INVESTIGATION OF WEAR PERFORMANCE OF ALUMINA BASED CUTTING TOOL BY USING DIFFERENT COLD ISOSTATIC PRESS (CIP) PRESSURE

MUHAMMAD HAKIM BIN ZAINUDDIN
B051410001

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
2018

© Universiti Teknikal Malaysia Melaka

INVESTIGATION OF WEAR PERFORMANCE OF ALUMINA BASED CUTTING TOOL BY USING DIFFERENT COLD ISOSTATIC PRESS (CIP) PRESSURE

Submitted in accordance with the requirement of the University Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Hons)

by

MUHAMMAD HAKIM BIN ZAINUDDIN
B051410001
921028085605

FACULTY OF ENGINEERING TECHNOLOGY

2018

© Universiti Teknikal Malaysia Melaka

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: **INVESTIGATION OF WEAR PERFORMANCE OF ALUMINA BASED CUTTING TOOL BY USING DIFFERENT COLD ISOSTATIC PRESS (CIP) PRESSURE**

Sesi Pengajian: **2017/2018 Semester 2**

Saya **MUHAMMAD HAKIM BIN ZAINUDDIN (921028-08-5605)**

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: 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.

© Universiti Teknikal Malaysia Melaka

DECLARATION

I hereby, declared this report entitled "Investigation of Wear Performance of Alumina Based Cutting Tool by Using Different Cold Isostatic Press (CIP) Pressure" is the result of my own research except as cited in references.

Signature : ……………………………………
Author's Name : MUHAMMAD HAKIM BIN ZAINUDDIN
Date :

© Universiti Teknikal Malaysia Melaka

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 are as follow:

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

(PM. Ir. Dr. Mohd Hadzley B Abu Bakar)

© Universiti Teknikal Malaysia Melaka

ABSTRAK

Kajian ini tertumpu kepada aplikasi tekanan isostatik sejuk dalam penghasilan pemotong perkakas seramik berasaskan alumina. Serbuk alumina semburan kering digunakan sebagai bahan mentah untuk menghasilkan perkakas pemotong ini dan ditekan dengan menggunakan mesin penekan hidraulik dengan tekanan 5 tan sebelum dimampatkan melalui tekanan isostatik sejuk pada tekanan yang berbeza iaitu 0 Mpa, 250 Mpa, 300 Mpa dan 350 Mpa. Jasad anum dikeluarkan dari acuan dan dibakar pada suhu 1400 ° C selama 9 jam dengan 4 jam waktu pegangan. Perkakas pemotong tersebut akan diuji di mesin larik kawalan berangka komputer dengan menggunakan operasi larik ke atas AISI 1045 keluli karbon sederhana. Ujian pemesinan dijalankan pada kelajuan pemotongan yang malar iaitu 200 m/min dengan kadar suapan yang malar iaitu 0.1 mm/rev dan kedalaman pemotongan yang malar iaitu 0.4 mm. Haus perkakas dan mekanisme haus akan dianalisis dan dikenal pasti dengan menggunakan mikroskop stereo. Keputusan ujikaji menunjukkan perkakas alumina dengan 300 Mpa tekanan isostatik sejuk berkemampuan memotong besi AISI 1045 dengan masa pemotongan paling lama iaitu 206 saat. Dari segi mekanisme haus, perkakas pemotong menunjukkan haus takuk, haus kasar dan haus lekat pada hujung perkakas pemotong. Kajian ini membolehkan industri untuk memahami bagaimana tekanan isostatik sejuk memberi kesan kepada perkakas pemotong dalam haus perkakas apabila pemesinan bahan kerja AISI 1045 dilakukan.

© Universiti Teknikal Malaysia Melaka

ABSTRACT

This study focuses on the application of cold isostatic press (CIP) to produce alumina based ceramic cutting tool. Spray dried alumina powder was used as a raw material to produce the cutting tool and was pressed using hyraulic hand press with the pressure of 5 tons before compressed through cold isostatic press machine at different pressure that is 0 Mpa, 250 mpa, 300 mpa and 350 mpa. Green body was ejected from the mould and sintered at 1400°C for 9 hours with 4 hours holding time. The cutting tools were then tested in CNC lathe machine using turning operation to machine AISI 1045 medium carbon steel. The machining tests were held at constant cutting speed of 200 m/min with a constant feed rate of 0.1 mm/rev and constant depth of cut of 0.4 mm. Tool wear and wear mechanism of the cutting tools were analyzed and identified using stereo microscope. The results show that alumina cutting tool with the CIP pressure of 300 Mpa adequate to machine AISI 1045 steel with the longest machining time that is 206 seconds. In terms of wear mechanism, the alumina cutting tool demonstrated notch wear, abrasive wear and adhesive wear at the edge of the cutting tool. This study enables the industry to understand how CIP pressure affects the cutting tool on tool wear when machining AISI 1045.

© Universiti Teknikal Malaysia Melaka

DEDICATION

To all those who lead monotonous lives, in the hope that they may experience at second hand the delights and dangers of adventure.

© Universiti Teknikal Malaysia Melaka

ACKNOWLEDGEMENT

I wish to acknowledge and express my appreciation and gratitude to my supervisor, Dr Mohd Hadzley Bin Abu Bakar for his supervision, encouragement, suggestion and his assistant through this project and my parents Zainuddin Bin Lamat and Zainab Binti Ishak whose constant encourage me and support my confidence continuously to finish this study.

Sincere thanks to all who helped me during this project to guide and solve experimental problem and active involvement in parts of this research especially to Mr Fauzi, Mr Naim, Mr Faiz and Dr Fatin Farhana.

Last but not least, to all my friends and those who are indirectly contribute in this project. Thank you very much.

© Universiti Teknikal Malaysia Melaka

TABLE OF CONTENT

© Universiti Teknikal Malaysia Melaka

© Universiti Teknikal Malaysia Melaka

© Universiti Teknikal Malaysia Melaka

© Universiti Teknikal Malaysia Melaka

LIST OF TABLES

© Universiti Teknikal Malaysia Melaka

© Universiti Teknikal Malaysia Melaka

LIST OF FIGURES

© Universiti Teknikal Malaysia Melaka

© Universiti Teknikal Malaysia Melaka

LIST OF ABBREVIATIONS

AISI	-	American Iron and Steel Institute
CIP	-	Cold Isostatic Press
CNC	-	Computer Numerical Control
DOC	-	Depth of Cut
ISO	-	International Organization for Standardization
MRR	-	Material Removal Rate
SM	-	Stereo Microscope
SEM	-	Scanning Electron Microscope

© Universiti Teknikal Malaysia Melaka

LIST OF SYMBOLS

Al_2O_3	-	Alumina Oxide
Cr_2O_3	-	Chromium Oxide
ZrO_2	-	Zirconia Oxide
MPa	-	Mega Pascal
GPa	-	Giga Pascal
mm	-	Milimeter
m/min	-	Meter per Minute
mm/rev	-	Milimeter per Revolution
°C	-	Degree Celcius
V	-	Cutting Speed
f	-	Feed
d	-	Depth of Cut
N	-	Rotational Speed of Workpiece
Psi	-	Pounds per Square Inch
C	-	Carbon
Fe	-	Iron
g	-	Gram
mm/s	-	Milimeter per Second

© Universiti Teknikal Malaysia Melaka

CHAPTER 1
INTRODUCTION

This chapter provides an introduction of the project background including the ceramic cutting tools, alumina, wear performance and wear mechanism. The problem statement, objectives and the scopes of this project on the investigation of wear performance of alumina based cutting tool by using different cold isostatic press (CIP) pressure will be introduced.

1.1 Background of Study

Machining is a process that removed the surface of metal by a sharp cutting tool from a larger body (Trent and Wright, 2000). There are three important factors that contributed to the efficiency of machining which is cutting tools, workpiece material and cutting parameters. In the manufacturing field today, machining of material is getting leading because there are various advancements of new alloys and engineered material which ultimately causes these materials to have high strength, toughness, and other material properties. In manufacturing operations, it is essential to view machining operations as a system including the workpiece, machine tools, cutting tools and also production personnel. Without a detailed knowledge of the interaction of these four components, machining cannot be carried out efficiently or economically (Kalpakjian and Schmid, 2013).

Among many factors that contributed to the machining efficiency, the use of right cutting tools considered dominant in machining practice. Among many cutting tools that available in industry, ceramic is one of the most frequently use. After all, it did not take long for makers in the metalworking industries to understand the benefits of using ceramics to

© Universiti Teknikal Malaysia Melaka

increase profitability and productivity in numerous applications. Most of the cutting tools that are made from ceramic are produced from alumina (Al_2O_3), silicon nitride (SiN), sialon, silicon carbide and zirconia. In general, ceramic materials have great hardness, thermal conductivity and toughness and the benefits of using these materials in manufacturing industry is the ability to withstand higher temperatures than cutting tools produced using high-speed steel or carbide. However, the limitation of ceramic based cutting inserts are the low toughness which can cause chipping and breakage during machining. To enhance the strength and toughen the ceramic based tool materials, some small scale particles like titanium carbide, titanium nitrade, titanium borides, silicon carbide and silicon carbide whisker were added (Wang *et al.,* 2017).

Among many ceramic cutting tools, the aluminium oxide or alumina (Al_2O_3) is the basis of many types of ceramics used for the cutting tools, especially for machining ultra-high-strength steels (Gevorkyan *et al.,* 2017) . Alumina is basic materials for ceramics, and they are useful for machining operations. Alumina cutting tools have been widely used in machining hard material due to its excellent properties particularly in high temperature and high speed machining. This material is obtained from Bayer process. This process is the most economic means of refining bauxite to obtained alumina. This powders possesses different powder size depend on the purity. In the application of alumina as a cutting tool, important criteria such as grain size, microstucture, reinforced particle and grain uniform are very important. Fine and uniform grain size would provide high protection from wear when this powder compact engages with different materials. Therefore, most of alumina based cutting tool were manufactured with added substance secondary powders such as zirconia and chromia to provide additive advantages not only to claim the high hardness as well as to resist wear from the tribological and heat actions during machining.

To apply alumina as cutting tool in machining operation, wear performance is very important in order to run prolong machining operation. Good wear resistance, toughness and chemical stability under high temperatures are the principal properties required for a high production rate and high accuracy machining (Valerio, 1991). Most of the cutting processes in turning are done by the nose of the inserts. When all the properties have been satisfactorily achieved, the only remaining failure of ceramic tools that has to be consider is wear (Chattopadhyay and Chattopadhyay, 1984). Flank and crater wear control the tool

© Universiti Teknikal Malaysia Melaka

life. The thermal and chemical conditions generate the formation of crater wear on the rake face of the cutting tool while flank wear keep on progressing.

1.2 Problem Statement

To produce alumina based cutting tool with excellent wear performance, the cutting toool can be fabricated with controlled parameters starting from powder metallurgy. Here specific powders of alumina have been processed with initial stage of ball milling process. This is followed by the shieving process before inserted into the mould. Inside the mould, the powders have been compacted to form stable green body.

During the compaction stages, pressure load plays important roles to make sure the particles can be compacted dense enough to form high density structure and adequate hardness. There are two stages of compaction process applied to form green body. The first stage focussed on to form the shape of alumina cutting tool based on the hand press. Since the process just use manual adjusted load from the hand, assisted by the hydraulic hand press. The process considered less critical for the purpose of shaping and holdable green body of alumina. The second stage of compacted process focussed on the effort to strengten the structure by using cold isostatic press. This process is very crucial as the pressure that engage to the alumina body pressure is very high and uniform through whole body. Therefore controlling the pressure during CIP enable high dense cutting tool to be fabricated.

Consequently, as the high density of cutting tool can be fabricated, the wear resistance of cutting tool is expected greater as a result of friction between each particle due tu high compaction that can hold the structure solidly. Therefore, investigation of pressure during CIP process is vital to determine the capability of alumina based cutting tool to be applied in machining operation.

The purpose of this project was to investigate the wear performance of alumina based cutting tool by using different CIP pressure. As the ceramic powders were compacted and

© Universiti Teknikal Malaysia Melaka

sintered, the performance of ceramic cutting tool was checked based on wear performance and wear mechanism. By referring to an experiment that will be done, the tools must undergo a machining test with constant cutting speed, depth of cut and feed rate before analysis is done with the tool. The evaluation of this research will be examined using Stereo Microscope (SM). In the end, this result will be used to purpose some improve or refinement for cutting tool development in the future.

1.3 Objective

The objectives of this project are as follows:

i. To fabricate alumina based cutting with different CIP pressure.
ii. To evaluate the performance of the fabricated cutting tool based on tool wear.
iii. To analyse the wear mechanism of newly fabricated cutting tool when machining AISI 1045 medium carbon steel.

1.4 Scope of Study

The scopes of this project are as follows:

I. CIP process, manual compaction and sintering process are used to fabricate the cutting tool.
II. The tools were tested in lathe machine using various parameters.
III. In this project, the selected process is turning which will be performed by using a CNC turning machine.
IV. The performance measure that been evaluated is tool wear.

© Universiti Teknikal Malaysia Melaka

CHAPTER 2

LITERATURE REVIEW

The literature review consists of the summarizing of the project in order to get the whole data about ceramic powders, cutting tools, machining, tool wear and wear mechanism which will give an idea to run the project. This chapter presents related study done by previous research and will be working as a reference, to give information and guide based on journal, book and other sources on the internet that could contribute to this project.

2.1 Ceramic Cutting Tool

Ceramics are nonmetallic materials consisting of nonmetallic elements and metallic elements bonded primarily with covalent and ionic bonds. Ceramics have the following relative characteristics such as high modulus of elasticity, high compressive strength, high hardness, good electrical insulation properties and brittle. In spite of that, the mechanical and physical properties of ceramics are different because of the variety of ceramics material arrangement and grain sizes (Kalpakjian and Schmid, 2013). Table 2.1 shows the properties of different ceramics at ambient temperature.

Table 2.1: Properties of different ceramics at ambient temperature (Shamsudin, 2007)

Material	**Compressive Strength (Mpa)**	**Elastic Modulus (GPa)**	**Hardness (HK)**	**Density (kg/m3)**
Alumina Oxide	1000-2900	310-410	2000-3000	4000-4500
Cubic boron Nitride	7000	850	4000-5000	3480

© Universiti Teknikal Malaysia Melaka