditions, cutting speed, feed rate, and depth of cut, cutting fluids, characteristics of the machine tool and work-holding and fixturing. The dependent variables in cutting are those that influenced by changes in the independent variables. They are: type of chip produced, force and energy dissipated during cutting, temperature rise in the workpiece, the tool and the chip, tool wear and failure, and surface finish and surface integrity of the workpiece.

In machining process, there are various types of material being used. The common materials machined are carbon steel, aluminium, tool steel, high speed steel, brass, and etc. These materials are machined according to their application. Thus, surface roughness is an important aspect in determining the quality of the finish product. The value of surface roughness desired is small and as smooth as possible. Based on the product requirement, the smaller R_a value obtained, the surface finish of the product is better.

A lot of studies are done in order to determine the best cutting parameters to be used in order to produce the best surface finish. In previous studies, the value of surface roughness is determined by the cutting parameters such as depth of cut, cutting speed, feed rate, cutting force and etc. which had been varied in order to get the best result. The major influence in determining good surface finish is feed rate. The feed rate provides primary contribution in influences most significantly on the surface roughness while cutting speed has no significant effect on surface roughness (Lalwani *et al.* 2008) similar to the depth of cut (Kassab *et al.* 2007).

As effect of water composition towards surface roughness is not widely discussed. So, this study has taken the opportunity to investigate the effect of water composition in coolant to the surface roughness. This effect will be studied through turning process with mild steel as the material. The surface roughness values will be analyzed after the workpiece being turned using different value of coolant concentration that varied from 2% to 8%. Each concentration will have three different workpiece with same dimension to be experimentally machined. So, total of the workpieces machined are twelve. The value of surface roughness will be compared to determine either they are directly proportional to the increment of coolant concentration or not.

1.2 Problem Statement

Coolant is a cutting fluid that is widely used in machining process to reduce frictional heating, and removing chips produced by workpiece. It is also give an effect on the surface quality, shape, dimensional accuracy of a workpiece also the ability in enhancing the tool life, and protecting the workpiece from corrosion. But, the less usage of coolant will reduce operational cost and also create green machining environment. The previous researches mostly studied on the cutting parameters like cutting speed, feed rate and depth of cut on the surface roughness but not on the contribution and effect of coolant itself. This study will investigate the effect of the coolant with different concentration on the surface roughness values of the workpiece after being turned. After the machining process is done, there will be formation of rust on the material as mild steel is widely known have high tendency of corrosion. The area ratio on the workpiece also will be determined. Beside that, the chip formation for every workpiece also being observed after every turning process in order to investigate the types of chip produced.

1.3 Objectives

The objectives of this study are to:

1. Compare the surface finish of workpiece when water composition is varied;
2. Observe the chip formation produced after machining process; and
3. Observe the rust formation on the workpiece.

1.4 Scope of Study

This study main emphasis is to investigate the surface roughness on mild steel after turning operation using coated carbide as cutting tools. The process is done on the HAAS SL Turning Center in the room temperatures. During the machining operation, cutting parameters that are feed rate, cutting speed and depth of cut are not varied and are constant and uniformed. The only parameter that is varied is coolant concentration in the cutting fluid. There are twelve samples used to complete the concentration and to test for the surface roughness analysis. The percentages of coolant diluted with water are varied from 2% to 8%. Chip and rust formation are observed in order to determine the types of chip formed and the percentage formation of corrosion area.

A profilometer or surface roughness tester, Mitutoyo SJ-301 is used to measure and identify the surface roughness and it values. This will determine the surface roughness of the material after completing the turning operations. Thus, effect of coolant concentration on the surface roughness is identified after the materials have been machined. Zoom Stereo Microscopes is used to evaluate the area ratio of the rust formed on the workpiece.

CHAPTER 2

LITERATURE REVIEW

2.1 Usage of Cutting Fluid/Lubricant in Machining Process

The aims of cutting fluid application are as cooling and lubrication in metal cutting (Adler *et al.,* 2006). In addition, cutting fluids can help to dispose the chips and control chip formation (Sokovic and Mijanovic, 2001) because it will decrease contact length between chip and tool, and this situation has a positive effect on chip braking (Shaw, 1996). Thus, it can help to achieve better tool life and surface finish. However, it is stated that cutting fluid application can either aggravate (Seah *et al.* (1995), Rakic and Rakic (2002)) or improve tool life (Avila and Abrao, 2001) depending on cutting conditions. Cutting fluids are used throughout industry in many metal cutting operations and they are usually classified into three main categories: neat cutting oils, water-soluble fluids and gases (El Baradie, 1996). Cutting fluids can be applied to the work-chip, tool-chip or tool-work interfaces (Shaw, 1986) in a metal cutting.

Lubrication using coconut oil is proved to be more effective when turning austenitic stainless steel using carbide tool. It can reduce tool wear and surface roughness value (Xavior and Adithan, 2008). Good surface quality can be obtained when using minimum quantity lubrication (MQL) when turning AISI4340 steel (Dhar *et al.,* 2006). Other researchers have stated that dry machining is a success in the fields of manufacturing environmental-friendly. But, it is less effective when higher machining efficiency, better surface finish quality and severe cutting condition are required.

Khan *et al.* (2006) describe that using vegetable oil as cutting fluid through MQL technique provides the benefits mainly by reducing the cutting temperature, improving the surface finish, dimensional accuracy and cutting force. In other study, Machado and Wallbank (1997) show the results of preliminary tests using very low quantities of cutting fluids while machining steel. The low quantities are applied in a fast flowing air stream. The results are compared to traditional flood cooling. The results indicate that surface finish, chip thickness and force variation are all affected beneficially with the low coolant volume compared to flood cooling.

Kumar *et al.* (2008) have study about the performance of TiCN and TiAlN tools in machining hardened steel under dry lubricating condition. As comparison, the wet and minimum fluid application also being study. The result showed that both tools performed better with minimal fluid application when compared with dry and wet machining. Better surface finish is obtained when using TiAlN tool. Che Harun *et al.* (2001) have done a study about wear of coated and uncoated carbides in turning tool steel. The use of dry machining technique and the performance of carbide tools in this dry lubrication machining is better. But, for the uncoated carbide tool, the performance is better in wet machining. Both coated and uncoated tools decrease in a short time at higher cutting speed.

2.2 Turning Process

Turning is the removal of metal from the outer diameter of a rotating cylindrical workpiece in order to produce straight, conical, curved or grooved workpiece, such as shafts spindles, and pins. Turning is used to reduce the diameter of the workpiece, usually to a specified dimension, and to produce a smooth finish on the metal. Often the workpiece will be turned so that adjacent sections have different diameters. The majority of turning process involved the use of simple singe-point cutting tools, with the geometry of a typical right-hand cutting tool. Each group of material has an optimum set of tool angles, which have been developed largely through experience. Such tool is described by a standardized nomenclature. The cutting process using a single-point tool is illustrated in figure 2.1

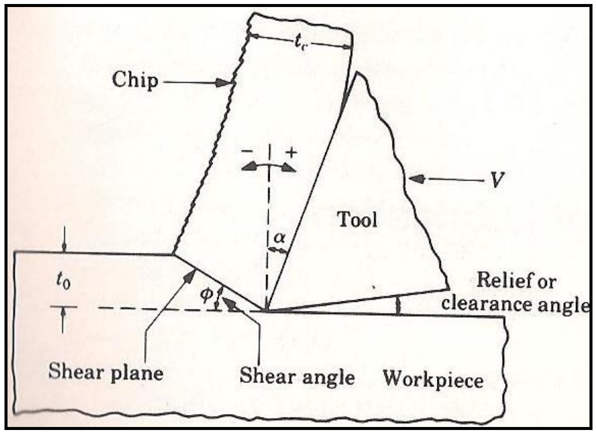

Figure 2.1: Schematic illustration of the cutting process with a single-point tool (Kalpakjian, 2006)

When turning, a piece of material is rotated and a cutting tool is traversed along two axes of motion to produce precise diameters and depths. Turning can be either on the outside of the cylinder or on the inside to produce tubular components to various geometries. Facing is part of the turning process. It involves moving the cutting tool across the face or end of the workpiece and is performed by the operation of the cross-slide, if one is fitted, as distinct from the turning. It is frequently the first operation performed in the production of the workpiece, and often the finishing process. The bits of waste metal from turning operations are known as chips.

The material removal rate (MRR) in turning is the volume of material removed per unit time in mm^3/min. For each revolution of the workpiece, a ring-shaped layer of material is removed. The MRR in turning process can be calculated using equation 2.1.

$$MRR = \pi \times D_{avg} \times d \times f \times N \tag{2.1}$$

where;
- D_{avg} : Average diameter
- N : Rotational speed of the workpiece
- F : Feed rate
- D : Depth of cut

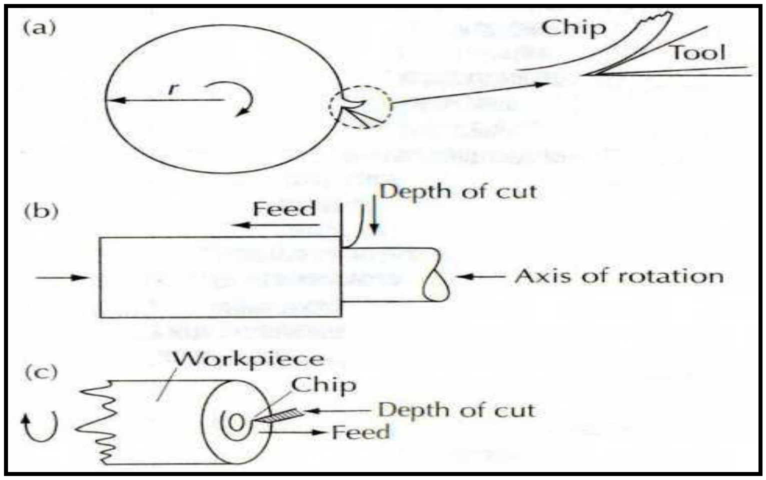

Figure 2.2: Modes of turning: (a) radial; (b) axial; (c) face (Whitehouse, 2002)

The forces acting on a cutting in turning are important in the design of machine tools. The machine tool and its components must be able to withstand these forces without causing significant deflections, vibrations, or chatter during the operation. There are several modes of turning process, radial, axial and face as illustrated in figure 2.2. There are three principal forces during a turning process: cutting force, thrust force and radial force.

i. The cutting force acts downward on the tool tip allowing deflection of the workpiece upward. It supplies the energy required for the cutting operation.
ii. The thrust force acts in the longitudinal direction. It is also called the feed force because it is in the feed direction of the tool. This force tends to push the tool away from the chuck.
iii. The radial force acts in the radial direction and tends to push the tool away from the workpiece.

Several considerations are important in designing parts to be machine by turning operations. Because machining in general takes considerable time, wastes materials and not economical, it must be avoided if possible. When turning operation is necessary, the following general guidelines should be followed:

i. Parts should be designed so that they can be fixture and clamped easily in work-holding devices.

ii. The dimensional accuracy and surface finish specified should be as wide as permissible for the part to still function properly.
iii. Sharp corners, tapers, steps, and major dimensional variations in the part should be avoided.
iv. Workpiece to be machined should be as close to final dimensions as possible to reduce production cycle time.
v. Parts should be designed so that cutting tools can travel across the workpiece without obstruction.
vi. Design features should be such that commercially available standard cutting tools, inserts, and tool-holders can be used.
vii. Workpiece material should be selected for their machinability as much as possible.

2.3 Cutting Tool

The selection of cutting tool materials for a particular application is almost important factors in machining operation. The cutting tool material must possess the following characteristics: hot hardness, toughness and impact strength, thermal shock resistance, wear resistance, and chemical stability and inertness. Hardness and strength are important with regard to the hardness and strength of the workpiece material to be machined, the impact strength is important in making interrupted cuts in machining, melting temperature of the tool material is important versus temperatures developed in the cutting zone, and the physical properties of thermal conductivity and coefficient of thermal expansion are important in determining the resistance of the tool materials to thermal fatigue and shock.

Tool materials generally are divided into the following categories: high-speed steel, cast-cobalt alloy, carbides, coated tools, alumina-based ceramics, cubic boron nitride, silicon-nitride-based ceramics, diamond, and whisker-reinforced materials and nano-materials. For this study, coated carbide tool is used. Carbides are among the most