TOOL PERFORMANCE OF UNCOATED TUNGSTEN CARBIDE INSERT DURING TURNING Ti-6Al-4V UNDER DRY AND NANOFLUID CONDITION

MUHAMMAD YUSRI BIN SHAFI'E
B051310260

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2017

TOOL PERFORMANCE OF UNCOATED TUNGSTEN CARBIDE INSERT DURING TURNING Ti-6Al-4V UNDER DRY AND NANOFLUID CONDITION

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Engineering Process) (Hons.)

by

MUHAMMAD YUSRI BIN SHAFI'E

B051310260

940728-01-5767

FACULTY OF MANUFACTURING ENGINEERING

2017

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk:
TOOL PERFORMANCE OF UNCOATED TUNGSTEN CARBIDE INSERT DURING TURNING Ti-6Al-4V UNDER DRY AND NANOFLUID CONDITION

Sesi Pengajian: **2016/2017 Semester 2**

Saya **MUHAMMAD YUSRI BIN SHAFI'E (940728-01-5767)**

mengaku membenarkan Laporan Projek Sarjana Muda (PSM) ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. *Sila tandakan (√)

☐ SULIT (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysiasebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)

☐ TERHAD (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/ badan di mana penyelidikan dijalankan)

☐ TIDAK TERHAD

Disahkan oleh:

______________________	______________________
Alamat Tetap: No 16 Jln Bunga Mawar, Rumah Awam Plentong ,81750 Masai	Cop Rasmi:
Tarikh: ______________________	Tarikh: ______________________

*Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this report entitled "Tool Performance of Uncoated Tungsten Carbide Insert during Turning Ti-6Al-4V Under Dry and Nanofluid condition" is the result of my own research except as cited in references.

Signature : ……………………………………

Author's Name : MUHAMMAD YUSRI BIN SHAFI'E

Date :

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Engineering Process) (Hons). The member of the supervisory committee is as follow:

……………………….................................

(Dr. Mohd Amri Bin Sulaiman)

ABSTRAK

Maksud hidup alat adalah sebagai masa pemotongan yang dapat alat digunakan sehingga mencapai kriteria hayat alat tamat. Dalam kajian ini, mata alat karbida tungsten tanpa salutan, (CNGG 120408-SGF H13A) digunakan dalam pelarikan benda kerja aloi titanium Ti-6AL-4V ELI (extra low interstitial). Aloi titanium tersebut digunakan secara meluas terutamanya dalam bidang aeroangkasa, automotif, perubatan dan kimia. Ini disebabkan aloi titanium memiliki sifat nisbah kakuatan terhadap berat yang tinggi, rintangan patah yang tinggi, dan rintangan kakisan yang sangat baik. Walau bagaimanapun, aloi titanium adalah bahan yang sukar dimesin walaupun pada suhu tinggi, mempunyai keberairan terma yang rendah, modulus kenyal rendah dan mudah bertindak balas kimia dengan bahan mata alat. Tujuan kajian ini adalah untuk mengkaji prestasi mata alat semasa pelarikan bahan Ti-6AL-4V ELI menggunakan mata alat karbida tungsten tanpa salutan dalam keadaan kering dan bendalir nano penyejuk. Reka bentuk eksperimen kajian ini adalah berdasarkan kaedah pemfaktoran. Reka bentuk Two Level Factorial digunakan untuk mengatur parameter eksperimen iaitu laju pemotongan dengan julat dari 100 hingga 140 m/min, kadar suapan dari 0.15 hingga 0.20 mm/rev dan kedalaman pemotongan adalah malar (0.35 mm). Haus rusuk diukur menggunakan optic mikroskop. Bacaan diambil dan direkod bagi setiap 20 mm pelarikan pada benda kerja sehingga nilai haus rusuk purata (Vb) mencapai 0.3 mm mengikut Piawai Antarabangsa ISO 3685. Berdasarkan kepada keputusan kajian, nilai hayat mata alat maksimum dihasilkan oleh laju pemotongan (100 m/min) dan kadar suapan (0.15 mm/rev) dalam keadaan bendalir nano penyejuk pemesinan.

ABSTRACT

The meaning of tool life is assumed as the cutting time that is needed for a tool to reach its tool life criterion. In this study, uncoated tungsten carbide inserts, (CNGG 120408-SGF H13A) were applied in turning workpiece titanium alloy, Ti-6AL-4V ELI (extra low interstitial). Titanium alloys have been applied widely in many applications especially in aerospace, automotive, medical and chemical industry. This is because high strength to weight ratio, high fracture resistance, and excellent corrosion resistance of titanium alloy. However, titanium alloys are difficult to machine materials even though at elevated temperatures. It has low thermal conductivity, low elastic modulus and easy to react chemically with the cutting tools material. The objective of this research was to investigate the tool performance of uncoated tungsten carbide in turning Ti-6AL-4V ELI under dry and nanofluid condition. Experimental design of this study based on Factorial method. Two Level Factorial design was designated to arrange the cutting parameters of cutting speed with range of 100 to 140 m/min, feed rate with 0.15 to 0.20 mm/rev, and depth of cut is constant (0.35 mm). Flank wear progression was measured using an optical microscope. The values were recorded for each 20 mm on the workpiece until flank wear (Vb) reached the tool life criterion followed by (International Standard ISO 3685). From the results, maximum tool life (62.82 minutes) obtained by cutting speed of 100 m/min and feed rate of 0.15 mm/rev under nanofluid machining.

DEDICATION

To my beloved family, friends and that accompanying me along the difficult pathway in my university life, thanks for your help and support.

ACKNOWLEDGEGEMENT

First of all, I would like to thank GOD for giving me strength and guidance to complete this project. I wish to express my sincere thanks and appreciation to my supervisor, Dr. Mohd Amri bin Sulaiman for his advice and guidance in completing this project.

Secondly, I would like to thank to Manufacturing Engineering Laboratory of Universiti Teknikal Malaysia Melaka (UTeM) for providing me the equipment and machines. Moreover, I would like to thank to Mr. Taufik and Mr. Hanafiah for giving me lot convenience in using the equipment in the Laboratory.

Furthermore, special thanks to all my friends Kamil Othman, Syukri Che Daud, Dayah Johari and Athirah. They had giving me advice, ideas, comments and sharing their time to completed my project.

Finally, I would like to extend my special thanks to my family members, all lecturers in the Department of Manufacturing Universiti Teknikal Malaysia Melaka and friends who have given me support during my studies.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANOVA	-	Analysis of Variance
CNF	-	Carbon Nano Fiber
CNC	-	Computer Numerical Control
DOE	-	Design of Experiment
ELI	-	Extra Low Interstitial
Fc	-	Cutting Force
Fr	-	Radial Force
Ft	-	Thrust Force
Kr	-	Edge Angle
KT	-	Crater Wear
l	-	Cutting Edge Length
PCBN	-	Polycrystalline Cubic Boron Nitride
rc	-	Nose Radius
s	-	Insert Thickness
Vb avg	-	Average Flank Wear
Vb max	-	Maximum Flank Wear

LIST OF SYMBOLS

m/min	-	Metre per Minute
mm	-	Millimetre
mm/rev	-	Millimetre per Revolution
N	-	Newton
%	-	Percentage
wt %	-	Chemical Composition
kW	-	Kilowatt
rpm	-	Rotation per Minute
kg	-	Kilogram
J/kg K	-	Joule per Kilogram Kelvin
^{O}C	-	Degree Celsius
$W/m^{o}C$	-	Watt per Metre Celsius
W/mK	-	Watt per Metre Kelvin
m^2/s	-	Metre per Second
kg/m3	-	Kilogram per Metre Cube
Mpa	-	Mega Pascal
Gpa	-	Giga Pascal
HRC	-	Rockwell Hardness Scale
Mpa-m1/2	-	Mega Pascal–square root Metre
^{O}	-	Degree

`

CHAPTER 1

INTRODUCTION

This chapter provides a short introduction of the project background on ―Tool Performance of Uncoated Tungsten Carbide Insert during Turning Titanium Alloy Ti-6Al-4V ELI under Dry and nanofluid. Furthermore, this chapter will explain on the background information, problem statement, and objective, importance of study and organization of the research.

1.1 Background Information

Turning is a type of machining operation a machining expulsion process which is utilized to make rotational parts by removing undesirable material and its requires a turning machine or machine and cutting tool. The work piece is a pre-shaped material that is secured to a jig, which itself it's connected to the turning machine and permitted to pivot at fast. In turning operation, cutting velocity and movement of cutting tool are ordinarily impacts by a few parameters, for example, cutting speed, depth of cut, and feed rate. The properties of work piece material, tool six more will have an impact on this parameter (Olugboji Oluwafemi Ayodejil and Kehinde, 2015).

Titanium alloys are metals that have a combination of titanium and other chemical components. Such alloys have very high tensile strength and toughness even at great temperatures. They are light in weight, have amazing corrosion resistance and the ability to resist extreme temperatures. However, the high cost of both material and processing limits their use to military applications, aircraft, spacecraft, medical devices, highly stressed

`

components such as joining road on luxurious sports cars and some superior sports equipment and user electronic. Titanium and its alloys are categorized as tough to machine material. The core problem in machining them are the high cutting temperature and the quick tool wear. Titanium and its alloys are lowly thermal conductors. As a result, the heat created when machining titanium cannot dissipate speedily; rather, most of the heat is focussed on the cutting edge and tool face. Titanium has a strong alloying tendency or chemical reactivity with the cutting tool material at tool action temperatures. This is effects galling, welding, and smearing, along with fast wear or cutting tool wear (Hong *et al.*, 2001).

Widely used cutting tool in machining this material is carbide insert because it's let quicker machining and permission better appearances on metal parts. Furthermore, carbide inserts can resist higher temperatures than high speed tools. Carbide insert have ability for machining a toughness of material types and this includes of great metal alloy such as Titanium Alloy. These types of material are hard to be machined due to its excellent characteristics such as high specific strength or are often known as strength-to-weight ratio which is sustain at elevated temperature, their excellent corrosion resistance and resistance to fracture is very high even when subjected to high heat or thermal activity (Ezugwu and Wang, 1997; Ezugwu, 2005).

Basically, the use of cutting fluid in machining will helps to reduce the defect of the product in industry. The basic types of cutting fluid that used in industry are water soluble fluid, cutting oil and gaseous. Conventional coolant fluid is one of the water soluble fluids that used during the machining to improve the tool life and surface characteristic of the material. This type of coolant has good lubrication properties but poor thermal properties (A. K. Sharma et al., 2015). In order to improve the thermal conductivity of the conventional coolant, small sized of solid particles (nanometre-sized) was added which is known as nanofluid.

Nanofluid coolant is one of the fluid that containing Nano-sized particles made up of, carbides, metals, oxides, or carbon nanotubes (Sharma et al., 2015). Then, nanofluid can be defined as the colloidal mixtures of nanometre-sized particles in the base fluid. This type of coolant has a good stability, better thermal conductivity which cans helps to reduce the temperature during machining, and lower pressure drop compared to base fluid coolant. In

`

addition, the improvement of this fluid coolant will helps in improvement of performance parameters during machining of various types of materials.

In industry, it is important to predict tool wear for gaining product quality. It is also important to get higher productivity and to plan about manufacturing process and also in computer aided process planning.

By using turning operation, tool performance of carbide insert during machining titanium alloy under dry and flooded condition is investigated. The objective of this experiment is to study the tool life lifespan during medium turning of the titanium alloy using different condition. In this study, a medium cutting speed range for uncoated tungsten carbide insert to cut titanium alloy under dry and flooded condition (nanofluid).

1.2 Problem statement

Machining of titanium alloy considered hard because of their properties which is, high chemical reactivity with most of the available cutting tool material. Furthermore, because it low thermal conductivity of these alloy, the heat generated during machining remains accumulated near machining zone. Then, cutting tool is more prone to thermal related wear mechanism like diffusion wear and adhesion wear. By selecting suitable cutting tools and turning condition, pattern performance of titanium alloy and tool lifespan can be improve. Study of machining in dry and flooded condition is still needed to be done in order reduce tool wear and improve tool life of carbide insert.

The tool wear is unavoidable in any machining condition. There have been quite a handful of techniques to improve tool life on cutting tools. One of it includes surface treatment on the carbide insert. Then, another way in optimizing the tool life is by controlling the machining parameters and investigating the tool wear behaviour. According to Nytsch-Geusen et al. (2005), the optimum tool is not essentially to be expensive and not always the same tool that was applied for the job last time but the best tool is the one that has been wisely chosen to develop the job done economically, quickly and efficiently. This mean, it is require characterizing specific cutting tool and work-piece combination to understand the relations between tools wear performance and machining parameters.

`

1.3 Objective

The objective of this are:

I. To investigate the tool life of uncoated tungsten carbide insert during turning Ti-6Al-4V ELI under dry condition and nanofluid coolant machining condition.

II. To compare tool life and wear progression of uncoated tungsten carbide insert on different cutting condition (dry and nanofluid).

III. To define optimum process parameter setting to improve tool life of uncoated tungsten carbide inserts.

1.4 Scope of project

There are several scopes for achieve the objective of the experiment; turning operation of this experiment is done by using computer numerical control (CNC) lathe machine. The uncoated tungsten carbide cutting tool are been chosen to perform the operation. Then, using different cutting condition (dry and nanofluid condition) to perform the experiment for carried out the effect of cutting condition towards tool performance. The cutting parameter considered feed rate of cutting, depth of cut and cutting speed. The feed rate and cutting speed will differ while depth of cut is constant. Then, from scope stated at above the lifespan of tool life will be discover by using CNC lathe machine.

1.5 Importance of study

In industry, dry and nanofluid machining condition has been applied widely. Different type of machining condition will be producing different affected tool performance due to heat generated and cutting force in cutting process. The tool performance under dry and nanofluid condition of machining is important to be explored or studying for describe the interaction of carbide insert with titanium alloy. The cutter parameter such as cutting speed, feed rate and depth of cut also essential factor to be investigate for produce optimum cutting parameter in machining titanium alloys.

`

1.6 Organization of Report

Chapter 1 covers about the introduction of this experiment. It contains the background of study, problem statement, objectives, scope of study and significance of study.

Chapter 2 covers about literature review of this study. It contains the literature review about turning machining, dry machining, nanofluid machining and tool performance.

Chapter 3 covers about methodology of this project. It contains flow chart, literature review and full factorial method.

Chapter 4 contains the results and discussion for this research. The data from this study is tabulated and analysed.

Chapter 5 about the conclusion of this research and recommendation for improve the future.