UNIVERSITI TEKNIKAL MALAYSIA MELAKA

A STUDY ON HARD TURNING PROCESS OF Ti-6Al-4V

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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ABSTRACT

In machining of parts, surface quality is one of the most specified customer requirements. Major indication of surface quality on machined parts is surface roughness. Therefore, this study on hard turning process of Ti-6Al-4V aims to investigate the surface roughness mechanism of the hard turning process, determine any significant of parameters that affect the surface roughness mechanism and utilize statistical tool for the analysis of the surface roughness mechanism. This study mainly focused in the investigation on cutting parameter which are feed rate, depth of cut, cutting speed using coated and uncoated cutting tool type. The experimental utilizes the Design of Experiment (DOE) as the approach to develop and analyze the whole study. By utilizing Okuma LCS-15 CNC Lathe machine, 24 numbers of runs was carried out and measured by using Surftest SJ-301. The result shown that for uncoated tools, feed rate was the main parameter that effected to surface roughness while for the uncoated tools the surface roughness most sensitive to cutting speed.

ABSTRAK

Di dalam pemesinan sesuatu bahagian, kualiti permukaan adalah spesifikasi penting di dalam kehendak pengguna. Indikasi major pada kualiti permukaan adalah kekasaran permukaan. Oleh itu, kajian terhadap pemesinan larik ke atas bahan kerja keluli keras (AISI D2) bertujuan untuk menyiasat mekanisma kekasaran permukaan pada proses melarik, menyatakan sebarang signifikasi parameter yang member kesan pada mekanisma kekasaran permukaan dan menggunakan alatan statistik untuk menganalisa mekanisma kekasaran permukaan. Kajian ini memfokuskan penyiasatan ke atas parameter pemotongan iaitu seperti kadar suapan pemesinan, kadar kedalaman pemotongan, kelajuan pemotongan mengunakan mata alat pemotongan yang bersalut dan tidak bersalut. Kajian experimental ini menggunakan pendekatan *Design of Experiment (DOE)* untuk membangunkan serta menganalisa keseluruhan kajian. Mesin larik Okuma LCS-15 CNC telah dipilih untuk menjalankan operasi pemesinan ke atas benda kerja dan kadar kekasaran permukaan akan diukur dengan menggunakan *Suftest SJ-301*. Keputusan menunjukkan bagi mata alat bersalut, kadar suapan pemesinan member kesan pada kekasaran permukaan manakala untuk mata alat tidak bersalut, kekasaran permukaan lebih sensitif terhadap kelajuan pemotongan.

DEDICATION

For a warmth of love to Abah and Emak, Siblings, friends and my love one.

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LIST OF ABBREVIATIONS

%	Percentage
^{0}C	Degree Celcius
AISI	The American Iron and Steel Institution.
ANOVA	Analysis of Variance
CAD	Computer Aided Drawing
CAM	Computer Aided Machine
CLA	Centre Line Average
CNC	Computer Numerical Control
Cr	Chromium
CVD	Chemical Vapor Deposition
DOC	Depth of Cut
DOE	Design of Experiment
F	Farenheit
f	Feed rate
HB	Brinalls Hardness Number
HRC	Rockwell Hardness Number
ISO	International Standard Organization
Ipr	inches per minutes
Mn	Manganese

mm	millimeter
PCBN	PolyCarbon Boron Nitride
PVD	Physical Vapor Deposition
Ra	Roughness Average
rev	revolution
SEM	Scanning Electron Microscope.
v	cutting speed
XRD	X-Ray diffraction

CHAPTER 1

INTRODUCTION

This study is mainly on the experimental test of the hard turning process on the Titanium Alloy Steel which mainly focuses on the surface quality of the steel. This study on the surface quality will investigate the three main parameters which including the cutting speed, feed rate and the depth of cut using coated and uncoated cutting tools. Thus, this study and investigation will assess the characteristics in high-precision of high - hardened components.

1.1 Background of study.

Most machining operations can be divided into those that remove metal from an item, and those that form metal in an item. Often an unfinished workpiece will need to have some parts removed or scraped away in order to create a finished product. For example, a lathe is a machine tool that generates circular sections by rotating a metal workpiece, so that a cutting tool can peel metal off, creating a smooth, round surface. A drill or punch press can be used to remove metal in the shape of a hole. Other tools that may be used for various types of metal removal are milling machines, saws, and grinding tools. Many of these same techniques are used in woodworking.

Metal can be formed into a desired shape much more easily than materials such as wood or stone, especially when the metal is heated. A machinist may use a forging machine to hammer or mold a hot metal workpiece into a desired shape. Dies or molds may be used if the metal is soft enough, or under high pressures. A press is used to flatten a piece of metal into a desired shape. Advanced machining operations might use electrical discharge, electro-chemical erosion, or laser cutting to shape metal workpieces.

As a commercial venture, machining is generally performed in a machine shop, which consists of one or more workrooms containing major machine tools. Although a machine shop can be a standalone operation, many businesses maintain internal machine shops which support specialized needs of the business. The inferior finish found on the machined surface of a workpiece may be caused by insufficient clamping, cutting conditions or perhaps an incorrectly adjusted machine. It is evident by an undulating or irregular finish, and the appearance of waves on the surface.

As quoted from Kaewkuekool, S. *et al.* (2007), the three principal machining processes are classified as turning, drilling and milling. Other operations falling into miscellaneous categories include shaping, planning, boring, broaching and sawing. Turning operations are operations that rotate the workpiece as the primary method of moving metal against the cutting tool. Lathes are the principal machine tool used in turning. Milling operations are operations in which the cutting tool rotates to bring cutting edges to bear against the workpiece. Milling machines are the principal machine tool used in milling. Drilling operations are operations in which holes are produced or refined by bringing a rotating cutter with cutting edges at the lower extremity into contact with the workpiece. Drilling operations are done primarily in drill presses but not uncommonly on lathes or mills. Miscellaneous operations are operations that strictly speaking may not be machining operations in that they may not be chip producing operations but these operations are performed at a typical machine tool. Burnishing is an example of a miscellaneous operation. Burnishing produces no chips but can be performed at a lathe, mill, or drill press.

An unfinished workpiece requiring machining will need to have some material cut away to create a finished product. A finished product would be a workpiece that meets the specifications set out for that workpiece by engineering drawings or blueprints. For example, a workpiece may be required to have a specific outside diameter. A lathe is a machine tool that can be used to create that diameter by rotating a metal workpiece, so that a cutting tool can cut metal away, creating a smooth, round surface matching the required diameter and surface finish. A drill can be used to remove metal in the shape of a cylindrical hole. Other tools that may be used for various types of metal removal are milling machines, saws, and grinding tools. Many of these same techniques are used in woodworking.

Machining requires attention to many details for a workpiece to meet the specifications set out in the engineering drawings or blueprints. Besides the obvious problems related to correct dimensions, there is the problem of achieving the correct finish or surface smoothness on the workpiece. The inferior finish found on the machined surface of a workpiece may be caused by incorrect clamping, dull tool, or inappropriate presentation of a tool. Frequently, this poor surface finish, known as chatter, is evident by an undulating or irregular finish, and the appearance of waves on the machined surfaces of the workpiece.

1.2 Problem Statement.

The challenge of modern machining industries is mainly focused on the achievement of high quality, in terms of workpiece dimensional accuracy, surface finish, high production rate, less wear on the cutting tools, economy of machining in terms of cost saving and increase the performance of the product with reduced environmental impact. Surface roughness plays an important role in many areas and is a factor of great importance in the evaluation of machining accuracy. Many researchers developed many mathematical models to optimize the cutting parameters to get lowest surface roughness by turning process. The variation in the material hardness, alloying elements present in the work piece material and other factors affecting surface finish and tool wear. This experimental study will investigate the influence of surface roughness by cutting parameters such as cutting speed, feed rate, depth of cut and the cutting tool types in order to obtain the best parameters to better finish of surface roughness. Thamizhmanii, S. *et al.* (2006)

Turning is very important machining process in which a single point cutting tool removes unwanted material from the surface of a rotating cylindrical work piece. The cutting tool is fed linearly in a direction parallel to the axis of rotation. Turning is carried on a lathe that provides the power to turn the work piece at a given rotational speed and to feed to the cutting tool at specified rate and depth of cut. Therefore three cutting parameters namely as cutting speed, feed rate, depth of cut utilizing the coated and uncoated type of cutting tools need to be determined in a turning operation.

In a typical turning operation, the workpiece is clamped by any one of the workholding devices. Long and slender parts must be supported by a steady rest and follow rest placed on the bed, as otherwise the parts deflect under the cutting forces. These rests usually equipped with three adjustable fingers or rollers that support the workpiece while allowing it to rotate freely. Examples of objects that can be produced on a lathe include candlestick holders, cue sticks, table legs, bowls, baseball bats, musical instruments, crankshafts and camshafts.

The turning operations are accomplished using a cutting tool; the high forces and temperature during machining create a harsh environment for the cutting tool. Therefore tool life is important to evaluate cutting performance. The purpose of turning operation is to produce low surface roughness of the parts.

Surface roughness is another important factor to evaluate cutting performance. Proper selection of cutting parameters and tool can produce longer tool life and lower surface roughness. Hence, design of experiments (DOE) on cutting parameters was adopted to study the surface roughness. Surface properties such as roughness are critical to the function ability of machine components. Increased understanding of the surface generation mechanisms can be used to optimize machining process and to improve component functionability.

1.3 Objective

In particular, the objectives of this study can be described as following:

- To investigate the surface roughness quality of the hard turning process.