Faculty of Manufacturing Engineering

SURFACE ROUGHNESS ANALYSIS ON TITANIUM ALLOY Ti-6AI-4V ELI DURING TURNING WITH UNCOATED CARBIDE INSERT

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SURFACE ROUGHNESS ANALYSIS ON TITANIUM ALLOY Ti-6AI-4V ELI DURING TURNING WITH UNCOATED CARBIDE INSERT

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DECLARATION

I declare that this thesis entitled "SURFACE ROUGHNESS ANALYSIS ON TITANIUM ALLOY Ti-6AI-4V ELI DURING TURNING WITH UNCOATED CARBIDE INSERT" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : Ammar Aizat bin Mastuki

Date : 27/1/2020

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 a partial fulfillment of Master of Manufacturing Engineering (Quality System Engineering).

Signature :.....

Supervisor Name : Dr Mohd Amri bin Sulaiman

Date :.....30/1/2020.....

DEDICATION

In the name of Allah the most merciful and the creator of everything from photons to stars above and beyond, I dedicate this thesis to my beloved parents Mastuki bin Kamis and Asiah binti Kasbi.

Through hardship and despair, through love and ultimate care, your infinite love hold us close so we will never tear, thank you for pushing and providing me the best of everything anyone could offer.

Sending love and appreciation to the one who support and walk with me through this journey, my 4 brothers and Intan Nur Farisa bin Mohd Fauzi.

ABSTRACT

This research work, focus on the turning of titanium alloy Ti-6Al-4V ELI by using the uncoated carbide insert. Titanium alloy is extensively used in aerospace, medical instruments, steam boiler, and heavy duty products because of their high specific strength (strength-to-weight ratio), which is retained at elevated temperatures, as well as their fracture resistance and exceptional corrosion resistance. However the machinability of titanium and its alloys is generally considered to be poor owing to several inherent properties of materials. The machining of titanium and its alloys is challenging owing to the elevated mechanical strength and low thermal conductivity of these alloys, which not only induces serious thermomechanical dynamic stress on the cutting instruments but also guarantees that most of the heat produced during cutting remains inside the instrument. In addition, titanium is extremely reactive at typical temperatures produced during machining, with most tool components and coatings further reducing the life of the instrument. These issues seriously affect the productivity of titanium alloys. Due to that, the tool will worn out very fast and hence poor surface finish on material generated. The objectives of this paper is to investigate surface integrity of surface machined material. These experiments are performed under dry condition. There are two significant factors involving surface roughness of alloy tested which are depth of cut and feed rate.

ABSTRAK

Kerja-kerja penyelidikan ini, memberi tumpuan kepada perubahan aloi Titanium Ti-6Al-4V ELI dengan menggunakan memasukkan karbida yang tidak bersalut. Aloi titanium digunakan secara meluas dalam aeroangkasa, instrumen perubatan, dandang stim, dan produk tugas berat kerana kekuatan spesifik yang tinggi (nisbah kekuatan ke berat), yang dikekalkan pada suhu tinggi, serta rintangan patah dan rintangan kakisan yang luar biasa . Walau bagaimanapun, kebolehkerjaan titanium dan aloinya pada umumnya dianggap miskin disebabkan oleh beberapa bahan yang wujud. Pemesinan titanium dan aloinya mencabar kerana kekuatan mekanikal yang tinggi dan kekonduksian terma yang rendah aloi ini, yang bukan sahaja menimbulkan tekanan dinamik mekanikal termomekanik yang serius pada instrumen pemotongan tetapi juga menjamin bahawa kebanyakan haba yang dihasilkan semasa pemotongan kekal di dalam instrumen . Di samping itu, titanium sangat reaktif pada suhu tipikal yang dihasilkan semasa pemesinan, dengan komponen alat dan salutan yang paling banyak mengurangkan kehidupan instrumen. Isu-isu ini secara serius menjejaskan produktiviti aloi titanium. Oleh itu, alat itu akan dipakai dengan sangat cepat dan dengan demikian permukaan permukaan yang buruk pada bahan yang dijana. Objektif makalah ini adalah untuk mengkaji integriti permukaan bahan machined permukaan. Eksperimen-eksperimen ini dilakukan di bawah keadaan kering. Terdapat dua faktor penting yang melibatkan kekasaran permukaan aloi yang diuji iaitu kedalaman pemotongan dan kadar suapan.

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CHAPTER 1

INTRODUCTION

This sections explains about background, objective and scope of the study. Background discusses about the material used in this research, CNC lathe machine and performance of machining that need to analyses. The objective is about the mission to be achieved for this research and scope covers about everything that is supposed to do in this research.

1.1 Background

Study on surface integrity of aerospace material, medical instruments, steam boiler, and heavy duty product as finished machining turns to a crucial issue, mainly, to produce a high quality of machined surface of mechanical parts. The mechanical part, which designed from titanium alloys, proves to be difficult in producing a great-machined surface causes by the high level of difficulty to machine and generated high amount of heat when machining (Che Haron, 2001). Selected machining conditions also affect the surface integrity of titanium alloys. Satisfied surface integrity requirements are based not only on surface roughness but also on surface strength, microstructure, plastic deformation of the machined surface, residual pressure and surface defects of the machined surface, residual stress and surface defects of the machined surface, residual stress and surface defects (porosity, micro crack, stress concentration etc.) (Field, 1973).

The surface quality of the machined element is determined by the finish of the surface and the integrity after machining. The integrity of the surface is described as the intrinsic condition or enhances the condition of a surface generated (Field, 1973). Metal extraction activities result in surfaces that contain geometric deviation (deviation from optimal geometric deviation) and metallurgical harm that differs from the bulk material. The geometric deviation refers to the different types of sucking deviations as roundness, straightness, etc. Types of metallurgical surface harm generated during machining include micro-crack, tearing of micro-pits, plastic deformation of feed marks, materials re-deposited, etc. Control of the machining method for the production of parts for aviation applications is therefore subject to strict surface evaluation in order to defer surface harm to the extremely costly machined elements. (Ezugwu *et al.*, 2005).

The material used in this studies is Ti6AI4V-ELI titanium alloy, which is usually used in the production sectors in contemporary procedures. Titanium alloys are predominantly mechanical, heat-safe and erosion-safe, widely used in business aerospace, biomedical, vehicle and oil industries. However, Titanium alloy has low heat conductivity, categorized as hard-to-machine. Due to the reduced modulus of titanium elasticity, the spring will change back after a deformation under cutting load. During the machining process, the titanium portion will migrate from the cutting tools. Then, There will be a high dimensional inaccuracy of the job piece. Thus, the lower of titanium hardness and the greater chemical reactivity leading to the inclination of titanium galling with the cutting tool. The geometry of the instrument has therefore altered.

To analyses the surface roughness of titanium alloy in different cutting parameters, it is needed a lot of research and experiment to be made and to distinguish the practically which

cutting parameters effect the surface personal satisfaction. The surface roughness was the estimates of the technological qualities of the component. The evaluating productivity of the machined parts and machine tools, surface roughness acts as indicators. To achieve quality of component which parameters is influences by the surface roughness, the desired value surface roughness of the product is generally defined. Thus as interpreter of machining performances measuring and characterizing the surface finish is considered.

The methodology that was used in this research is experimental procedures. By referring to the experiment that will be done, the work piece will undergo a machining test at various cutting conditions before analysis is done with the tools. The evaluation of this research will be examined by using a surface roughness test

1.2 Problem Statement

There are many distinct kinds of surface finish issues, such as roughness of the surface. It must therefore be researched in order to enhance end product surface finish characteristics. Many parameters affect the job piece's surface roughness. Cutting velocity, cutting depth and feed rate are the most significant ones to explore.

According to Amini, S. (2015), the titanium alloy's primary strengths are its low ductility, which at room temperature is less than 2 percent, has elevated crack growth rates and low fractures, which is ~20Mpa.m1/2. This weakness may be the cause of certain surface defects that have been discovered after machining. Due to their elevated strength, powerful reactivity and low heat conductivity, this titanium alloy is also difficult to machine. All of the above weaknesses will lead in low productivity of machining, bad surface finishing or quality and high price of manufacturing. This is because a product's quality and efficiency depends on the shape and quality of the surface.

1.3 Objective

The objectives of the research are:

1) To identify the most significant cutting parameters which effect the surface roughness of the titanium alloy.
2) To analyse the surface roughness during turning of titanium alloy Ti6Al4V-ELI under dry cutting process.
3) To develop the mathematical model for surface roughness of machined surface.

1.4 Scope of Study

This research only focuses on surface roughness of Titanium alloy Ti6Al4V-ELI in turning under dry cutting process. The machining parameter that are evaluated in this studies are cutting speed, depth of cut and feed rate. The cutting tools that used in experiment is carbides insert. The performances measure to be evaluated in this research are surface roughness which will be analyses using surface roughness tester.

1.5 Structure of Thesis

The finals project covers five chapters that contains the introduction, the literature review, the methodology, the result and the discussion and lastly conclusions. Chapter 1 is introduction the need to study material used in this research, CNC lathe machine and performance of machining that need to analyses that is divided into the introduction of study, problem statement, objectives, scope as well as the significant of study.

For chapter 2: Literature review: covers the gathered findings of numerous information from various sources such as books, journals, articles, and websites. Topics that related to the study of material used in this research, CNC lathe machine and performance of machining that need to analyses which is surface roughness. Chapter 3: Methodology will be discussing about the collect experimental data, methods and procedures for data analysis. Chapter 4 is about the findings of chapter 3 which about result and discussion. Here, justification will be given with respect to the results obtained primarily related to the objectives. Finally, the chapter 5 is about the conclusion and recommendations for future work is included in this chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter shows a brief overview of information about work piece material, cutting tools and lathe machine. This chapter presents thoroughly the related study done by the previous research and work as reference, to give information and guide about this whole project. Other important aspects included in this review are general knowledge of dry machining and design of experiment.

2.2 Machining

As indicated by Bushan, B (2001), machining is a material removal process by using a sharp cutting tool to mechanically cut out material to obtain the desired part. It is most commonly used to shape metal parts Machining is the most versatile and precise in its ability to create variety or part geometries and geometric features compared to other manufacturing processes. Each machining procedure generates a distinctive geometry portion owing to two variables and the shape of the cutting instrument that are relative motions between the instrument and the workpiece.

Without machine tools, there would be no airplanes, computers and other modern technology (Walker, 2000). Nowadays, machine tools become one of the important technologies in order to produce a product. It is difficult to name a product that does not require the use of machine tool somewhere in its manufacture whether directly or indirectly. Some of the basic machine tool operation are drill press, grinding machine, band machines, milling and many more.

2.3 CNC Turning

Computer Numerical Control (CNC) may be considered to be a means of operating a machine through the use of discrete numerical values fed into the machine. The machine follows a predetermined speed necessary to produce a product of the right shape and size according to completely a predictable result (IC Professional Training, 2009). CNC turning machines referred as a computer numerical control (CNC) lathe which has replaceable cutting edge by inserting specific tool. Drilling, tapping, reaming, knurling, and threading process is possible to be done by attaching all the tools that required to perform in an operation (W. H. Yang, 1998).

2.3.1 Turning Process

With a single-point instrument, turning process produces axially symmetric shapes. Using one cutting edge, a single point tool removes. The instrument is kept in a fixed place in most instances with the workpiece rotating around a turning axis. There are also instruments on the centerline of the spindle to make a hole application like drills, reamers or taps with speed and feed constraints. (MachiningCloud Inc, 2016).

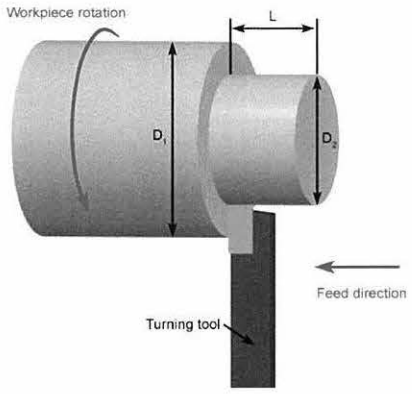

Figure 2.1 Schematic representation of oblique turning process (Y.H. Yang, 1988)

As indicated in **Figure 2.1**, A single-point tool moves axially along the side of the workpiece to remove material to form different features, including steps, tapers, chamfers and contours. Typically, at a small radial cutting depth these features are machined and countless passes are made to achieve the end diameter. Turning is carried out on a lathe which provides the power to turn the workpiece at a specified rotational speed and feed the cutting tool at a specified speed and cutting depth. Therefore, three parameters of cutting are cutting speed (V), feed rate (f) and cutting depth (d) should be chosen correctly for better surface finish., i. e., surface roughness with lower cutting force. Selecting cutting parameters to obtain high cutting efficiency is an significant job in a turning procedure. The required cutting parameters are usually determined on the basis of experience or manual use. (Y. H. Yang 1988). However, this does not guarantee the optimum or near optimum cutting efficiency of the chosen cutting parameters for a specific device and environment. Several mathematical models are used to select the cutting parameters correctly (Y. Kazancoglu, 2011).

2.3.2 Machining Operations

CNC machine is known widely as a versatile machine that can fit various cutting tools. This machine capable of producing various cutting shapes and process. Below are the machining process that can be operates by CNC machines.

1. Facing / Turning – To create a cylindrical shape, a single point cutting instrument removes material from a rotating workpiece
2. Facing – Cutting on perpendicular to its axis and produce a flat surface on the part
3. Grooving – A method of forming a small cavity of a certain depth on a cylinder, a cone or a part face
4. Boring – similar operation as turning except for the area of metal removal where the actual machining takes place
5. Threading – The point-shaped tool is fed linearly across the surface of the rotating workpiece parallel to the rotation axis at a high feed rate, creating threads.
6. Cutting off – Tool is radially fed into rotating job somewhere to cut the end of the portion.

2.4 Insert Shape

In a variety of shapes, sizes and thicknesses, turning inserts are produced. The shape can be round to maximize the power of the edge, diamond-shaped to enable a sharp point to cut fine, square or even octagonal features to increase the number of separate edges that can be applied as one edge after the other.

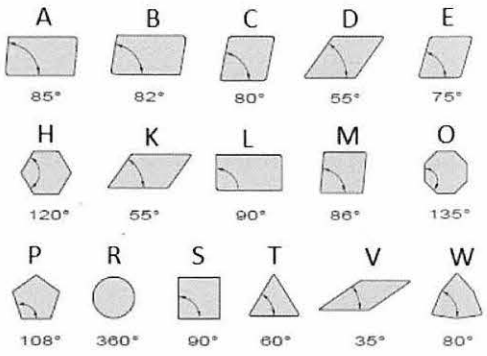

Figure 2.2 Typical insert shape used in turning machining (MachiningCloud inc, 2016)

Based on **Figure** 2.2, because of their bigger point angle, C and W turning inserts are often used for rough machining, which makes them more rigid. For finishing, inserts with a lower point angle, such as D and V, are frequently used. Even though they have less power, more information can be reached by the lower angle. Large point angle will give stronger cutting edge, higher feed rates, increased cutting forces, and increased vibration while small point angle produce weaker cutting edge, increased access to part details, decreased cutting forces, and decreased vibration (MachiningCloud Inc, 2016).

2.5 Cutting Tools Materials

There are various types of cutting material in machining process used according to the applications. Many cutting tools materials have been developed for different purposes and has different properties. A proper selection of cutting tools is important to perform the machining process in order to get the best or accurate result of production.