UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Manufacturing Engineering

STUDY OF PERFORMANCE OF NICKLE QUARRY DUST COMPOSITE COATED CUTTING TOOL

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Master of Manufacturing Engineering (Industrial Engineering)

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DECLARATION

I declare that this research entitled with "The study of the performance of nickel quarry dust composite coated cutting tools" is my own work and I own the full responsibility of all the material in it except any information that has been cited to their respected authors in the reference.

Signature : ....

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Date : 29/01/2020

APPROVAL

I hear by state that I have reviewed and approved this thesis and in my opinion it is nicely prepared and has sufficient qualities is terms of objective met and report quality and is therefore enough for the award of master of manufacturing engineering (industrial Engineering).

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DEDICATION

To my loving and caring parents

ABSTRAK

Alat memotong adalah penting dalam hal ini apabila ia datang kepada pemesinan. Industri dan makmal bergantung kepada mereka untuk produksi pelbagai. Salah satu alat memotong yang paling biasa digunakan adalah tungsten karida alat memotong. Alat ini adalah harga berpatutan dan boleh didapati di mana-mana. Walau bagaimanapun, satu industri masalah besar sentiasa menghadapi alat yang memakai selepas beberapa berjalan. Dalam projek ini, Tujuannya adalah untuk mencuba dan menangani masalah dengan bereksperimen jenis baru memotong alat. Tungsten karide memotong alat mempunyai masalah memakai cukup awal, jadi dengan salutan dengan komposit habuk kuari nikel, alat ini boleh bertahan lebih lama. Dalam ujikaji projek ini akan dilakukan dengan menggunakan alat pemotongan komposit habuk ini. Dengan menggunakan proses tamat kilang, prestasi alat pemotongan akan diperiksa. Blok aluminium akan digunakan sebagai bahagian kerja. Parameter dan kadar suapan yang sama akan digunakan untuk menguji dan membandingkan prestasi alat pemotongan. Kedalaman pemotongan akan disimpan di malar juga. Microsoft Excel akan digunakan untuk menganalisis dan membandingkan data untuk mencari keputusan yang diperlukan.

ABSTRACT

Cutting tools are a major important when it comes to machining. Industries and labs depend on it for their various productions. One of the most commonly used cutting tools is tungsten carbide cutting tool. This tool is reasonably priced and available in everywhere. However, one big problem industries always face is tools wearing out after couple of runs. In this project, the aim is to try and tackle the problem by experimenting a new type of cutting tool. Tungsten carbide cutting tool has the problem of wearing out quite early, so by coating it with a nickel quarry dust composite, the tool can last longer. In this project experiments will be done using this nickel quarry dust composite coated cutting tool. By using an end mill process, the performance of the cutting tool will be examined. Aluminium block will be used as a work piece. Same parameters and feed rates will be used to test the and compare the cutting tool performances. Depth of cut will be kept at constant as well. Microsoft excel will be used to analyse and compare the data to find required results.

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CHAPTER 1

INTRODUCTION

1.1 Background

Tungsten carbide, or commonly known simply as carbide is a widely used cutting tools in machining process. As carbides are used during machining, gradual wear on the flank and the rake faces of the cutting tool causes carbide to fail. Coating promotes longer tool life to tungsten carbide cutting tools because coatings increase cutting tools hardness. Thus, the nickel-quarry dust composite coating via electrodeposition process is introduced to coat the tungsten carbide. Quarry industries in Malaysia plays an important and crucial role in the development of the country. However, the environmental concern is currently increasing as one of the main challenging matters affecting the natural aggregate and limestone production. According to Sridharan et al. (2016), about 20-25% of the total production in each crusher unit is left out the quarry dust as waste material. So, effort have been taken to control environmental pollution arising due to disposal of these industrial wastes by converting them into utilizable raw materials for usable application. Quarry dust is one of the by-product from the crushing process during quarrying activities, which have gained attention to be used for various applications. Recently, the utilization of the quarry dust which is high in silica and alumina content have been extended to be used as reinforcement for metal matrix composite due to high cost of the conventional ceramic particles.

Therefore, the effect of various compositions and sizes of quarry dust on nickel matrix composite coatings electrodeposited on tungsten carbide substrate will be studied. The influence of heat treatment process on the tribological, mechanical and hardness of nickel matrix composite will also be studied.

In this project, nickel-quarry dust composite coatings nickel will be electrodeposited on tungsten carbide substrate in a nickel-citrate bath at various compositions and size of quarry dust. Subsequently, the selected coating will be heat treated. The effect of heat treatment process to tribological, mechanical and hardness of the composite will also be covered.

This research will contribute to the knowledge on the improvement of tribological, hardness and corrosion properties of nickel-quarry dust composite coating electrodeposited on tungsten carbide via various compositions and sizes of quarry dust and heat treatment process. The findings would be benefited by the cutting tools industries.

1.2 Problem statement

Tungsten carbide cutting tool which is one of the most commonly used cutting tools for machining processes due to its cheapness and availability in the market, has the problem of wearing out after few number of runs. The flanks and rake faces of the cutting tool gradually wear out during the machines process. Buying new cutting tools all the time is a problematic issue for industries. It is less economical to replace cutting tools all the time. it is important to find some alternative solution to this matter since machining is a pivotal process for the production and manufacturing of parts and industries rely on machining heavily. The solution is to find a more economical alternative to the exiting tungsten carbide cutting tools. In this study we propose a new composite material that can replace existing tools. By using a cutting tool that is reinforced or coated with nickel quarry dust composite, we will be able to do machining without the need to replace cutting tool easily. The new cutting tool can be re coated every time it is about to wear out and then reused again to save money and time for industries.

1.3 Objectives of the research

1. To investigate the effect nickel quarry dust composite will have on tungsten carbide cutting tool after being coated with it.
2. To perform a machining process using nickel quarry dust coated cutting tool and examine its performance.
3. To evaluate and identify the best performing coated cutting tool during the Computer Numerical Control(CNC) end mill process application among four different coated cutting tools which are, nickel only coated, nickel only coated heat treated, nickel quarry dust composite coated and finally nickel quarry dust composite coated heat treated.

1.4 Project scope

This research is focused on the multiple objectives to propose suitable parameter coated tungsten carbide cutting tools and optimum cutting tool condition during end mill process application.

i. End mill process is used to study the performance of cutting tool after being coated with nickel quarry dust composite
ii. Quarry dust used is characterized and composition of quarry dust will used to 80 g/L.

iii. The data will be collect and analyse based on the surface morphology, wear rate, coefficient of friction and the performance during the process application.

1.5 Hypothesis and research questions

The deposition of nickel-quarry dust composite coating on tungsten carbide via electrodeposition method needs a dedicated study as it involves several different steps.

1. The addition of various compositions and size of quarry dust particles to the nickel matrix would affect the microstructure formation of the deposited nickel quarry dust composite coating.
2. Application of the heat treatment process on nickel-quarry dust composite coating may also influence the microstructure of the composite coating and interlayer between composite coating and substrate.
3. The resulting microstructure would affect the tribological, mechanical and hardness properties of the composite coating.

1.6 Research questions

There a few questions that need to be asked and answering along the research. The research questions to complete the process are as follows:

1. How does the nickel quarry dust composite coated cutting tool perform during machining?
2. What effect does the coating have on the cutter?
3. Does the cutting tool get better if it gets heat treatment process after being coated?
4. Which type of coating make the tool perform best nickel only or nickel and quarry dust composite?

CHAPTER 2

LITERATURE REVIEWS

2.1 Introduction

Machining operations are a tant to the manufacturing industry since the Industrial revolution. Machining is a process in which materials are disposed of using eye-tools and machinery to obtain the desired form of product with a good surface. Manufacturers strive to produce a maximum product with a minimum expenditure cost and achieve machining quality standards (RAO 2011).

Although cutting material is a long-lasting technique in the manufacturing process, the most basic features and results such as the life of the eye, cutting force, machine stowage and energy consumption are only done through experiments. As a result, many improvements occur to the tools, machinery and process design. However, it will require high costs and a long time. Some need to be sophisticated equipment and experienced personnel. As such, the strategy and design of experiments, data acquisition and development of the appropriate statistical model need to be more conducive in this experiment (Astakhov 2006).

The grinding process is influenced by the reallowed input and output specifications. Input machining process input is a variable that does not lean while the output result is relying on the input process (Alauddin et al. 1996; Rao 2011).

2.2 Machining process

Previous opinion says the deduction occurs when the formation of debris during the metal disposal process. It occurs when the applicable change of plastic shape on the workpiece is caused by conflicting movements between the eye-tool and the workpiece (Childs et al. 2000). For this metal cutting, it is different from the concept of cutting the blade when cutting the soft material in which the wedge-shaped instrument is forced in symmetry into the cut body (Trent & Wright 2000).

Merchants have built a complete first model in Flake formation, it involves the model plane RICIH, model change shape, the pace diagram model and power model known as the Merchant Power Spheres model (Astakhov 2006). The Model is used so that now that the formation of debris when machining is caused by the process of work materials due to the movement of the Eye-tool (Boothroyd & Knight 2006).

When it comes to contact with things, it requires more efforts to overcome the resistance of these works. In the early stages, the accumulated force will cause a change of shape on the work and to reject the surface of the eyes as fragments. This was due to the angle of contact. A strong and persistent pressure will lead to the Ricihan, the substance of the shear of the things and will reject the bendakerja to form the fragments (Schrader & Elshennawy 2000).

A critical border when cutting is called a shear plane, which is a line opposite the surface of the eyes. The pressure increased at the bottom of the line and the stress will spread at the top of the shear line. The power of the need is dependent on the shear direction of the material and the shear plane, if the angle of shear planes, small-and-needed force will increase. Likewise, the increase in the feed and cutting depth, T1 directly proportional to the Force (Trent & Wright 2000).

For the machining process, the work material is discarded through the rotating of the gadget. When the eyes are rotating, the occurrence is also an iterator between things and curling tools. Every tooth on the eyes will remove a small number of materials due to both the two movements (Rao 2011).

There are two methods of milling; Namely down-milling and also up-milling. Down-milling is the direction of the eyes of the gadget is the same as the direction of the feed while the cycle of the eyes is against the direction of the feed on grinding upward (Tschätsch 2008). Grinding down is arguably a better method than grinding upward, this is due to the discarded material starting with a larger volume and is getting narrowed during the eyes of the gadget. Grinding decreases produce a better surface neatness, less shaking, lower cutting force, low kapit force and lack of feed marks. This is due to the plastic flow of the material is in the direction of the tangent on each cut (Stephenson 1997).

Unlike the bullish machining where the surface abuse is poor due to the Gelatuk (Haynes International 2009). The heat generated will be higher and the debris are more likely to stick to each other, causing other effects that will arise against the eyes (Coromant 2010). However, the study by Kim et al. (2001) found grinding upward resulted in a more accurate surface accuracy than grinding down. This is due to the more rigid tools where producing low cutting force because the small cut depth is used in a range of 0.1-0.15 mm compared to the size of the diameter of the gadget.

2.3 Performance evaluation of Milling process

The performance of these devices is not only measured through cutting time and length of the points line in the standard condition of the acceptable tools, but also other outputs as stated in Figure 2.1 (Astakhov 2006). As such, there are many previous studies that diversify the cutting parameter. Among these parameters are cutting speed, feed rate, cutting depth, celak angle, lubricants and type of coating. The objective of the study was to find the most optimal set of combinations to produce life-span and abuse of good-engine surfaces. Sharif et al. (2006) reviewed the impact of cutting speed, feed rates and depth of cut in producing the longest lifespan. It is found that the contact angle will not have a big impact versus cutting speed and the feed rate.

However, the most popular in the milling is involving cutting speed, feed rate and depth of cut. This is to coincide with the Ezugwu et al. (2000) which found 80% of the eye-instrument performance is caused by these three factors. Previous investigations by Alauddin et al. (1995), Jawaid et al. (2001) and Thamizhmanii et al. (2009) have probing the endurance of the tools when the flattened blender. Other studies involving power have been undertaken by Alauddin et al. (1996) and Li et al. (2006). The impression of this power gives the impression of the thirsty mechanism carried out also by Liao et al. (2008) with a focus on the formation of debris when the Groove blender.

2.4 The effects of cutting speed on the life of the cutting tool

In general, at the high-cut speed of the mechanism of friction, iteration, oxidation, fatigue and more serious adhesion due to higher temperature increase (Shaw & Vyas 1998). At low speed, the dominant failure modes are wear friction, debris, cracks and fracture due to grounding between the spy and the things. At high speed, the points will become gentle, worn which occur due to the breaking of terms, the "wear kimiaterma where worn-in and oxidation occurs (Fenglian et al. 1998; Gu et al. 1999; Dolinsek et al. 2001; Ghani et al. 2004).

The advantage of high temperatures is that the shear plane, Ø will increase with a cutting speed increase. At the same time the distance between a shear plane cutting tool with the original surface will diminish, this makes the surface of the shear plane going to be small and will make the force resultant, Fr is low. The impact of cutting speed on the life of the points is shown in Figure 2.3 where the rib wear rate increases with the increase in the cut speed (Astakhov & Outeiro 2005).

2.5 Effects of feed rates on surface abuse

Savage & Chen (1999) in their studies on the differences of the diameter of the gadget, found that the rate of feed is more influence on the neatness surface than the diameter of the spectacer. Li et al. (2011) In his study found that the effects of 0.02 mm/tooth feed rates resulted in a low abuse effect (0.1 μm), however abuse were equivalent to 0.03-0.06 mm/dental where abuse was around 0.15 μm. Considerations for productivity are also important despite taking into account the surface neatness. Baek et al. (2001) in performing optimisation of feed rates (164 mm/min) When the grinding process finds the Ra increase is no iterations with the addition of FZ. With the maximum waste disposal rate, he only managed to produce surface neatness, Ra = 13 μm.

2.6 Cutting depth impact on surface roughness

The depth of cut can be divided into two parts, the depth of the axis (DOC), AP and WOC, AE which are even in the diameter of the eye-tool, D. According to the limits proposed by the ISO, the selection of the DOC axis and radius are as follows; If AE < 0.25 D, then AP > 0.25 D and if AE > 0.25 D, then ap < 0.25 D (ISO 8688-2 1989). But for high speed machining, both AP and AE should be less than D (Grzesik 2008).

The study by Li et al. (2011) found that the effect of WOC is not a significant abuse of surface, but the direction of the trend is declining with an increase of WOC. The widely used range is also between 0.2-2.2 mm, which produces a range of abuse between 0.09-0.15 μm. However, the gradient is relatively low as the 0.02 μm/mm show seems not influenced by WOC. This differs from the study by Bouzakis et al. (2003) using a ball eye in construction algorithm that found an increase in the surface abuse increases with an increase of WOC with a range between 0.1-0.6 μm.

2.7 High speed machining (HSM)

The concept of waste disposal process in the high speed State (HSM) is gaining attention in this decade due to a number of advantages (Haber et al. 2004). The advantages of HSM not only accelerate the machining that causes low cost and high productivity, but also produces high surface quality without needing the second process (Dolinsek et al. 2001). High speed machining is more suitable in the grinding process compared to the run, this is due to the kinematic mechanism difference between these two processes. At high speed the fragments become shorter and thinner than the Larik process. Furthermore, it is difficult to control the heavy work at high speeds than on the rotating parts (Tschätsch 2008).

There are varieties in the interpretation of High speed machining (HSM). Some of them think it is faster to cut faster than the normal speed for a material. The speed of HSM is 3-4 times faster than conventional speeds without affecting accuracy and quality. The definition adopted by the Research Centre at the University of Florida is HSM when the frequency of dental run approaches the dominant original frequency system (Leigh et al.

1999). This condition makes the revolving cycle in a stable state at maximum speed (Tlusty et al. 1996).

Opinion by (Sharman et al. 2001) says HSM generally is a high speed disconnection starting around 8000 RPM to 100,000 RPM. The cutting speed below the range is considered as a conventional disconnection speed. Chevrier et al. (2003) thinks HSM for steel is 500 m/min. However, the speed of the HSM cut varies by type of material. It is divided into three parts (normal range, transition range and high velocity range) as stated in Figure 2.4. The main advantage of HSM is to reduce the cut-off time, therefore, the temperature generation was low (Liao et al. 2008). Comparisons were done by Davoodi & Hosseinzadeh (2012) found a temperature generated less flowing into things (5-10%) Otherwise transferred through debris during a short cut-off time.

For grinding edges, the temperature generated is variable due to a deduction (Shaw 2005). Heat is formed on the main shear zone and the Geresan area at the rib surface. The temperature rises rapidly in this area. A micro structure change will occur several micrometers under the surface at a certain temperature (Rech et al. 2008). However, on high speed machining, the effect of residual stress is low, and it is in connection with low cutting force. This was due to the high speed cutting. the volume of the discarded material was small in order to produce the same volume of MRR (Delio 2010).

2.8 Performance of cutting tools

The selection of the cutting tool is very critical for the machining process. The ideal cutting tool is a tool that is capable of fulfilling three criteria. The first is that it can withstand the drain so that the edges of the eye-tool are not easily thirsty. It has low friction characteristics to avoid the formation of BUE. Secondly, it is a red-hard trait so that it can withstand high temperatures, the eye-side tools are not sued by an extreme temperature when machining is performed. It has a high heat flow so that the temperature is not centered on the cutting zone. A third feature is the strength of the eyelash-tool, in which the edge-tool's eyelash ability survives upwards by the power imposed. It also needs to be able to withstand the enactment of form changes, the moaning, vibration and inalignment (Stephenson 1997; Walker 2004; Davim & Astakhov 2008).

The use of single tools is practical in grinding experiments to reduce experimental costs. This approach was widely adopted by former researchers. This is due to the use of the number of points that will increase the rib wear. The heat generated is higher due to the frequency of the items to contact with work. These results differ on grinding experiments with single-used tools that produce lower temperatures. This was due to shorter cut times than idle time rounds when a turn occurred (Richetti et al. 2004). In general, the Poli-hablzation Diamonds (PCD) and the boron nitic Kubic (CBN) are only mempunyai satu pinggir pemotong disebabkan oleh kos unit yang tinggi, manakala bentuk empat segi tepat adalah 2 – 4 penjuru. Segi empat sama mempunyai lebih banyak sehingga 8 penjuru. Mata-alat bebola secara teorinya adalah tidak terhad, walau bagaimanapun, pengeluar telah menghadkan hanya kepada 8 penjuru (Sumitomo Electric Carbide Inc. 2009).

2.9 Cutting tool geometry

The cutting geometry needs to be taken into effect in affecting the lifespan of the eye-appliance and the packing of the machine surface. Ezugwu et al. (1999) In his review he found that the quadrilonal eye-shaped tool performance was lower than the rounded and rectangular shape in the same machining state. This is due to the large sadak angle of the rounded eye-shaped tool making it more resistant to resistance. This makes a lower focus