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TAJUK: **SURFACE ROUGHNESS STUDY ON MILD STEEL IN CONVENTIONAL TURNING PROCESS UNDER THREE CONDITION CUTTING FLUIDS**

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Faculty of Manufacturing Engineering

SURFACE ROUGHNESS STUDY ON MILD STEEL IN CONVENTIONAL TURNING PROCESS UNDER THREE CONDITION CUTTING FLUIDS

Abd Halimnizam Bin Hj Abdullah

Master of Manufacturing Engineering (Industrial Engineering)

2019

SURFACE ROUGHNESS STUDY ON MILD STEEL IN CONVENTIONAL TURNING PROCESS UNDER THREE CONDITION CUTTING FLUIDS

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A thesis submitted
in fulfillment of the requirements for the degree of Master of Manufacturing Engineering (Industrial Engineering)

Faculty of Manufacturing Engineering

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DECLARATION

I declare that this thesis entitled "Surface Roughness Study On Mild Steel In Conventional Turning Process Under Three Condition Cutting Fluids" is the result of my own research except as cited in the references. The dissertation has not been taken for any degree and is not concurrently submitted in the candidature of any other point.

Signature	:	....
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Date	:	....

APPROVAL

I hereby declare that I have read this dissertation/report and in my opinion, this dissertation/report is sufficient in terms of scope and quality as partial fulfilment of Master of Manufacturing Engineering (Industrial Engineering).

Signature : ....

Supervisor Name : Dr. Mohd Amri Bin Sulaiman

Date : ....

DEDICATION

To the many people who encouraged me to grow professionally and spiritually over the years, especially my wife, Haliza Binti Hj.Mohamed Salleh, my beloved parents Hajjah Maznah and Haji Abdullah, my lovely sons and daughters, Ahmad Azzem, Alyaa Najihah, Auni Raihanah and Adam Hassan and my inspirited siblings. Included also are a great many fellow educators, students and people that I am indebted to.

ABSTRACT

Surface integrity is the surface condition of a workpiece after being modified by a manufacturing process and it can change the material's properties. In surface topography, surface roughness (Ra) was concerned with the geometry of the outmost layer of the workpiece texture and interface exposed with the environment affects several functional attributes of parts, such as friction, wear and tear, heat transmission, ability of distributing and holding a lubricant, etc. Therefore, the desired surface finish was usually specified and appropriate processes were required to assess and maintain the quality of a component. The research was to investigate the influence of machining parameters and optimum process parameter to the surface roughness value of mild steel material in conventional turning using CVD (chemical vapor deposition) coated carbide insert in three condition (dry, wet and oil). Optimization of the cutting parameters is very important in determine the optimum cutting condition thus reduce machining cost and time consumed. From the results obtained, better surface roughness value was determined by combination of cutting speed 150 m/min, and feed rate 0.1 mm/rev with under coolant oil condition.

ABSTRAK

Integriti permukaan adalah keadaan permukaan bahan kerja selepas diubah suai oleh proses pembuatan dan ia boleh mengubah sifat sesuatu bahan. Di dalam permukaan topografi, kekasaran permukaan (Ra) dikaitkan dengan geometri tekstur dan antara muka lapisan paling luar bahan kerja yang terdedah kepada keadaan persekitaran dan akan memberi kesan kepada sifat-sifat fungsi bahagian seperti geseran, haus dan lusuh, penghantaran haba, keupayaan mengedarkan dan memegang pelincir, dan lain-lain. Dengan itu, kemasan permukaan yang dikehendaki biasanya ditetapkan dan proses yang sesuai diperlukan untuk mengekalkan dan menentukan kualiti komponen. Kajian ini adalah untuk menkaji kesan parameter pemesinan larik konvensional ke atas nilai kekasaran permukaan dan menentukan parameter pemesinan optimum pada bahan keluli lembut menggunakan mata alat karbida CVD dalam tiga keadaan (tanpa cecair penyejuk, cecair penyejuk berasaskan air and minyak penyejukan). Pengoptimuman perubahan adalah sangat penting untuk mengurangkan kos dan masa pemesinan. Daripada keputusan yang diperolehi, nilai kekasaran permukaan yang terbaik adalah dari gabungan kelajuan pemotongan 150 m/min dan kadar suapan 0.1 mm/rev dengan keadaan minyak penyejukan.

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"Bismillahirrahmanirrahim"

"In the name of Allah, The most Beneficent, The Most Merciful"

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BUE	-	built-up-edge
D	-	diameter of workpiece
F	-	feed rate
Fx	-	axial force
Ra	-	roughness average
V	-	cutting speed
VBb	-	width of flank wear
N	-	spindle cutting speed
CVD	-	coated

CHAPTER 1

INTRODUCTION

This chapter explains the introduction of the research on “Surface Roughness Study on Mild Steel in Conventional Turning Process Under Three Condition Cutting Fluids”. In extension, this chapter will elaborate on the problem statement, objectives and scopes of the research.

1.1 Project Background

Coolant or cutting fluids are widely use to reduce the heat in process of metal machining operations such as for turning machine, drilling machine and milling machine. Historically, cutting fluids have been use extensively for the last 200 years. Today, it is estimated that over 100 million gallons of metalworking oil are use each year in United States and the volume of cutting fluids used is many times that of metalworking oil. Cutting fluids are most fundamental and important part in metalworking industries. Cutting fluids are widely employed due to their ability to reduce friction, cutting temperature, generated heat and also to enhance workpiece surface quality (Gajrani & Sankar, 2017).

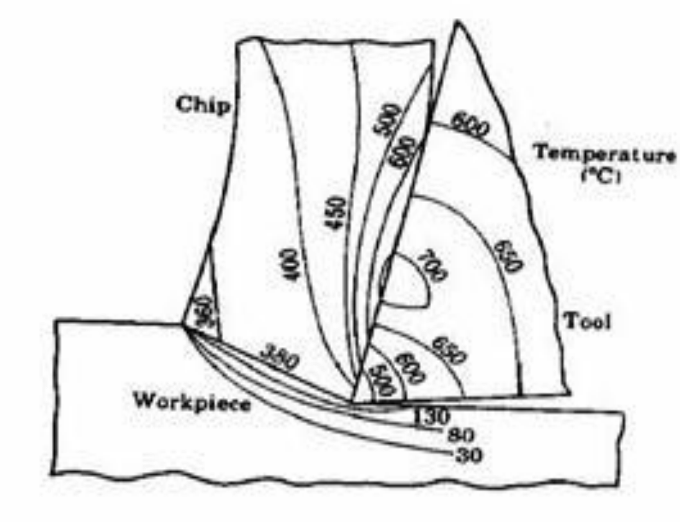

Figure 1.1: Temperature distribution at the cutting zone (Niclas Anmark, 2015)

The most common metalworking fluids use today belong to one of two categories:

- Emulsion type coolant (water base).
- Cooling oil fluids including synthetics and semisynthetics.

High cutting zone temperature conventionally tried to be controlled by applying flood cooling by soluble oil. In high speed machining, cutting fluid applied fails to penetrate the tool-chip interface and thus cannot remove heat generated effectively. However, the adequate selection and application of coolant or cutting fluids is not a simple task due to number of parameters involved. In addition, the cost associated to cutting fluids represent 16-20 percent of the production costs, therefore, their use should be restricted to circumstances where they are strictly necessary. According to (Raj, Leo, & Varadajan, 2015), cutting fluid application plays a significant role in the manufacturing industries that acts as a coolant as well as a lubricant. The conventional flood cooling application of cutting fluids not only increases the production cost on account of the expenses involved in procurement, storage and disposal but also creates serious environmental and health hazards.

In order to overcome these negative effects, techniques like Minimum quantity lubrication (MQL) and Minimal Cutting fluid application (MCFA) have increasingly found their way into the area of metal cutting and have already been established as an alternative to conventional wet machining.

An important feature of cutting fluids is the easiness to remove the contaminants from it, which leads to a longer fluids life and lower environment impact and cost. With this respect, cooling oil coolant is better in tool life and product surface finish and allow the removal of contaminants with minimal alterations on their properties. However, high pressure jet of cooling oil, if applied at the tool-chip interface could reduce cutting temperature and improve tool life to some steels. But, application of emulsion types coolant (water base) will cause environmental problems:

- Dermatological problems to the operators when physically contact with the cutting fluid.
- Water pollution when disposes to the earth.
- Extra space for pump, filtering, recycling and storage required.

1.2 Problem Statement

Cutting fluids or coolants is a significant role in machining operations and impact shop productivity, tool life and quality of work. The primary function of coolants is temperature control through cooling and lubrication (Debnath, Reddy, & Yi, 2014). A fluid's cooling and lubrication properties are critical in decreasing tool wear and extending tool life. Cooling and lubrication also important in achieving the desired size, finish and shape of the workpiece (Wasik & Kolka, 2017).

A secondary function of coolants is to flush away chips and metal fines from the tool or workpiece interface to prevent a finished surface from becoming marred and also to reduce the occurrence of built-up edge (BUE). Monitoring and maintenance of coolants is required due to contamination and degradation. Eventually, coolants require disposal once their efficiency is lost. Waste management and disposal become a major problem concerning environmental liability. The primary concern is the significant negative effects to worker's health associated with use of the cutting fluids. This paper focused on the performance of the CVD carbide cutting tool and surface roughness of machined surface with three different cutting conditions i.e.dry, wet/flood and oil cooling.

1.3 Objectives

The objectives of the research are;

i. To investigate the influence of machining parameters to surface roughness value during conventional speed turning of mild steel material under dry, coolant water base and cooling oil condition with CVD cutting tool performance

ii. To analyse the optimization of the surface roughness value for every cutting condition and define optimum process parameter setting to minimize surface roughness value of each condition.

iii. To develop mathematical model for surface roughness of machined surface in using software DOE 6.0 by ANOVA results.

1.4 Project Scope

The project scope on the surface integrity (surface roughness) on surfaces of machined mild steel materials grades JIS G3101 SS400 during conventional lathe machine withdry, coolant (water base) and cooling oil cutting condition. The surface roughness variations in single point turning operation are in different cutting speed and feed rate. The machining parameters evaluated are cutting speed, feed rate and depth of cut. The depth of cut will be constant value while the cutting speed and feed rate are will be manipulate. The value of parameters and types of cutting tool are discussed in Chapter 3.

CHAPTER 2

LITERATURE REVIEW

This chapter consists of the information gathered regarding to the project title which is surface roughness study on mild steel material in conventional lathe machine. Every aspect that will be involved in this research will be discussed and elaborated extensively by the by the guidance prior research by the previous researcher. The review covers about workpiece material (mild steel), turning operation, cutting condition (dry, coolant water and cooling oil condition), cutting tool, tool wear, surface roughness and the design of experiments of methods.

2.1 Introduction

For many machining operations including turning, drilling and milling cutting fluids can be used to allow higher cutting speeds to be used, to prolong the cutting tool life, and to some extent reduce the tool work surface friction during machining. The fluid is used as a coolant and also lubricates the cutting surfaces.

The advantages of using cutting fluids are (Jacobs and Liebenberg, 2016),

- Cools the work surface and tool
- Lubricates the interface between the work surface and tool
- Flushes away some dust, chippings and swarf
- Reduces tendency for chip adhesion/pressure welding to tool tip
- May improve resulting surface finish
- May increase tool life

- Allows higher cutting speeds

There are some advantages in using cutting fluids as listed below,

- For certain machine tools – a costly engineering system is required for applying the fluid.
- The fluid used has to be prepared and after use, filtered for re-use of disposed.
- Some fluids have a health risk if not used properly.
- Some cutting materials are affected by thermal shock e.g. cemented carbides. Used of cutting fluids should be avoided for these materials.

There are three types of coolant applied method which are through manual flood and mist application. Manual method requires an operator using a container such as oil can to apply the coolant to the tool or workpiece. This method is lowest cost method among other but it is lack in consistence of application. It also limited for several machining operations. Flood method delivers the fluid to tool and workpiece interface to produce maximum result by using a pump. The purpose of the pump is to suck in coolant from its tank and give more pressure to the coolant and send it via hose directed it to tool and workpiece interface. Mist method by atomized and blown the coolant onto the tool and workpiece interface. The mist coolant already pressurized by its tank. A valve needed to control the coolant flow rate and also as the precautions when accident occurs by stopping the coolant flow. Emulsion type coolant (water base) is the most used for mist method as the coolant (Kiwala, 2017).

2.2 Literature Review

The application of coolants and lubricants in machining operations helps overcome problems associated with tribological performance of the cutting tool. However, there are a number of factors such as the method of application, temperature, cutting speeds and type of machining operations and ecological concerns that may affect the coolant efficiency (Denkena, Helmecke, & Hulsemeyer, 2014). Water-based coolants can noticeably result in increased rates of corrosion of the machine tool and workpieces. In addition, they may have serious problems associated with the working environment. Some operators machine may have skin allergy, inhale mist or even swallow mist particles. This may cause health problems in the respiratory and digestive system due to their toxicity. On the top of that, cutting fluids demonstrate less effectiveness in machining operations conducted at high cutting speed.

In some operations such as end milling, the coolant or cutting fluids can be detrimental. This is due to the interruption nature of this operation, where the cooling action will intensive the effect of thermal cycling (alternating heating and cooling) of the cutting inserts. Other researchers (Petrilin, 2016), have been reported in their papers this finding and proved that flood coolant or cutting fluids could be the main reason of premature failure of cutting inserts, especially those made of ceramics and coated carbides. Some contributors concluded that dry machining or machining with minimum quantity of lubrication (MQL) can result in longer tool life with satisfying surface roughness.

In addition (Liu & Cheng, 2010), applied different coolant strategies when machining aluminium alloys at high-cutting speeds. They found that tool flank wear progress of uncoated carbide inserts was accepted when using MQL. (Nourredine & Vasim, 2015) indicated that the application of MQL in turning of 100Cr6 steel with triple coated carbide inserts showed some advantages in terms of tool wear reduction.

However, with the development of coolants, some of mentioned above limitations were eliminated. The researchers concluded that cooling oil are good choices for applications where heat exchange is the primary requirement of the coolants. In another study that it was concluded that semi-synthetic cutting fluids exhibited a good ability to save tool life especially at high-cutting speeds. By using low alloy steel (Krolczyk, Nieslony, & Legutko, 2015), flank wear surface area was measured by a surface texture instrument using a software package. Cutting forces were measured by a dynamometer. The experimental results show that there is an increase in the three directional components of the cutting force with increase in flank wear area. Among the three cutting forces measured, the tangential force is largest while the radial force is smallest.

However, when the tool inserts begins to fail, all the three cutting forces increase sharply. In titled (Rao, Murthy, & Rao, 2014), to observed that while turning the steel rod with TiN coated carbide tool, surface finish improves with increasing feed up to some feed where from it starts rating with further increase of feed. This type of behaviour is not observed in turning with HSS tool Dimensional deviation is significant only in the case of turning of a slender work piece. The cutting forces (Sun, Brandt, & Dargusch, 2015) and its effect due to the factors such as feed rate and rake angle on the turning process. The experimental results shown that the smallest cutting forces at negative 15° back rake angle, feed rate is 0.8 mm/rev which is the biggest in the experiment.

In titled (Kosaraju & Chandraker, 2015), which is mentioned honed edge geometry and lower piece surface hardness resulted in better surface roughness cutting-edge geometry, work piece hardness and cutting speed are found to be affecting force components. The lower work piece surface hardness and honed edge geometry resulted in lower tangential and radial process.