Faculty of Manufacturing Engineering

FABRICATE AND INVESTIGATE THE PERFORMANCE OF ALUMINA BASED CERAMIC CUTTING TOOL WITH DIFFERENT EDGE

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Master of Manufacturing Engineering (Industrial Engineering)

2018

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A thesis submitted in fulfilment of the requirements for the degree of Master of Industrial Engineering

Faculty of Manufacturing Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018

DECLARATION

I declare that this thesis entitled “Fabricate and Investigate the Alumina Based Ceramic Cutting Tool with Different Edge” 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 : MOHD IMRAN BIN MAT AMIN

Date : .....

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 (Industrial Engineering).

Signature :…….....

Supervisor Name :…….....

Date :…….....

DEDICATION

I dedicate to my precious son Ahmad Shah'Isyraf and Ahmad Qyser Irwad, who are indeed a treasure from Allah. Also my lovely wife, Hariati, whose scarifies care for me and our children made it possible for me to complete this study. Others person most important in my life is my mother Pn.Indon, mother-in-low, father-in-low, brother and sister.

ABSTRACT

The research in this project focused on the comparison performance between two cutting tools with different edge. Both cutting tools will be fabricated based on the alumina powder processing with round and sharp edges. For each cutting tool, a special mould will be utilized according to the required shape. Specific weight of alumina powder will be processed with ball mill and poured into the designated mould to produce the green body of alumina inserts. These green bodies will be sintered at proposed 1400^{o}C with 9 hours soaking time to produce refractory solid ceramic inserts. The mechanical properties of both insert will be examined according to the density, hardness and dimensions. The cutting tools will be further tested in tool wear evaluation by machining with AISI 1045 with variation of cutting speeds and feed rates around 200-250 m/min and 0.1-0.125 mm/rev respectively, while depth of cut will be kept constant at 0.5 mm. The wear at the edge of both inserts will be monitored with optical microscope and further scrutinized using Scanning Electron Microscope for failure modes analysis. On the same time, the surface roughness will be assessing using surface roughness tester and optical microscope to differentiate the surface characteristics machined by the cutting tools fabricated. The results from this study should be useful to develop alumina based cutting tool for low cost and small scale machining operations.

ABSTRAK

Kajian dalam projek ini memfokuskan kepada perbezaan prestasi antara dua jenis perkakas pemotong yang mempunyai hujung yang berbeza. Kedua-dua perkakas pemotong akan difabrikasi berasaskan serbuk alumina dengan hujung berbentuk bulat dan tajam. Untuk setiap perkakas, bekas acuan khas akan digunakan mengikut bentuk yang telah dikenalpasti. Berat spesifik serbuk alumina akan diproses menggunakan kisaran bebola sebelum dimasukkan ke dalam bekas acuan yang direkabentuk untuk menghasilkan jasad hijau. Jasad-jasad hijau ini akan disinter pada cadangan suhu 1400^{o}C dengan 9 jam masa persinteran untuk menghasilkan jasad seramik yang padat. Sifat mekanikal untuk kedua-dua jasad tersinter ini akan dinilai berdasarkan ketumpatan, kekerasan dan dimensi. Jasad tersinter ini kemudiaanya akan diuji dari segi prestasi haus dengan memesin AISI 1045 dengan variasi halaju pemotongan dan kadar suapan masing- masing pada 200-250 m/min dan 0.1-0.125 mm/rev, sementara kedalaman pemotongan ditetapkan malar pada 0.5 mm. Haus pada hujung mata perkakas akan diperhatikan dengan menggunakan mikroskop optikal dan seterusnya Mikrosckop Imbasan electron untuk mode kegagalan perkakas. Pada masa yang sama, kekasaran permukaan akan dinilai dengan menggunakan Penguji Kekasaran Permukaan dan mikroskop optik bagi membezakan sifat permukaan yang dimesin dengan menggunakan kedua-dua perkakas tersebut. Dapatan daripada kajian ini akan membantu untuk menbangunkan perkaas pemotong berasakan alumina yang lebih murah dan sesuai untuk operasi pemesinan berskala kecil.

ACKNOWLEDGEMENTS

Alhamdulillah, I am grateful to Allah S.W.T, on HIS blessing and mercy for making this Report complete and successful. Thank to Allah and Rasulullah, who made all things possible. Firstly, thanks to my lecturer, IR. Dr. Mohd Hadzley B Abu Bakar for his vital encouragement, the thoughtful and assistance and also for the continuous reminders and much needed motivation throughout my project. Not overlooking, to all batch members, thanks for the full support, shared ideas, data and knowledge during the completion of this project. Without the assistance from the whole group members of course this project cannot be done completely. Lastly, I would like to give a special and greatest thank to my mother, family and friends for their moral support, understanding, inspiration and patience, in which without their support and love I may not be able to complete this dissertation. May Allah S.W.T. grant you all the Jannah.

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LIST OF ABBREVIATIONS

CIP	Clean in Place
CNC	Computer Numerical Control
CLA	Centre Line Average
EDM	Electrical Discharge Machining
HSM	High Speed Turning Machining
SEM	Scanning Electron Microscope
SM	Stereo Microscope

CHAPTER 1

INTRODUCTION

This chapter includes the introduction about the research background, problem statement of the study, objectives of the study and scope of study.

1.1 Background Study

Ceramic cutting tools have been widely used in machining hard material due to its excellent properties especially in high temperature and high speed machining (Kalpakjian & Schmid, 2013). Alumina based materials are among the most popular choices to produce the ceramic and to be used for fabricate cutting inserts because it has high hardness, high resistance to abrasion and chemical inertness against the environment and the workpiece. It is widely used in major industrial practice such as automotive, aerospace, medical, nuclear, oil and gas.

Machining process is used in order to produce component parts by removing the material into required shaped. Nowadays, machining of material is getting leading as various advancements of new alloy and engineered material which improve the mechanical properties of the material itself such as having high strength, toughness, and others.

In order to evaluate the performances of machining, surface integrity must be concern as one of the service life. Surface topography and surface metallurgy can be categorized under surface integrity. Surface topography is about the appearance of outer surface of the work piece while surface metallurgy more about the nature of the altered layers below the surface with respect to the base or matrix material. The value of surface roughness must be lower in order to achieve good quality product in industry (Gupta & Kumar, 2015). It is important to study surface roughness to relate the condition of machined surface with certain parameter.

There two conditions in machining which is dry and wet. Wet machining process involve usage of cutting fluid during the machining process while dry machining not using any cutting fluid. Dry machining usually applied during finishing process to gravy cast iron or powder base material. Dry machining help to reduce cost and hazard to environment. Dry machining has been proved to give better surface roughness due to softening cause by heat generation during machining the material (Azevedo, 2013). Despite those advantages, it may affect the life span of cutting tool.

In dry machining there are many cutting tool available. Some examples are carbide, ceramic, diamond and cubic boron nitride. Selection the suitable cutting tool is important to produce a high dimensional accuracy and good surface finish product. One of the cutting tool that significant in dry condition is alumina based cutting tool. Alumina(AL_2O_3) based cutting tool popularly used as cutting tools due to their excellent hardness and abrasive resistance, good chemical stability and high temperature performances (Zhou et al., 2016). These properties enable alumina cutting tool to be the materials research in order to develop its capabilities as a cutting tool. The nature of alumina cutting tool such as alumina that hard,

high wear resistance and chemical stability is suitable as research material in order to develop its capabilities as a cutting tool.

Methodology involve in this project is experimental procedures. By observation through the whole experiment that will be done, the tools must undergo machining test at certain condition before it been analyse. The evaluation of this research will be examined using Portable Surface Roughness Tester, Stereo Microscope (SM) and Scanning Electron Microscope (SEM).

1.2 Problem Statement

The ceramic cutting tool represents different class of cutting tool material with unique chemical and mechanical properties. The cutting tool is an important basic tool required in the machining process of a part in production and helps in getting required surface finish and accuracy of the part (Narasimha et al., 2013).

Today in manufacturing industry, there are many existed ceramic tool used in machining process. One of the pure ceramics that has been widely found as cutting tools in the industry is alumina. This material is commonly used as the base of a cutting tool. The ceramic cutting tools give an alternative to the manufacturing industries to exploit low costs cutting tools (Kamely et al, 2011). Since that other material are expensive to support as a based materials in cutting tools especially in machining process. Senthil et al. (2006) pointed out that the initial cost of alumina based ceramic inserts is generally higher than carbide or cermet inserts, but the cost per part machined is often lower. Production cost is the main concern of the industry and it has to be optimised to fully utilize the advantages of ceramic cutting tools.

1.3 Objectives

The objectives of this project are:

1. To evaluate the performance of different edge cutting tool in terms of tool wear and surface roughness.
2. To compare the performance of difference edge cutting tool based on tool wear and surface roughness.
3. To investigate type of failure made for cutting tools.

1.4 Scope of Study

This project involves fabrication alumina based cutting tool, in comparing their different edge. On this project will compare the performance of difference edge cutting tool based on tool wear and surface roughness. This project also will involve in designing the new cutting tool using the mould that designed for comparing the different edge.

Here, the evaluations of criterion are density, hardness, grain size and microstructure will be held to evaluate the performance of different edge cutting tool in terms of tool wear and surface roughness.

1.5 Significance of Study

This research will study the comparison different edge cutting tool in terms of tool wear and surface roughness. At the end of this research, the writer expects to come out with the new idea on redesign cutting tool based on the edge in low cost cutting tool. This project will come out with the benefit to training centre in education, and the industrial which used this material of tool.

1.6 Research Planning

Activity planning of this research is outline in a Gantt chart in Appendix A.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter provides the literature review on technical specification and materials requirements also comprise of the research development that has been done to gather all the data about the principle thought of this project. The information and knowledge are obtained through hardbound and online journals, relevant articles and reference texts.

2.1 Turning Process

Turning is a machining process to produce parts round in shape by a single point tool on lathes. The tool is fed either linearly in the direction parallel or perpendicular to the axis of rotation of the workpiece, or along a specified path to produce complex rotational shapes. The primary motion of cutting in turning is the rotation of the workpiece, and the secondary motion of cutting is the feed motion.

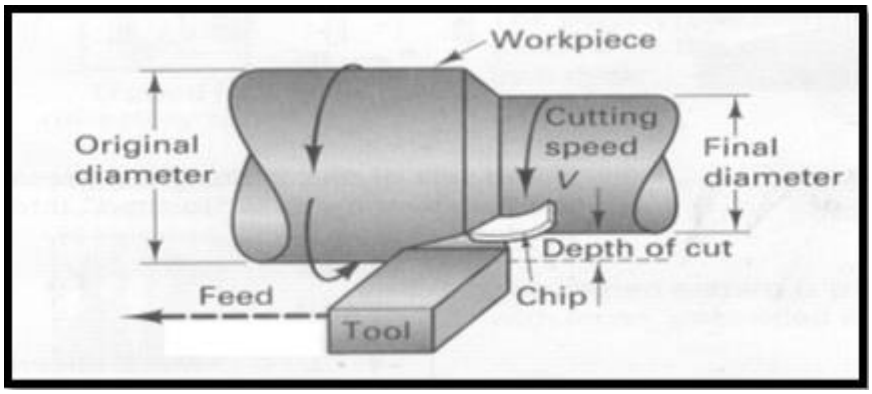

Figure 2.1: The turning process

The workpiece is rotated while the tool is fed at some feed rate (mm per revolution). The desired cutting speed V determines the rpm of the workpiece.

2.1.1 High Speed Turning Machining

Machining with high speeds (HSM) is one of the advanced technology and usually use in manufacturing operation, which in examination with customary slicing empowers to build effectiveness, precision and nature of workpieces and the opportunity to diminish costs and machining time (Pasko et al., 2000). The use of HSM allow us to shorten the production time and to increase the accuracy of machined parts. HSM is frequently utilized as a part of completing in solidified steels with both high speeds and bolsters. HSM can be called rather the High Productive Machining while machining segments in roughing to completing and furthermore in completing to higher-completing in parts of all sizes. This manufacturing procedure is not considered as a cure for underproductive and high-cost operations. However, it can be economically when used in a proper way (King, 2013). The high speed machining is highly depends on the variability of the cutting action. Cutting force and cutting speed are assumed crucial to the cutting action which could affect the performance of cutting process. The surface integrity is cause by the deformation of new surface when the chip is removes by cutting action.