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I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering (Hons)Manufacturing Engineering

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at University Malaysia Pahang or any other institutions.

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THE DEVELOPMENT OF CERAMIC INSERT OF ALUMINA TOUGHENED BY ZIRCONIA AND COPPER

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ABSTRACT

Ceramic material has been popularly used in the industry for the different sector over a century. This is because of its productivity and efficiency in many applications including machine tools and cutting tool material. The ceramic cutting tools have high demand from the market due to its efficiency and wear resistance. However, ceramics itself inherit the brittleness in its mechanical properties. In order to build the high strength of ceramic cutting tools, there needs to choose the suitable reinforcement to improve its toughness. In this case, copper and zirconia materials were added to investigate the mechanical and physical properties. Besides, the composition of the powder between alumina matrix, zirconia and copper has to be precise in order to produce high strength ceramic insert cutting tools. Several methods were used in the manufacturing of insert and one of them is pre-forming process of mix powder parts prior to densification by sintering. In this experiment, uniaxial pressing method was also used to form a green compact of the insert and it was found with uniform density and good structural integrity. Solid state sintering was used in in the solidification process using Naberthem furnace. The effect of the composition of the reinforcement on the shrinkage, hardness, density and microstructure of the inserts was also investigated. In this project an optimum density of 3.26% and hardness 1385HV was obtained for a composition of 80% by weight alumina, 10 % by weight zirconia and 10 % by weight copper.

ABSTRAK

Bahan seramik telah popular digunakan dalam industri untuk sektor yang berbeza lebih satu abad. Ini kerana produktiviti dan kecekapan dalam banyak aplikasi termasuk peralatan mesin dan bahan alat memotong. Alat-alat memotong seramik mempunyai permintaan yang tinggi daripada pasaran kerana kecekapan dan rintangan haus. Walau bagaimanapun, sifat seramik diri mewarisi kerapuhan dalam sifat-sifat mekanikal. Dalam usaha untuk membina kekuatan yang tinggi alat pemotong seramik, perlu untuk memilih tetulang yang sesuai untuk meningkatkan keliatan. Dalam kes ini,bahan tembaga dan zirconia ditambah untuk menyiasat sifat-sifat mekanikal dan fizikal. Selain itu, komposisi serbuk antara matriks alumina, zirkonia dan tembaga haruslah tepat untuk menghasilkan kekuatan yang tinggi bagi alat pemotong seramik. Beberapa kaedah telah digunakan dalam pembuatan alat pemotongan seramik ini sendiri.Bagi menghasilkanya proses dari sebahagian serbuk campuran dibentuk melalui pemadatan oleh pensinteran. Dalam eksperimen ini, kaedah penekanan ekapaksi juga digunakan untuk membentuk *green compact* dan didapati dengan ketumpatan yang seragam dan struktur integriti yang baik. Pepejal pembakaran bentuk telah digunakan dalam dalam proses pemejalan menggunakan mesin Naberthem. Kesan komposisi tetulang pada pengecutan, kekerasan, ketumpatan dan mikrostruktur turut dieksperimentasikan. Dalam projek ini kepadatan optimum sebanyak 3.26% dan kekerasan 1385HV telah diperolehi bagi komposisi berat 80% oleh alumina , 10% mengikut berat zirconia dan 10% oleh berat tembaga .

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LIST OF SYMBOLS

Al2O3	Alumina
Cu	Copper
Zr	Zirconia
H_C	Height Compaction
H_S	Height Sintering

LIST OF ABBREVIATIONS

ZTA	Zirconia Toughened Alumina

CHAPTER 1

INTRODUCTION

1.1 Ceramic Insert View in Industry

Ceramic material has been popularly used in the industry for the different sector over a century. This is because of its productivity and efficiency in many applications including machine tools and cutting tool material. The different type of machine such as CNC lathe and milling machine used the cutting insert tools. The development of the tools using ceramic also can low the material cost and improve the process cutting performance. Ceramic material also owns greater hardness, toughness and thermal conductivity characteristic. The ceramic cutting tool itself has high demand from the market due to its efficiency and wear resistance. Usually, the ceramic cutting tools are fabricated from alumina (Al_2O_3), zirconia (ZrO_2) and ceramic matrix composite (CMCs).

In this case, copper acts as ceramic matrix composite (CMCs) is to improve the performance of the cutting inserts. The mixture of copper powder also can improve the toughness and thermal conductivity. While, zirconia is the material that has a stable condition. Zirconia also has known as zirconium dioxide. The mixture of zirconia in alumina matrix composite commercially known as Zirconia Toughened Alumina (ZTA). In this study, alumina produces high strength and hardness while zirconia acts as a toughening effect. This both combination will react more effectively and double the strength of the material by producing a composite that tougher than alumina itself. The advantages of using the ceramic material in manufacturing are the ability of ceramic that can withstand the tool's heat resistance exceeds 2204.4 °C compares with tools that made

from carbide 871.1° C only. Furthermore, the ceramic material allows deeper and cleaner cuts due to its ability to operate at higher temperature (Kulzer, 2012).

The development of ceramic inserts typically prepared using powder metallurgy technique. This is because it can produce closer to the net finish. This technique also can eliminate machining operation and cost to manufacture this insert. By using this technique, the energy consumption also can be reduced. The process in this powder metallurgy involves mixing, compacting, sintering and finishing.

The aim of this project, is to find and research the right mixture in order to enhance the knowledge about the ceramic cutting insert. In this study, the aluminum oxide (Al_2O_3), zirconium dioxide (ZrO_2) and copper (Cu) material will be used. These all material mixtures will be fabricating the insert cutting tool using powder metallurgy process. The most problem, in this case needs to overcome is the performance of the tool to reduce tool wear. This will rate, according to hardness, density, shrinkage, and physical microstructure performance.

1.2 Problem Statement

The insert cutting tools that are available in the market normally required high cost because of its type of material such as carbide and high speed steel (HSS).While ceramics insert cutting tools that have much lower cost because of its material has low strength properties. But, for the ceramics itself, they inherit the brittleness in its mechanical properties. Comparing with the available ceramic cutting tools with others cuttings tools such as carbides, ceramics cutting tools has low tool life performance. In order to build the high strength of ceramics cutting tools, there need to choose the suitable reinforcement to improve its toughness. In this case, the copper material are adding to investigate this problem Besides, the composition of the powder between alumina matrix, zirconia and copper have to be precise in order to produce high strength ceramic insert cutting tools

In this study, the right composition between the powder need to discover related with temperature and compaction pressure. In addition to temperature, the cutting tools normally required at high temperature. While, copper has high thermal productivity. This will might improve with the cutting tools can withstand extremely at high temperature during an operation..

1.3 Objective

There are three specific objectives have been stipulated for this study:

1. To develop ceramic insert of alumina with Zirconia (ZrO_2) and Copper Powder (Cu) using powder metallurgy processes.

2. To study the effect of Zirconia (ZrO_2) and Copper Powder (Cu) in base alumina matrix for hardness, density, shrinkage, and physical microstructure properties.

1.4 Scope of The Project

1. Produce output result involving hardness, density, shrinkage and physical microstructure

2. Measure the capability of the Zirconia (ZrO_2) and Copper Powder (Cu) in sintering and compaction process during the formation of insert.

3. Three major processes which are blended, compacting and sintering with the normal sintering process, will be discovered to fabricate this ceramic insert.

4. Experimenting the composition of Zirconia (ZrO_2) and Copper Powder (Cu) through Alumina matrix.

REFERENCES

1. Astakhov, V. P. (2003). The Assessment Of Cutting Tool Wear. International Journal Of Machine Tool & Manufacture.

2. Carlos Nelson Elias. (2003). Mechanical Properties of alumina-zirconia composite for ceramic abutments. 26-29.

3. Ceramics, D. (2016).

4. GERIC, K. (2010). Ceramics Tool Materials With Alumina Matrix.

5. Jens Fruhstorfern, S. S. (2014). Dry ball mixing and deagglomeration of alumina and zirconia composite fine powders using a bimodal ball size distribution.

6. Kalpakjian, S. (2001). *Manufacturing Engineering and Technology. London: Prentice Hall International.*

7. Katholieke, 1. O. (2002). Perspectives on the Development of Ceramic Composites or Cutting Tool Applications. Kasteelpark Arenberg, Belgium.

8. Kuzler, F. (2012). Why Ceramic Cutting Tools? *CERAMIC INDUSTRY (CI)*.

9. Materia. (oct 2009). principle of powder metallurgy.

10. Mohammad Asadikiya, H. S. (2016). Phase diagram for a nano-yttria-stabilized zirconia system .

11. Mondal, A. A. (2008). Microwave Heating of Pure Copper Powder With Different,.

12. Pasaribu, H. R. (2005). Friction and wear of Zirconia and Alumina Ceramic doped with CuO.

13. Shunzo Tashima, Y. Y. (1996). Cutting Performance of High Purity Alumina Ceramic Tools formed by a High-speed Centrifugal Compaction Process.