Faculty of Manufacturing Engineering

EVALUATION ON MACHINING PERFORMANCE OF AISI 1045 STEEL UNDER DRY CONDITION

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EVALUATION ON MACHINING PERFORMANCE OF AISI 1045 STEEL UNDER DRY CONDITION

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A dissertation submitted
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DECLARATION

I declared that this dissertation entitled "Evaluation on Machining Performance of AISI 1045 Steel under Dry Condition" is the results of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……………………………………

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Date :

APPROVAL

I hereby declare that I have read this dissertation and in my opinion this dissertation is sufficient in terms of scope and quality as a partial fulfilment of Master of Manufacturing Engineering (Quality System Engineering).

Signature : ……………………………………

Supervisor Name : **Dr. Mohd Shukor Bin Salleh**

Date :

DEDICATION

This dissertation is dedicated to my beloved parents, my lovely wife, my daughter and son, family and friends.

ABSTRACT

Surface integrity and tool wear is important to determine the quality of machine surface in order to achieve optimum cutting parameter. This project was conducted to study the optimum of cutting parameters on tool wear and surface roughness using AISI 1045 steel under dry turning process. The cutting tool that has been selected was coated carbides insert and the size of the AISI 1045 steel is 300 mm X ϕ55 mm. HAAS SL-20 CNC lathe machine was utilized in this project to remove the surface of material. The main controllable turning parameters that have been investigated in this project were cutting speed, feed rate and depth of cut. The machining parameters used in this experiment are cutting speed (150 m/min, 200 m/min and 250 m/min), feed rate (0.05 mm/rev, 0.1 mm/rev and 0.15 mm/rev) and depth of cut (1.0 mm). In this experiment, multilevel factorial design used to get the optimum parameters. Mitutoyo surface roughness tester was used to determine the average of surface roughness. The surface integrity of the workpiece and the tool wear rate of the cutting tool is analyse using the stereo microscope. Analysis was performed using experimental result, graph, and ANOVA. This project has explained the effect of dry machining condition on surface roughness and tool wear of the workpiece. Based on the analysis, the optimum cutting parameter to get the minimum surface roughness was cutting speed (200 m/min), feed rate (0.1 mm/rev) and depth of cut (1.0mm). It shows that the feed rate is the most influence parameter that contributed to the highest effect of surface roughness and followed by the cutting speed and depth of cut.

ABSTRAK

Keutuhan permukaan dan haus mata alat merupakan perkara yang penting dalam menentukan kualiti permukaan sesuatu komponen yang dimesin untuk mencapai parameter pemotongan yang optimum. Projek ini mengkaji kesan parameter pemotongan pada kehausan mata alat dan kekasaran permukaan menggunakan keluli 1045 dalam proses larik kering. Alat pemotongan yang dipertimbangkan adalah karbida bersalut dan saiz bahan kerja adalah 300 mm X ϕ50 mm. Mesin CNC larik HAAS telah digunakan dalam projek ini untuk membuang permukaan bahan. Parameter – parameter yang dipertimbangkan ialah kelajuan pemotongan *(150 m/min, 200 m/min and 250 m/min), kadar suapan (0.05 mm/rev, 0.10 mm/rev and 0.15 mm/rev) dan kedalaman pemotongan yang tetap (1.0mm). Reka bentuk eksperimen dalam projek akan menggunakan kaedah Pelbagai Faktor dalam perisian Minitab 17 . Kemudian, dengan menggunakan penguji kekasaran permukaan Mitutoyo, purata kekasaran permukaan akan diukur. Keutuhan permukaan bahan kerja dan kadar kehausan mata alat pemotongan akan dianalisis menggunakan mikroskop stereo. Analisa yang dilakukan adalah menggunakan keputusan eksperimen, carta dan juga ANOVA. Projek ini menerangkan kesan pemotongan larik kering ke atas kekasaran permukaan dan haus mata alat. Daripada analisis, parameter pemotongan yang optimum untuk mendapatkan kekasaran permukaan minimum adalah kelajuan pemotongan 200 m/min, kadar suapan adalah 0.1 mm/rev dan kedalaman pemotongan ialah 1.0 mm. Ia menunjukkan bahawa kadar suapan adalah parameter yang paling menyumbang kesan paling tinggi pada kekasaran permukaan dan diikuti dengan kelajuan pemotongan dan kedalaman pemotongan. Parameter pemotongan optimum yang menyumbang kepada kehausan mata alat yang paling rendah adalah kelajuan pemotongan 250 m/min, kadar suapan adalah 0.1 mm/rev dan kedalaman pemotongan ialah 1.0 mm.*

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

AISI	-	American Iron and Steel Institute
C	-	Carbon
CNC	-	Computer Numerical Control
Co	-	Cobalt
Cr	-	Chromium
HSS	-	High Speed Steel
Mn	-	Manganese
Mo	-	Molybdenum
Ra	-	Mean Roughness
V	-	Vanadum
Vb	-	Flank Wear
Vc	-	Crater Wear

CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, machining of materials is getting more advance as there are many developments of new alloys and engineered material which eventually causes these materials to have high strength and toughness as well as other material properties. According to Gaitonde et al. (2016), machining is a process of removing material from a workpiece using power-driven machine tools to shape it into an intended design. Meanwhile, traditional machining processes can be divided into several types including turning, drilling, boring, milling, broaching, sawing, shaping, planing, reaming, and tapping. Kalpakjian (2013) stated that the machinability is usually defined in terms of four factors which are surface finish and integrity of the machined part, tool life obtained, force and power requirements, and chip control.

The CNC turning machining parameters plays an important role in producing parts with low surface roughness. Optimized parameters will be able to machine aluminium alloy 6061 to produce low surface roughness. There are many studies have been attempted to solve this issue. However, coolant condition are often ignored in most of these studies. The coolant condition also effects the response variable of machining (Galanis, Manolakos, & Vaxevanidis, 2008). These factors that were considered as the main challenge of producing part with low surface roughness. This main objective was to identify the relationship of machining parameters of turning on surface roughness and tool wear in dry machining condition.

The experimental work is carried out by using turning process to the medium carbon steel AISI 1045 which is highly usable in the manufacturing industry to produce various machine parts. This material is suitable for a wide variety of automotive-type applications. Axle and spline shaft are two examples of automotive components produced using this material where the turning is the prominent machining process used (Noordin et.al., 2014). In today machining issues, the studies have been done to evaluate the machinability of the AISI 1045 steel by using the coated carbide cutting tools.

1.2 Problem Statement

The quality of surface finish is an important requirement of work pieces and parameter in machining process. Generally cutting fluid used to help extend the life of tools and to maintains workpiece surface properties from damages. However, if this is not taken care seriously, there is several negative effect causes by cutting fluid when handled inappropriately during machining process. Boubekri and Shaikh (2012) investigated that the exposure to such amounts of metal working fluid may contribute to adverse health effects and safety issues. This indicates that the operator may experience negative effects from the cutting fluids. Due to the issues of using cutting fluid in machining have many negative impact in manufacturing, therefore, parameters analyse under dry machining condition need to be done to ensure better surface roughness and tool ware. According to Sreejith (2008) the cost of coolants and lubricants contribute approximately around 16-20% of the overall cost of manufacturing. Thus, the price of the machining parts also increased. Therefore, in this research, machining under dry condition is selected in order to evaluate the outcome of the machining results.

1.3 Objectives

There are three main objectives by doing this project:

i. To identify appropriate cutting parameter when machining using coated carbide cutting tools.

ii. To evaluate the effect of cutting speed and feed rate on tool wear and surface roughness when machining under dry condition.

iii. To determine and validate optimal cutting parameters that produces the lowest surface roughness and tool wear under dry machining.

1.4 Scope of Project

The study focuses on the effect of surface roughness of AISI 1045 steel and tool wear during machining under dry condition. The machining process will be using high speed HAAS CNC Turning machine and coated carbide cutting tools. The surface roughness of AISI 1045 steel will be analyzed by portable surface roughness and tool wear will be analyzed by stereo microscope. The different effect of surface roughness and tool wear are based on 3 different cutting speed and feed rate.

CHAPTER 2

LITERATURE REVIEW

2.1 Machining

Kalpakjian (2013) stated that machining is a process of utilising cutting tools to expel overabundance or undesirable material from the surface of a workpiece as chips to acquire the last shape and size of the finished result. Gaitonde et al. (2016) express that machining is a process of removing material from a workpiece utilizing power-driven machine instruments to shape it into a planned outline. Okokpujie et al. (2013) stated that milling is a process of generating machined surfaces by progressively removing a predetermined amount of material or stock from the work-piece at a relatively slow rate of movement or feed by a milling cutter rotating at a comparatively high speed. Chips are framed amid machining because of the shear disfigurement of the work material. The development of the chip relies on upon the kind of material being machined and the cutting conditions taken after for the machining operation. There are four essential sorts of chips that are by and large created amid machining.

They are discontinuous chips, continuous chips, continuous chips with built-up edge, and serrated chips. A chip-breaker geometry present on the cutting tool helps in maintaining a strategic distance from the era of continuous chips. A schematic diagram of a two-dimensional machining process demonstrating the fundamental terminology is given in Figure 2.1 (Kalpakjian and Schmid, 2013). Machining is a standout amongst the most vital manufacturing process and is most frequently applied to shape metals.

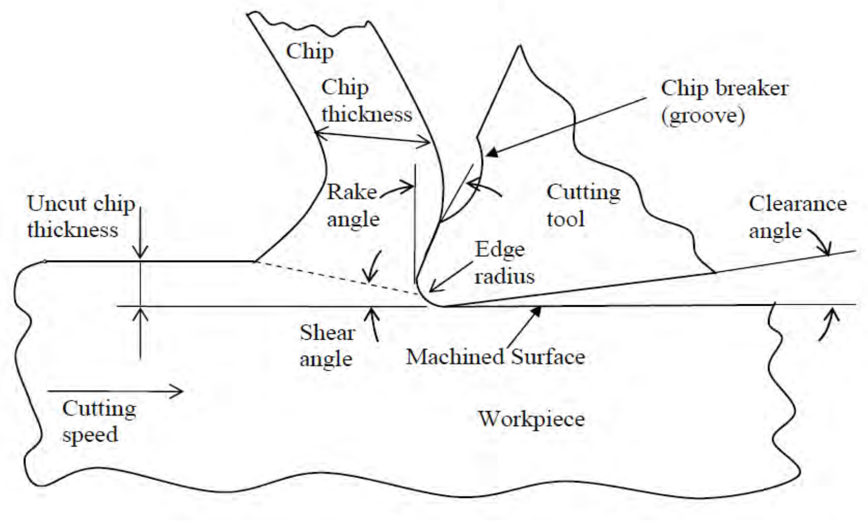

Figure 2.1: Terminology used in metal cutting (Kalpakjian and Schmid, 2013).

Material removal processes are extensively arranged into three categories which is conventional or traditional machining, abrasive processes, and non-traditional machining processes. Conventional or traditional machining involves mechanical cutting of the material using relatively sharp tools to achieve the desired geometry. There are several types of traditional machining processes such as turning, facing, milling, drilling, etc. Abrasive processes involve removal of material mechanically using hard, abrasive particles. Processes such as grinding, honing, lapping, etc., come under this category. Non-traditional machining uses various forms of energy different from those used by traditional machining and abrasive processes for the material removal.

2.1.1 Dry Machining

Dry machining is an alternative to enforce environmental protection laws for occupational safety and health regulations regarding conventional flooded cooling practice. Besides offering cost reduction in machining, the advantages of dry machining include non-injurious to skin and allergy free. Moreover, it reduced disposal and cleaning costs. However, Wernsing and Büskens (2015) stated that dry machining is not established in mass production yet, since the maintenance of shape and functionality of the machined parts is not guaranteed. In terms of surface quality, operation time and tool life, dry machining processes need to give comparable results as conventional machining processes.

The manufacturing taken a toll as coolants and lubricants utilized for machining represents to 16-20% of the manufacturing costs (Sreejith, 2008). Nonetheless, the execution of dry machining can't be refined by simply cut off the cutting fluid supply. It needs the usage of hard, wear resistant, low thermal diffusivity tool materials and coatings that can hold their properties at higher machining temperatures.

2.1.2 Wet Machining

Friction between workpiece and cutting tool cause high temperature on cutting tool during machining process. The effect of this generated heat decreases tool life and increases surface roughness. Therefore, the application of cutting fluids is to protect cutting tool from the generated heat. Besides that, cutting fluid significantly provides more efficient chip removal. As discussed by Najiha et al. (2012), metal working fluids or cutting fluids is used to minimize the thermal expansion of the worked metals, and thus aid in achieving a better surface finish on the finished product and a longer tool life.

Debnath et. al (2016) carried an experiments out on mild steel bar using a TiCN + Al2O3 + TiN coated carbide tool insert in the CNC turning process, cutting fluid also showed a significant contribution to surface roughness (33.1%) as well as to tool wear (13.7%). It showed that cutting fluids helps increase tool life and improve efficiency of the production systems by providing both cooling and lubricating during machining and remove chips from the work surface.

However, several negative effects causes by cutting fluid when handled inappropriately. Boubekri and Shaikh (2012) investigated that the exposure to such amounts of metal working fluid may contribute to adverse health effects and safety issues. This indicates that the operator may experience negative effects of the cutting fluids. Due to the issues of using cutting fluid in machining have many negative impacts in manufacturing, a detail study need to be done for an option to reduce their use.

2.1.3 Minimum Quality of Lubrication (MQL)

In machining process, the function of the cutting fluid is to minimize the heat produced between the surface of the part and tool. Minimum Quantity of Lubrication (MQL) is an alternative in machining by using the minimal amount of cutting fluids. MQL can be used in order to provide cooling over the tool-workpiece interface and reduce the quantity of heat generated due to friction. Amini et al. (2015) stated that fluid flow rate, fluid frequency, nozzle position and distance are effective parameters in MQL machining.

Yazid et al. (2011) conducted an experiment on the effects of Dry and Minimun Quantity Lubrication conditions on finish turning Inconel 718 using PVD coated TiAIN carbide tool showed that MQL produces better surface roughness than dry condition. Furthermore, it's supported by Vishwakarma et al. (2014) that the cutting performance of MQL machining is better than that of dry and conventional machining and helps improve tool life and also gives better finished surface. Elmunafi et al. (2015) showed that, by using small amount of lubricant of 50 ml/h during turning process was able to produce better results compared to dry cutting, especially in terms of longer tool life. This proves that with flood cutting fluid supply MQL provides the benefits mainly by reducing the cutting temperature, which improves the chip–tool interaction and maintains sharpness of the cutting edges.

2.2 Turning Process

Turning process is a material removal method that machines a horizontally revolving cylindrical workpiece. Atul et. al. (2011) stated that turning processes are more common for analysis of the processes parameters on the surface roughness of a general component. Turning is still use in machining operation in industry although it is the oldest machine tools. Turning means the material is remove by cutting tool while the part is rotating when machined. Normally, the starting material use is a workpiece that has been made by other processes such as casting, forging, extrusion or drawing (Kalpakjian, 2013). The typical parts in a CNC turning machine is shown in Figure 2.2.

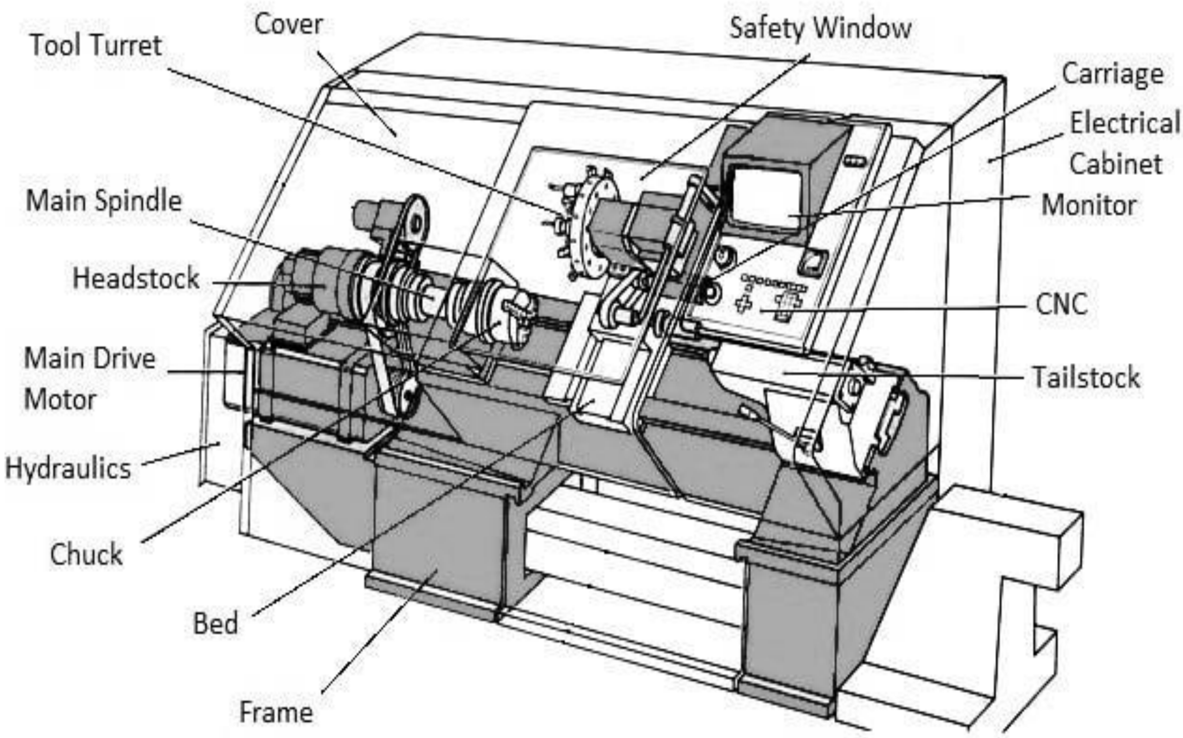

Figure 2.2 Typical parts in CNC turning machine (Kalpakjian, 2013)

The cylindrical workpiece will be gripped in spinning spindle, then the cutting tool will be feed into the workpiece to remove its material as explained by Ronald & Denis (2006). The Figure 2.3 clearly illustrates the turning process with workpiece rotation and tool feed. Basically, turning process can be classified into two main cutting processes as stated by George & Ahmad (2000). Those are cutting in the center of rotating workpiece such as drilling, boring, and reaming. Another type is the cutting done on the horizontal surface of revolving workpiece such as straight turning, threading, and contour turning.

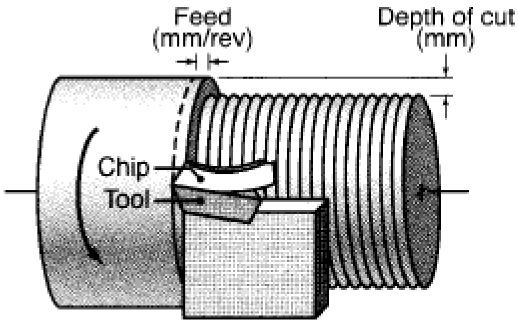

Figure 2.3: Schematic representation of turning process (Kalpakjian, 2013).

According to Groover (2012), there are few important cutting conditions involve in turning process. Those conditions are rotational speed (N), feed rate (fr), final diameter (Df), machining time (Tm), and material removal rate (RMR). First, the rotational speed is described as the cutting speed of the turning process on a surface of round workpiece as given in the equation 2.1. According to Groover (2012) feed rate of turning process is the total linear feed cut per minute as given in equation 2.2. Next, final diameter is the desired diameter that the process will produce. This can be find using equation 2.3 which is the difference of original diameter (D0) and two times of the depth of cut (*d*). Then, machining time is described as time needed to finish a cutting process. This can be calculated using equation 2.4. Finally, there is the material removal rate which is the total volume of materials removed per minute as shown in equation 2.5. These are the important cutting conditions that must be known before machining turning process.

$rotational\ speed, N = v/\pi Do$ Equation 2.1

$feed\ rate, fr = NF$ Equation 2.2

$final\ diameter, Df = Do - 2d$ Equation 2.3

$machining\ time, Tm = L/fr$ Equation 2.4

$material\ removal\ rate, MRR = vfd$ Equation 2.5

2.3 CNC turning Parameters

A CNC turning operation has many parameters to be considered before start machining. Harish Kumar, et al, (2013) have explained about all major parameters that involves in CNC turning. The parameters of CNC turning classified into five main categories which are cutting parameter, environment parameter, workpiece parameter, and cutting tool parameter as shown in Figure 2.4. Each of these parameter can be further break down into few subcategories. First, cutting parameter has cutting speed or spindle speed, feed rate, and depth of cut. Then, environment parameter can be divided into wet and dry conditions. Workpiece parameter has different types of material, their machinability, their fabrication method, and their temper designation. Finally, cutting tool also act as a parameter of turning. It can be divided as into tool's geometry, tool nose radius, and tool material (Yang et.al., 1998).