SURFACE INTEGRITY OF TITANIUM WHEN MACHINING WITH VARIOUS CUTTING PARAMETER

MOHD ‘AZIM BIN AB. HALIM

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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project report and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with manufacturing.

Signature : ....
Name of Supervisor : Dr.Dhaw Thet Thet Mon
Position : Lecturer
Date : 6 DECEMBER 2010

STUDENT’S DECLARATION

I declare that the work in this thesis entitled surface integrity of titanium with various cutting parameter is the works of my own project accept as cited in references. The thesis has not been accepted for any degree and is not concurrently submitted for award o other degree.

Signature : ………………………….

Name : Mohd ‘Azim bin Ab. Halim

ID Number : ME08004

Date : 6 DECEMBER 2010

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ABSTRACT

A comprehensive study of the surface integrity of the machine workpiece in the CNC machine of titanium with various cutting parameter is presented in this thesis. Polycrystalline diamond brazed into carbide substrated as the tools in this research.. For machining tests, all of the machining experiments were carried out by using ROMI C420 CNC turning machine. The machining parameters that will be manipulated in this experiment are feed rate and cutting speed. The surface roughness of the bar will be measured by using perthometer Surfcom 130A and chip hardness will be measure by using Micro Vickers Hardness test. The data is analyzed in STATISTICA and manually plot in excel.

ABSTRAK

Dalam laporan ini sebuah kajian menyeluruh integriti permukaan benda kerja iaitu titanium dengan berbagai parameter pemotongan. Polliskritallin berlian bersalut di atas karbit digunakan sebagai alat pemotongan di dalam kajian ini. Pemesinan proses dilakukan degan menggunakan mesin CNC model ROMI C420 CNC pembentukan mesin. Parameter mesin yang akan dimanuplasi adalah halaju pemotongan dan kadar kemasukan. Kekasaran permukaaan akan disukat dengan denagan menggunakan mesin pengukuran permukaan yang bermodel Surfcom 130A dan kekerasan tatal akan disukat dengan ujian kekerasan mikro Vickers. Data akan dianalisa di dalam Statistica dan juga diplot di dalam Excel.

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Ra	Coefficient of Surface Roughness
SS	Statistical Significant
df	Degree of Freedom
P	Probability
F	Function
Mm	Milimeter
$\%$	Percentage
Mm/rev	Milimeter per revolution
m/min	Meter per min
μ	Micro
V	Cutting speed
f	Feed rate
in	inch

LIST OF ABBREVIATIONS

AISI	American Iron and Steel Institutes
ANOVA	Analysis of Variance
CNC	Computer Numerical Control
DOE	Design of Experiment
FKM	Faculty of Mechanical
FKP	Faculty of Manufacturing
ISO	International Standard Organization
LAM	Laser Assisted Machining
NC	Numerical Control
UMP	Universiti Malaysia Pahang

CHAPTER 1

INTRODUCTION

1.0 OVERVIEW

Titanium is a relatively lightweight metal that provide excellent corrosion resistance, a high strength to weight ratio and good high temperature properties. Titanium and its alloys are poor thermal conductors. As a result, the heat generated when machining titanium cannot dissipate quickly, rather most of the heat is concentrated on the cutting edge and tool face. Therefore, machining of titanium to improve its mach inability still needs extensive research. This project applied of design of experiment to help experimenter in making the experiment in systematically order. In machining titanium there are two parameters need to be manipulate. It is the speed and the feed rate. The study of the chip hardness and surface roughness of material will be analyzed

1.1 PROBLEM STATEMENT

Machining of titanium induce drastic change in surface integrity due to high cutting temperature which down grade machine surface quality. Surface integrity and particularly material response are relatively lack in study.

1.2 PROJECT OBJECTIVE

(i) To investigate surface integrity of titanium when machining with various machining parameter.

(ii) To determine feasible machining parameter with various cutting speed for good surface finish and hardness of the chip.

1.3 SCOPE OF PROJECT

(i) Machining experiment will be designed in STATISTICA.

(ii) Machining parameters considers are cutting speed and feed rate.

(iii) The cutting speed range will be 90-150 m/min and feed rate 0.05-0.15mm/rev.

(iv) Surface roughness and hardness of the chips will be study for analysis

(v) The experiment result will be analyzed in STATISTICA.

1.4 SUMMARY

Chapter 1 has been discussed briefly about project background, problem statement, objective and scope of the project on role play by various cutting speed in machining to achieve the objective mentioned. This chapter is as a fundamental for the project and act as a guidelines for project research completion.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, the finding and previous study regarding to this project title will be explain. Most of the finding is based on published journal from previous experiment and study. From the finding, the general information about the project can be gathered before the experiment began.

2.2 TITANIUM MACHINABILITY

Titanium and its alloys have high strength to weight ratios, good temperature and chemical resistance, and relatively low densities, which make them ideal for applications in the aerospace industry. Ti–6Al–4V is a common alloy of titanium and is generally classified as “difficult to machine” because of its thermo-mechanical properties. The primary challenge when machining titanium is overcoming the short tool life that typically prevents people from using high cutting speeds. Titanium has low thermal conductivity, which impedes heat transfer out of the cutting zone while creating high cutting zone temperatures. Lastly, there is a strong tendency for titanium chips to pressure-weld to cutting tools (Ezugwu et al 1997).

2.2.1 What Makes Poor Surface Finish?

The analysis of surface topography confirmed that the negative of flank wear profile is replicated on the machined surface. A strong correlation between evolution of notch wear and that surface of finish was observed. In the case of continuous cutting

,the Ra , Rz and Rpk tend to increase significantly with tool wear, while in the case of interrupted cutting, a special care should be given to burr formation, can damage the adjacent surface.(Z. Cessier et al 2008)

The machining condition of the highest cutting speed and low feed rate and low to moderate of depth of cut induces compressive residual stress condition in the machined surfaces. Which mean the parameter impart the best surface integrity to the machine surface.

Titanium and its alloys are considered as difficult to cut materials due to high cutting temperature and the high stresses and close to the cutting edge during machining (catastrophic thermoplastic shear forces), the thin chips, a thin secondary zone, a short chip tool contact length and the poor heat conductivity of the metal, while the high stresses are due to the small contact area and the strength of titanium even at elevated temperature. The fact that titanium sometimes is classified as difficult to machine by traditional methods in part can be explained by the physical, chemical, and mechanical properties of the metal. For example:

(i) Titanium is a poor conductor of heat. Heat, generated by the cutting action, does not dissipate quickly. Therefore, most of the heat is concentrated on the cutting edge and tool face.

(ii) Titanium has a strong alloying tendency or chemical reactivity with materials in the cutting tools at tool operating temperatures. This causes galling, welding, and smearing along with rapid destruction of the cutting tool.

(iii) Titanium has a relatively low modulus of elasticity, thereby having more “Springiness” than steel. Work has a tendency to move away from the cutting tool unless heavy cuts are maintained or proper backup is employed. Slender parts tend to deflect under tool pressures, causing chatter, tool rubbing, and tolerance problems. Rigidity of the entire system is consequently very important, as is the use of sharp, properly shaped cutting tools.

(iv) Titanium’s fatigue properties are strongly influenced by a tendency to surface damage if certain machining techniques are used. Care must be exercised to avoid the loss of surface integrity, especially during grinding.

2.3 MACHINING TURNING PROCESS

The majority of turning operations involve the use of simple single-point cutting tools, with the geometry tool. As shown in figure 2.1 turning is performed at various rotational speed(1) ,N, of the work piece clamped in a spindles, (2) depths of cut, d, and (3)feeds, f ,depending on the work piece materials, cutting-tool materials, surface finish and dimensional accuracy required and the characteristics of the machine tool. (S. Kalpakjian 2006).

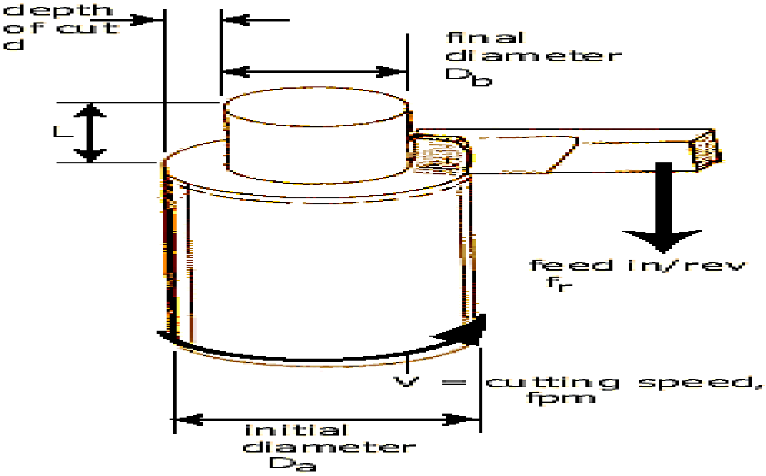

Figure 2.1: Turning process

Source: S.kalpakjian ,2006

Important machining parameters in turning:

(i) Cutting Speed
(ii) Depth of cut
(iii) Feed Rate

2.3.1 Equations and the Terminology

The forgoing equation and terminology used are summarized:

(i) Cutting Speed, V

The speed of the work piece surface relative to the edge of the cutting tool during a cut, measured in surface feet per minute (SFM).show in Equation 2.1.

$$V = \pi D_o N \quad \text{(max. speed)} \qquad (2.1)$$
$$= \pi D_{avg} N \text{ (min. speed) (m/min)}$$

(ii) Feed Rate , F

The speed of the cutting tool's movement relative to the work piece as the tool makes a cut. The feed rate is measured in inches per minute (IPM) and is the product of the cutting feed (IPR) and the spindle speed (RPM) show in Equation 2.2.

$$F = fn \text{ (mm/min)} \qquad (2.2)$$

(iii) Depth of Cut , d

The depth of the tool along the axis of the work piece as it makes a cut, as in a facing operation show in Equation 2.3.

$$d = (D_0 + D_f)/2 \text{ (mm)} \qquad (2.3)$$

2.3.2 Tool Materials, Feeds and Cutting Speeds

The general characteristics tool materials have a broad range of applicable cutting speeds and feeds for the tool materials. Figure 2.2 is a guideline in turning operations. Specific recommendations regarding turning process parameters for various work piece materials and cutting tools are given in table E in appendix.

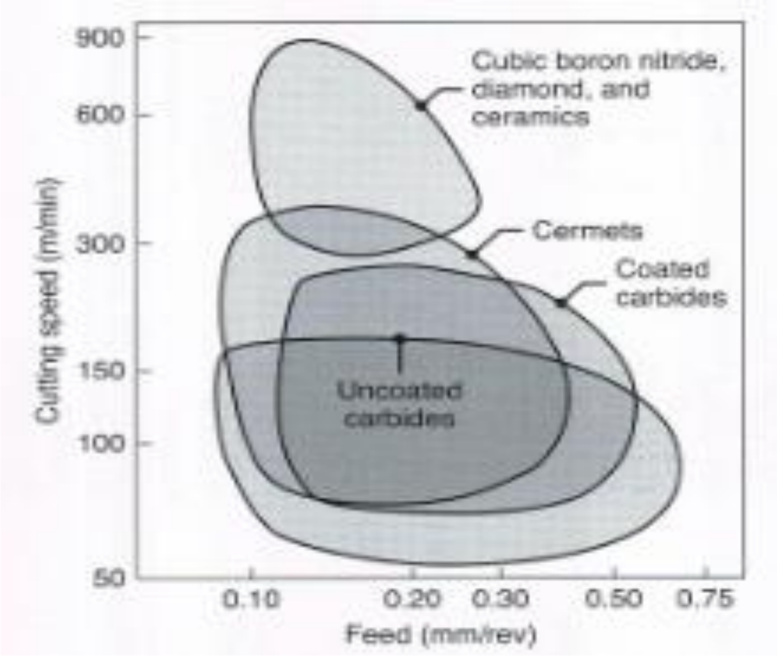

Figure 2.2: The range of applicable cutting speeds and variety of tool materials

Source: S. Kalpakjian 2006

2.3.3 Cutting Fluids

Many metallic and non metallic materials can be machined without a cutting fluid, but in most cases, the application of a cutting fluid can improve the operation. General recommendations for cutting fluids appropriate to various workpiece materials are given in table.

2.4 SURFACE ROUGHNESS

Kalpakjian et al (2006) explain about regardless of the method of the production, all surfaces have their own characteristics which collectively are referred to as surface structure .As a geometrical property is complex, certain guide lines have been established for texture in terms of well defined and measurable quantities. Figure 2.3 shown standard terminology and symbols to describe

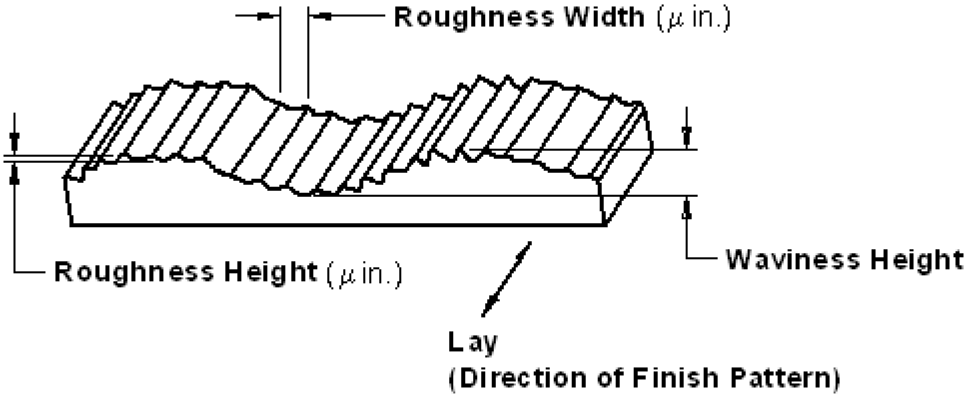

Figure 2.3: Standard Terminology

Source: S.Kalpakjian, 2006

The ability of a manufacturing operation to produce a specific surface roughness depends on many factors. For example, in end mill cutting, the final surface depends on the rotational speed of the end mill cutter, the velocity of the traverse, the rate of feed, the amount and type of lubrication at the point of cutting, and the mechanical properties of the piece being machined. A small change in any of the above factors can have a significant effect on the surface produced.

Surface roughness generally is described by two methods. The arithmetic mean value (Ra) is based on the schematic illustration of a rough surface, as shown in equation. it is defined as

$$\mathrm{Ra} = \frac{\mathrm{a} + \mathrm{b} + \mathrm{c} + \cdots}{\mathrm{n}}$$

Where all ordinates,a,b,c and etc. are absolute values and n is the number of readings. The root mean square roughness (rq, formerly identified as RMS) is defined as shown in equation

$$\mathrm{Rq}=\frac{\sqrt{a^2}+b^2+c^2+d^2+\ldots..}{n}$$

The datum line in figure 2.4 is located so that the sum of the areas above the line is equal to the sum of areas above line is equal to the sum of areas below the line. The maximum roughness height (Rt) also can be used as defined as the height from the deepest through to the highest peak. It indicates how much material has to be removed in order to obtain in a smooth surface, such as by polishing. The units generally used for surface roughness are µm (micron). In general a surface cannot be described by its Ra or Rq value alone, since these values are averages. Two surfaces may have the same roughness value but have actual topography which is very different. For example, a few deep through on an otherwise smooth surface will not affect the roughness values significantly. However the type of surface profile can be significant in terms of friction, wear and fatigue characteristics of a manufactured product. Consequently, it is important to analyze a surface in great detail, particularly for parts to be used in critical applications. (Serope Kalpakjian, et al 2006)

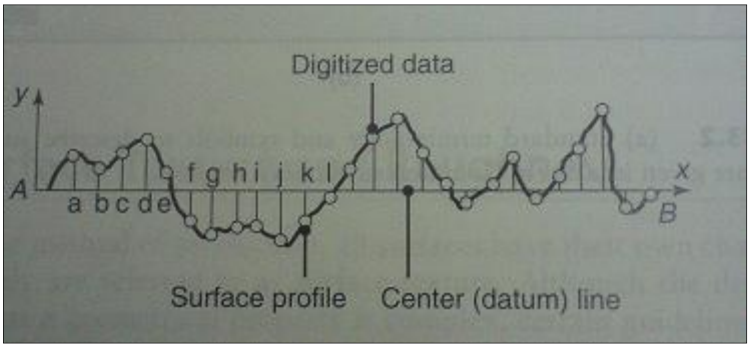

Figure 2.4: Datum Line

Source Kalpakjian, 2006

2.4.1 Surface Roughness Average Obtainable by Common Production.

Figure 2.5 below show that roughness rating relates to process. From the table we can relate that different process have different roughness height rating.

Figure 2.5: Roughness Rating

Source: Surface Roughness Review

2.5 HARDNESS

Hardness is a commonly used property; it gives a general indication of the strength of the material and of its resistance to scratching and to wear. More specifically hardness usually is defined as a resistant to permanent indentation, thus for example, steel is harder than aluminum, and aluminum is harder than lead. However, hardness is