UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF MOULD TO FABRICATE ALUMINA CUTTING TOOL BY USING 3D PRINTER TECHNOLOGY WITH ABS AND PLA MATERIAL

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

by

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Tajuk: **DEVELOPMENT OF MOULD TO FABRICATE ALUMINA CUTTING TOOL BY USING 3D PRINTER TECHNOLOGY WITH ABS AND PLA MATERIAL**

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I hereby, declared this report entitled “Development of mould to fabricate alumina cutting tool by using 3D printer technology with Abs and Pla material” is the results of my own research except as cited in reference.

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Date : 24 May 2018

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering (Hons.).

The members of the supervisory committee are as follows:

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Prof Madya Dr IR Mohd Hadzley Bin Abu Bakar

Project Supervisor

ABSTRAK

Bahagian paling penting dalam industri adalah alat pemotong. Alat pemotongan ini penting kerana banyak penggunaan dan fungsi dalam bahagian pengeluaran. Ia bertindak sebagai alat penghapus atau juga dikenali sebagai pemotong atau pemotong. Bahagian pengeluaran mempunyai banyak bentuk seperti bulat, persegi dan juga segi empat tepat. Bahan alat pemotong biasa yang digunakan adalah alat pemotong seramik. Untuk menghasilkan alat pemotong ia mesti mempunyai acuan. Bentuk tetap yang mempunyai rongga untuk mengisi bahan dan padat untuk menghasilkan alat pemotong. Acuan konvensional menggunakan perkakas dan kos tinggi yang membebankan industri sederhana kecil. Oleh itu, projek ini adalah untuk merekabentuk dan membangunkan acuan dengan menggunakan teknologi pencetak 3D dengan bahan Acrylonitrile Butadiene Stryene (ABS) dan Poly Lactic Asid (PLA). Pengembangan acuan akan dipaparkan. Untuk menjalankan kajian ini, model acuan telah direka bentuk dengan menggunakan CATIA. Tambahan pula, dalam banyak aspek akan dipertimbangkan seperti reka bentuk, prestasi, kekuatan dan kekasaran permukaan. Acuan akan difokuskan pada analisis prestasi. Ia akan melalui beberapa proses dan ujian untuk mengumpul tarikh kerana mendapatkan produk selesai yang cemerlang. Acuan akan diuji dan diuji kerana meningkatkan produk.

ABSTRACT

Most important parts in industrial are the cutting tool. This cutting tool is important due to many usage and function in the production parts. It acts as a removing tool or also knows as cutting or cutter. The production parts have many shapes such as round, square and also rectangular. The common cutting tool material that been used is ceramic cutting tool. To produce a cutting tool it must have the mould. A fixed shape that have cavity to fill in the material and been compact to produce the cutting tool. The conventional mould is using high tooling and cost that burden the small medium industrial. Therefore, this project is to design and develop a mould by using the 3D printer technology with Acrylonitrile Butadiene Stryene (ABS) material and Poly Lactic Acid (PLA). The development of mould will be show. To conduct the study,a mould model wasdesigned by using CATIA. Furthermore, in many aspects will be considered such as the design, performance, strength and also surface roughness. The mould will be focused on the performance analysis. It will through some of process and test to collect date due to get excellent finish product. The mould will test and experimented due to improve the product.

DEDICATION

To everyone that contributes to this research my supervisor, my family and my friends that has been helping me during this project.

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In the name of Allah, the Most Gracious and the Most Merciful.

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LIST OF ABBREVIATIONS

2-D	-	2 Dimensional
3-D	-	3 Dimensional
ABS	-	Acrylonitrile Butadiene Styrene
CAD	-	Computer Aided Design
CAE	-	Computer Aided Engineering
CAM	-	Computer Aided Manufacturing
CATIA	-	Computer Aided Three-Dimensional Interactive Application
CNC	-	Computer Numerical Control
CIP	-	Cold Isostatic Press
FYP	-	Final Year Project
3DP	-	Three-Dimensional Printing
SLS	-	Selective Laser Sintering
UV	-	Ultra Violet
RP	-	Rapid Prototyping
SLA	-	Stereolithography
DLP	-	Digital Light Processing
FDM	-	Fused Deposition Modelling

CHAPTER 1

INTRODUCTION

This chapter of introduction will presents and explains generally about the research of final year project. In which will provide a review of the project background, the problem statement, goal objectives, and also the scope of the research. Issues in this project will be explained and it will achieve distinguish of the objective of the research. The main of the this project is to figure out and investigate the development of mould for fabrication of alumina cutting tool by using 3D printing with ABS and PLA material.

1.1 Project Background

In industry, cutting tool is one of the most important parts. It can be consider as a major industrial prerequisite as it is function to apply mostly in parts production. The parts production in machining process has many shapes such as rectangular, square and round. It also has the nose radius such as straight, bent, cranked and round-nosed cutter and the cutting tool classes will follow according to the shapes given. The shaped of cutting tools was designed depended on the definite condition. Such as the material of the tools, the materials that need to be cut and also the process condition on the mechanical properties.

This final year project is mainly about development mould of alumina cutting tool that fabricated by using 3D printing. The ceramic cutting tool is a substantial by combination of ceramic powders that are fabricated by compacting and applied machining operations. Usually, the ceramic cutting tool used such as silicon nitride, silicon carbide, sialon and titanium carbide. Artistic cutting devices have been generally utilized as a part of machining hard material because of its magnificent properties particularly in high

temperature and fast machining. Alumina based materials are among the most prevalent decisions to be utilized to manufacture cutting supplements since it has high hardness, high protection from scraped spot and concoction inactivity against the earth and the workpiece. Notwithstanding, the confinement of alumina based cutting additions is the low sturdiness of the pottery, which can cause chipping and breakage amid machining. Keeping in mind the end goal to conquer this issue, extra materials, for example, yttria balanced out zirconia, titanium carbide, silver and ceria are utilized to build the crack sturdiness of the alumina.

In making this cutting tool, must through some process. The cutting tool has many shapes according to the production parts given. To fabricate the cutting tools, it must have the main and fixed shape. A special mould is required to compact the powders to become a cutting tool. This research is mainly about the mould to fabricate the ceramic cutting tool. The mould is different than the conventional mould that mainly used in industry. The new idea of mould is more convenient and low cost. The new design of mould is by using the easy method than before this. Using the 3D printing to shape and act as a mould for the cutting tool. Furthermore, the mould was fabricated by ABS and PLA material. Which means the mould are easier to design and less cost than the conventional mould that use steel material.

The purpose of this project was to develop the mould to fabricate the ceramic cutting tool based on the specific composition of alumina powder. As the ceramic powders were compacted and sintered, the performance of ceramic cutting tool was evaluated based on wear performance and surface roughness of the machined surface. This project will evaluate the new development of mould based on the result of wear performance, surface roughness and strength test. In the end, this result will be used to propose some improvement and refinement for the development of mould to fabricate the cutting tool.

1.2 Problem Statement

There are many ceramic-based cutting tool produced in the industry. Some of the ceramic cutting tools are cemented carbide, cubic boron nitrite, silicon carbide and

diamond. These ceramic cutting tools has been widely known for their excellent performance in high speed and high temperature machining (Kalpakjian and Schmid, 2013). This is because the ceramics possess variety properties such as high hardness, high thermal shock resistance and high chemical stability. Besides, these cutting tool that produced in the industry are mainly using the mould that made by steel. The mould that using steel material is having a little bit problem. The problem where the process of fabricating it is high in tooling cost. The tooling to fabricate the cutting tool is using high cost tooling than can cause wastage to industry. The high tooling costs make this method uneconomical for little creation runs. Exactly when the technique is used to cast steel or iron the shape life is to an awesome degree short. For cut down melting point metals the frame life is longer however warm depletion and crumbling regularly control the life to 10,000 to 120,000 cycles. Besides, the current mould steel is complicated to fabricate it. There too many processes in making it. Furthermore, the mould is taking too much time to producing it while it can make it simpler. If considering on the material, it is hard to shape in making complex shape of mould. Also, the cost of material is high and expensive.

1.3 Objective

The objectives of this project are as follows:

i. To design a mould for alumina cutting tool by using 3D CATIA software.
ii. To fabricate a mould for alumina cutting tool by using 3D printing with ABS and PLA material.
iii. To evaluate the precision, surface roughness and strength of fabricated mould.

1.4 Scope of Study

This study involved development of mould to fabrication of alumina based cutting tool by using 3D printing with ABS and PLA material. This development of mould is to fabricate the cutting tools that apply on the turning machine. This mould will undergo the strength test to determine the durability of the mould. The outcome of the new

development of mould with two types of material will be compared with the current mould to determine the performance in term of producing the cutting tool.

CHAPTER 2

LITERATURE REVIEW

This chapter will discuss about the research of development of mould for fabrication of alumina cutting tool by using 3D printing with ABS and PLA material. In this part also will explain about cutting tool, turning machine, the material used for the mould, 3D printing, acetone for polishing and the main part is the mould. All the references are from the book, journal, conference paper, website and also article.

2.1 Cutting Tool

The choice of cutting device in metal cutting is exceptionally vital. An appropriate slicing device must be all around chose and reasonable to machine a given work material. Cutting instruments are available in an extensive variety of choice comprises of different properties, machining capabilities and costs. It has been demonstrated that parameters including cutting instruments, for example, apparatus geometry, device materials cutting parameters and have critical impacts on the profitability and execution of a machining operation (Black and Kohser, 2008).

2.1.1 Cutting Tool Geometry

As indicated by Kalpakjian and Schmid (2013), device geometry is a parameter including different edges in a solitary point cutting device, which have imperative parts in machining operations. Ojolo (2014) specified about the apparatus geometry of a standard single-point device that influence the device life which are nose span, end front line edge,

side rake edge, side alleviation edge, back rake edge and back help edge. The points that have the hugest impact on apparatus life are the nose range, side rake edge and side front line.

(a) Rake angle

The most noteworthy capacity of the rake edge is to control the stream course of the chips and the apparatus tip quality. Positive rake angle can limit powers and temperature. Be that as it may, positive rake points may conceivably cause untimely apparatus chipping and inability to the cutting instrument with low toughness. (Kalpakjian, 2013)

(b) Side rake angle

The introduction of the rake confront is characterized by two edges which are side rake point and back rake edge. The last controls the stream heading of chips however side rake edge in more critical in machining. In metal cutting utilizing embeds, the point go are from - 5° to 5°. (Kalpakjian, 2013)

(c) Cutting edge angle

The cutting edge has huge impacts in the arrangement of chips, quality of the device, and cutting powers. The point of angle is often around 15°. (Kalpakjian, 2013)

(d) Relief angle

The alleviation edge is generally 5°. In machining, the rubbing and obstruction at the interface amongst device and workpiece are controlled by help point. The apparatus tip chipping may happen in the event that it is too expansive while too little edge may bring about over the top flank wear. (Kalpakjian, 2013)

(e) Nose radius

The strength quality of the apparatus tip and surface complete can be influenced by the estimation of nose radius. A sharp device, which has little nose radius, creates harsh surface complete of the workpiece and has low quality. In the event that it is substantial, apparatus gabbing may happen. (Kalpakjian, 2013)

2.1.2 Shape and Size of Cutting tool

Current innovation prompts the manufacture of assortment of embeds shapes and sizes. Each design is proposed to accomplish better cutting execution that can limit the time and expenses. The states of the supplements are differing as per their nose radii. The distinctive in nose radii makes each of the shapes to have diverse properties. The quantity of slicing indicates change concurring the shapes. Figure 2.1 demonstrates the states of the additions and the properties, which they have.

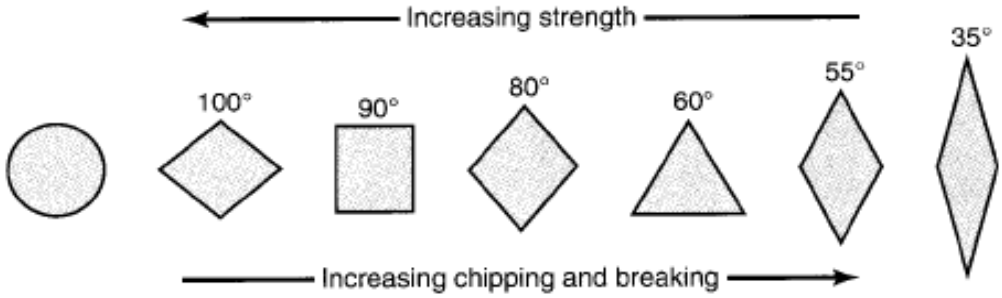

Figure 2.1 The arrangement of strength and tendency for various insert shapes (Source: Courtesy of Kennametal Inc.)

2.1.3 Ceramic Cutting Tool

Ceramic materials are comprised of solid ionic or covalent holding and have high shear protection. These solid bonds result in mechanical properties, for example, low malleability and high compressive quality controlled by the materials. Ceramic productions

have high rigidity hypothetically, but since of the absence of pliability and high dissolving focuses, these materials are typically handled as powdered material (Black and Kohser, 2008).

Artistic, as a class of materials, have reliably had potential as cutting gadgets. They are hard, hold their hardness at high temperatures and have a by and large low reactivity with steel. Hence, it can be used at high cutting velocities without contorting or crumbling wears frames deciding device life. The disservice to stoneware as device materials is that absence of toughness and protection from both mechanical and warm stun. This has compelled the use of imaginative device materials before. There are three arrangements available, to be particular unadulterated oxide fired, blended oxide in addition to carbide and nitride and silicon nitride based material. Each class has its own trademark properties, which must be understood if the materials are to be most effectively manhandled in metal cutting.

Table 2.1 Mechanical properties of ceramic materials (Black and Kohser, 2008)

Material	Density (g/cm^3)	Tensile Strength (ksi)	Compressive Strength (ksi)	Modulus of Elasticity (10^6 psi)	Fracture Toughness (ksi $\sqrt{in}$)
Al_2O_3	3.98	30	400	56	5
Sialon	3.25	60	500	45	9
SiC	3.1	25	560	60	4
ZrO_2 (partially stabilized)	5.8	65	270	30	10
ZrO_2 (transformation toughened)	5.8	50	250	29	11
Si_3N_4 (hot pressed)	3.2	80	500	45	5

2.1.4 Alumina-based Ceramic Cutting Tool

The excellent properties of alumina-based pottery, for example, high resistance from scraped spot, high hot hardness, and its compound inactivity against unforgiving environment settle on it a dependable decision as a material for cutting tool. Because of its unrivaled properties, alumina is normally utilized as cutting apparatus in the application at hoisted temperature contrasted with rapid steels and carbides (Rejab et al, 2014)]. The study on alumina to contemplate its potential as a cutting apparatus has been directed since 1905 by the Germans. The hot pressing method is utilized to set up the alumina cutting supplements utilizing couple of sorts of sintering specialists, such as, Cr2O3, MgO,NiO and TiO2. These sintering specialists are generally named white porcelain (Like et al, 2007). Alumina cutting inserts, which contain fewer than 2% porosity, are comprised of fine grains, which under 5 μm, has moderately high density. The cutting embeds are appropriate to be utilized as a part of the machining of alloy steel, cast iron with hardness beneath than HB235 and carbide steel with hardness underneath than HRC38. (Azhar et al, 2010).

In spite of the fact that the sintered oxide ceramic has been broadly known because of its different valuable physical properties in the machining application, it isn't adequate when connected in a state of high mechanical load and thermal shock because of its low brittleness and low quality of strength (Rittedech et al, 2013). Li et al (1994) expressed that the real issue identified with ceramic inserts is its low durability and catastrophic failure. They led a trial utilizing monolithic alumina as the cutting inserts and found that the inserts experienced untimely or catastrophic failure because of high anxiety and high shock experienced by the edge and face of the cutting inserts at elevated temperature. In order to evaluate the properties of the material, a few added substances, for example, some additives such as partially stabilized zirconia, ceria, titanium carbide, carbon and titanium nitride have been to alumina matrix.