RESEARCH REPORT UMP GRANT

Laporan Prestasi Skim Geran UMP

Final	√	Progress		*Progress Period : Final*	*√ Please tick*

PROJECT DETAILS *(Keterangan Projek)*

A	**Grant No**	RDU1703253
	Faculty/CoE	FAKULTI TEKNOLOGI KEJURUTERAAN PEMBUATAN DAN MEKATRONIK
	Project Title	STUDY OF AN OPTIMAL SURFACE PROPERTY OF CARBIDE CUTTING TOOL BY SURFACE MODIFICATION METHOD
	Project Leader	DR. MOHD NIZAR BIN MHD RAZALI
	Project Member	1. ZAMZURI BIN HAMEDON 2. AHMAD RAZLAN BIN YUSOFF 3. SYARIFAH NUR AQIDA BINTI SYED AHMAD 4. AHMAD REDZA BIN AHMAD MOKHTAR 5. AHMAD SHAHIR BIN JAMALUDIN

PROJECT ACHIEVEMENT *(Pencapaian Projek)*

B

ACHIEVEMENT PERCENTAGE				
Project progress according to milestones achieved up to this period	**0 - 25%**	**26 - 50%**	**51 - 75%**	**76 - 100%**
Percentage (please state %)				√

EXPENDITURE *(Perbelanjaan)*

C

Budget Approved *Peruntukan diluluskan*	**Amount Spent** *Jumlah Perbelanjaan*	**Balance** *Baki*	**% of Amount Spent** *Peratusan Belanja*
RM 20500.00	**RM 20000**	**RM32**	**99.8%**

RESEARCH OUTPUT *(Output Penyelidikan)*

D

NO OF PUBLICATION

KPI FOR NO OF PUBLICATION

	ISI	Scopus	Index Proceedings	Others
KPI	**0**	**1**	**1**	**2**
Achievement	**0**	**1**	**1**	**2**

The contribution of funder (UMP, MOHE, MOSTI, Industry etc.) as the fund provider must be acknowledged at all times in all forms of publications. Please state the grant number (RDU/UIC) and grant name.

	ISI	**Scopus**
Number of articles/ manuscripts/books *(Please attach the First Page of Publication)*	1. 2.	1. Rosli A.M., Jamaludin A.S., Razali M.N.M., Sani A.S.A., Hamzah S.B., Osman M.S. (2020) Modelling of Fuzzy Inference System for Micro

		Milling—A Preliminary Study Through FEM. RITA 2018, Lecture Notes in Mechanical Engineering. Springer, pp 445-456
Conference Proceeding *(Please attach the First Page of Publication)*	**International**	**National**
		1. Modelling of fuzzy inference system for micro milling - a preliminary study through FEM,THE 6TH INTERNATIONAL CONFERENCE ON ROBOT INTELLIGENCE TECHNOLOGY AND APPLICATIONS 2018 2. Dip-coating methods for carbon membrane fabrication: Effects of coating-carbonization-cycles on Hydrogen separation prepared from BTDA-TDI/MDI (P-84) polyimide blends with Nanocrystalline cellulose (NCC), 4TH INTERNATIONAL MANUFACTURING ENGINEERING CONFERENCE (IMEC) 2019 3. A comprehensive review and perception of carbon molecular sieve membranes for hydrogen production and purification, ENERGY SECURITY AND CHEMICAL ENGINEERING CONGRESS (ESCHE) 2019

HUMAN CAPITAL DEVELOPMENT

KPI FOR HUMAN CAPITAL DEVELOPMENT

	PhD Student	Master Student
KPI	**0**	**0**
Achievement	0	**0**

Human Capital Development	**Number**				**Others** (please specify)
	On-going		**Graduated**		
Citizen	Malaysian	Non Malaysian	Malaysian	Non Malaysian	
PhD Student					
Masters Student					
Undergraduate Student					
Total					

Name of Student: **ID Matric No:** **Faculty:** **Thesis title:** **Graduation Year:** **Name of Student:** **ID Matric No:** **Faculty:**	

	Thesis title: **Graduation Year:** *** enter for more space*	
	INTELECTUAL PROPERTIES	
	KPI FOR INTELECTUAL PROPERTIES Patent, Copyright, Trademark,Industrial Design: ___________	
	Patent, Copyright, Trademark, Industrial Design ect	
	OTHERS	
	KPI FOR OTHERS Prototype, Technology,Collaborations etc: ___________	
	Prototype, Technology, Collaborations etc	

ASSET *(Aset)*

E

Bil	**Peralatan** *(Equipment)*	**Model**	**No Daftar Aset** *(Asset Tagging No)*	**Amount** (RM)	**Lokasi** *(Location)*

PRODUCT DESCRIPTION FOR UMP R&D DIRECTORY (SHORT & BRIEF) *Only for Final Report*

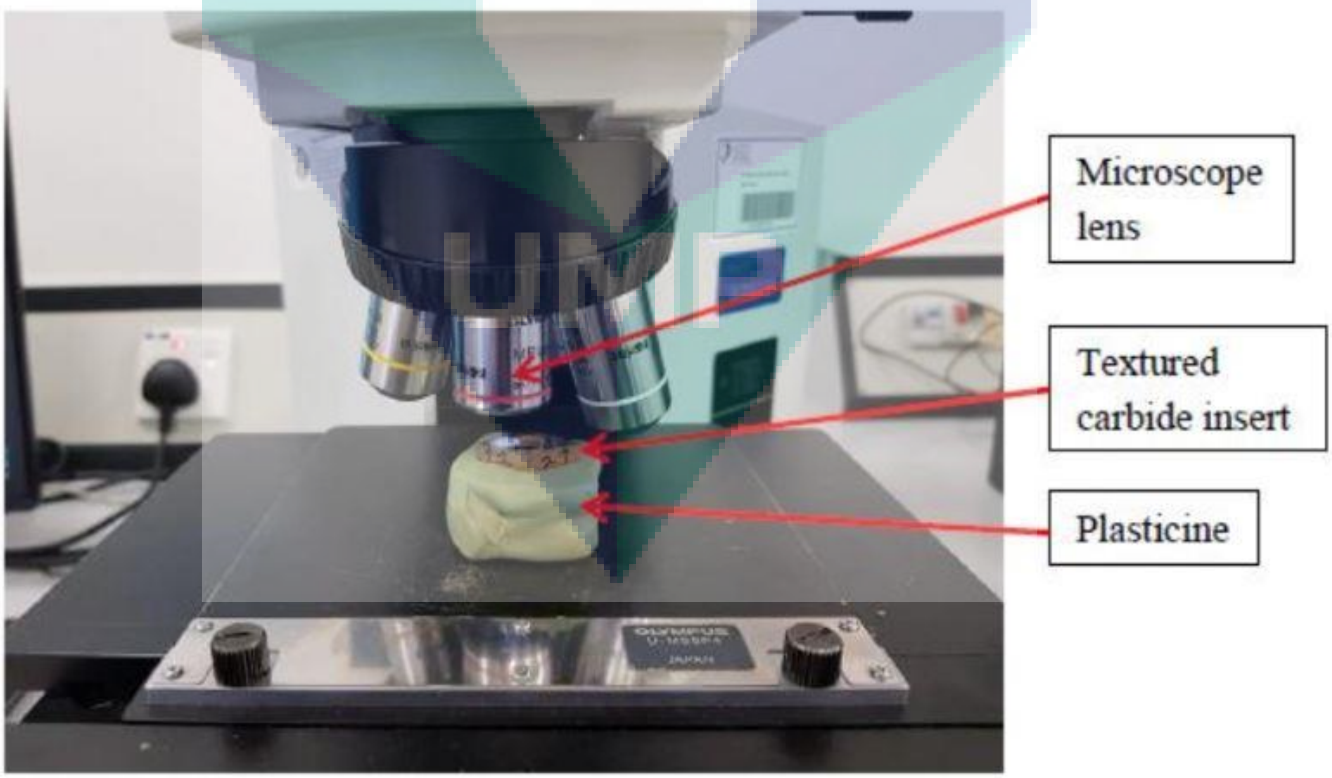
F

Grinding process was capable to fabricate textures on carbide insert which were then effective to improve anti-adhesive behavior of aluminum alloy. A higher speed of reciprocating work table and a lower depth of cut resulted in larger roughness of textures on carbide insert rake surface. This large roughness of texture had higher possibility to perform as lubricant reservoirs to reduce cutting friction in turning process. And thus the adhesive behavior of aluminum alloy was coped too. Additionally, the results clearly indicated that textured carbide insert performed relatively better on minifying the aluminum alloy adhesion than non-textured carbide insert during turning process. In dry cutting condition, textured carbide insert offered less aluminum alloy adhesion with low cutting speed and depth of cut. In wet cutting condition, the aluminum alloy adhesion could only be reduced with high cutting speed and depth of cut. For non-textured carbide insert, a set of low cutting parameters was preferable to contribute less aluminum alloy adhesion. However, the presence of lubricant was highly effective to minimize the adhesion for non-textured carbide insert. It not only acts as reservoir to retain lubricant at the textures but also reduce the actual contact at tool-chip interface. These results were corresponding to the research studied by Rathod et al. (2016). Textured carbide insert was valid to reduce cutting force, friction force, and material adhesion during machining process especially when lubricant or coolant was being applied.

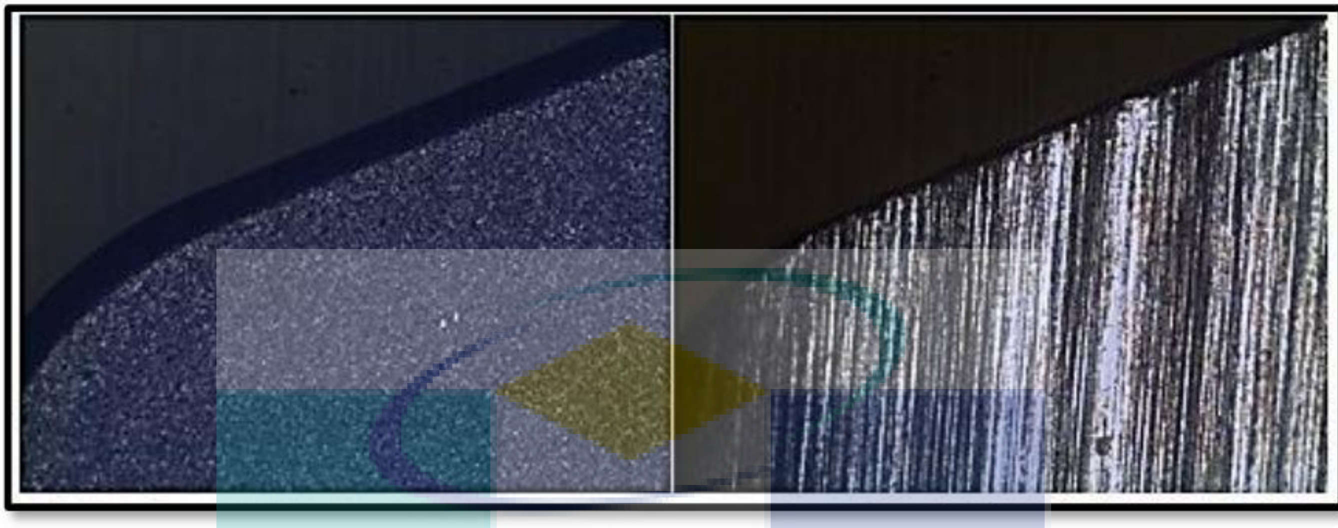
PRODUCT PICTURE FOR UMP R&D DIRECTORY *Only for Final Report*

G

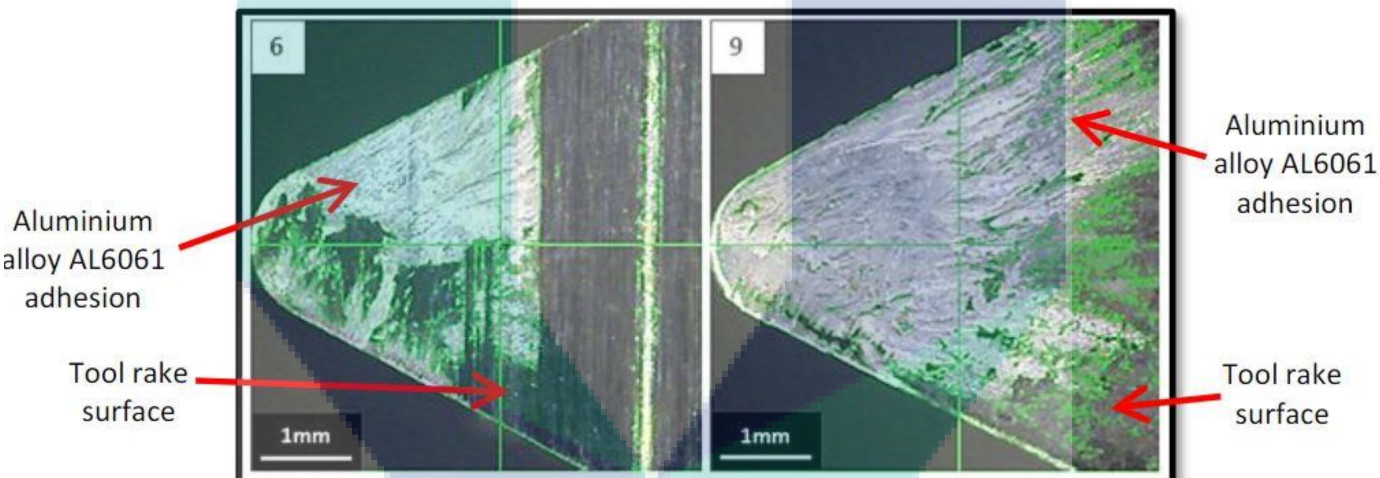
Surface texturing by grinding process



Texture on tool rake surface observation process



Rake surface of carbide insert before(left–smooth surface) and after(right–rough surface) being textured viagrinding process



Condition of aluminum alloy material adhesion on textured [Exp 6 -left] and non-textured carbide insert after turning test[Exp 9 –right]

SUMMARY OF RESEARCH FINDINGS (*Ringkasan Penemuan Projek Penyelidikan)*

H

1. Grinding and laser surface machining process was capable to fabricate textures on carbide insert which were then effective to improve anti-adhesive behaviourof aluminium alloy Al6061.
2. A higher speed of reciprocating work table and a lower depth of cut resulted in larger roughness of textures on carbide insert rake surface.
3. This large roughness of texture had higher possibility to perform as lubricant reservoirs to reduce cutting friction in turning process. And thus the adhesive behaviourof aluminium alloy Al6061 was coped too.
4. Additionally, the results clearly indicated that textured carbide insert performed relatively better on minifying the aluminium alloy Al6061 adhesion than non-textured carbide insert during turning process.
5. In dry cutting condition, textured carbide insert offered less aluminium alloy Al6061 adhesion with low cutting speed and depth of cut. In wet cutting condition, the aluminium alloy Al6061 adhesion could only be reduced with high cutting speed and depth of cut.

	6. For non-textured carbide insert, a set of low cutting parameters was preferable to contribute less aluminiumalloy adhesion. However, the presence of lubricant was highly effective to minimize the adhesion for non-textured carbide insert. 7. It not only acts as reservoir to retain lubricant at the textures but also reduce the actual contact at tool-chip interface. 8. Textured carbide insert was valid to reduce cutting force, friction force, and material adhesion during machining process especially when lubricant or coolant was being applied.
PROBLEMS / CONSTRAINTS IF ANY *(Masalah/ Kekangan sekiranya ada)*	
I	
Date : *Tarikh* 3 Disember 2019	**Project Leader's Signature:** *Tandatangan Ketua Projek*
COMMENTS, IF ANY/ ENDORSEMENT BY FACULTY (*Komen, sekiranya ada / Pengesahan oleh Fakulti)*	
J	**Recommend / Not Recommend / KIV / Need Ammendment** .... **Name:** *Nama:* **Signature:** *Tandatangan:* **Date:** *Tarikh:* **** Dean/TDR/Director/Deputy Director**
COMMENTS, IF ANY/ ENDORSEMENT BY RMC PNI (*Komen, sekiranya ada / Pengesahan oleh RMC PNI)*	

K	**Recommend / Not Recommend / KIV / Need Ammendment** .... **Name:** *Nama:* **Date:** *Tarikh:* **Signature:** *Tandatangan:*

STUDY OF AN OPTIMAL SURFACE PROPERTY OF CARBIDE CUTTING TOOL BY SURFACE MODIFICATION METHOD

MOHD NIZAR BIN MHD RAZALI

RESEARCH VOTE:
RDU1703253

Faculty of Manufacturing and Mechatronic Engineering Technology (FTKPM)
Universiti Malaysia Pahang

2019

ACKNOWLEDGEMENTS

The author would also like to acknowledge Universiti Malaysia Pahang for providing the financial support for the study to be success. The author hopes that the study is going to provide the motivation and knowledge for the future study can be extend over the same study field.

ABSTRACT

This thesis introduces the effect of textures on carbide insert rake surface to the surface roughness on using laser surface texturing. Surface texturing is one of the techniques for enhancing tribological properties of mechanical components. This is also widely used which contributes a lot in numerous engineering applications. Various parameters of pattern have been used to improve tribological performance. Parallel grooves has been used because able to trap wear debris, change stress distribution and low surface roughness. The fabrication of textures on carbide insert surface is one of the predominant methods to enhance the sustainability of laser process with cemented carbide insert. Laser process was utilized using CK-FB3D 3-Axis Control fiber laser marker to fabricate textures that were effective use to cut the tool. Olympus BX51M metallurgical microscope was using to check condition of the rake surface carbide insert. After that, depth of cut of the laser on the carbide insert was investigate using video measuring system. Furthermore, the surface roughness was utilized using surface roughness tester. Carbide insert has been tested using four parameters and found that relatively low scanning speed and frequency resulted in less surface roughness for textured carbide insert. Low surface roughness was discovered because high hardness of the carbide insert would make the less friction when cutting the tool.

ABSTRAK

Tesis ini memperkenalkan kesan tekstur pada permukaan sisipan karbida ke peralihan geseran aloi aluminium. Aloi aluminium adalah bahan yang digunakan secara meluas yang menyumbang banyak dalam aplikasi kejuruteraan. Kadangkala, kelakuan pelekatnya menghalang operasi pemesinan dalam bidang pembuatan. Pembuatan tekstur pada permukaan sisipan karbida adalah salah satu kaedah utama untuk meningkatkan kelangsungan proses berpaling dengan sekeping kerja aloi aluminium. Proses pengisaran telah digunakan dengan mesin pengisar permukaan Okamoto ACC52ST untuk mengarang tekstur yang berkesan untuk mengekalkan pelincir dan mengurangkan geseran pada antara muka alat-cip. Proses pengaliran dilakukan dengan menggunakan mesin bubut ROMI C420 untuk menyiasat kelakuan pelekat aloi aluminium dan memakai alat sisipan karbida. Tingkah laku pelekat aloi aluminium telah diminimumkan dengan penggunaan sisipan karbida bertekstur terutamanya dalam keadaan pemotongan basah. Kelajuan pemotongan yang agak tinggi dan kedalaman pemotongan mengakibatkan lekatan aloi aluminium yang kurang untuk sisipan karbida bertekstur dalam keadaan pemotongan basah. Untuk sisipan karbida tiada tekstur, lekatan aloi aluminium berkurangan dengan penurunan kelajuan pemotongan dan kedalaman pemotongan dalam keadaan pemotongan basah. Tambahan pula, ketebalan cip didapati berkurangan kerana kelajuan pemotongan dan kedalaman potongan meningkat. Pakai alat ini dapat dikurangkan dengan kehadiran pelumas semasa proses berputar.

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LIST OF SYMBOLS

K	Surface texture
	Wear volume
t	Temporal variable
f	Normal load
L	Length
F	Oscillating frequency
µm	Micrometer
D	Gap width
g	Gram
H	Height
Ø	Diameter
α	Angle
	Normal or tangential

LIST OF ABBREVIATIONS

3D	Three-Dimensional
AISI	American Iron And Steel Institute
BUE	Build-Up-Edge
CNC	Computer Numerical Control
DOE	Design Of Experiment
ECM	Electrochemical Machining
EDM	Electron Discharge Machining
FIB	Focused Ion Beam
LCD	Liquid Crystal Display
OCM	Orthogonal Cutting Method
PCBN	Polycrystalline Cubic Boron Nitride
SEM	Scanning Electron Microscope
UHC-steel	Ultra High Carbon Steel
WC-Co	Tungsten Carbide Cobalt
WEDM	Wire-Cut Electrical Discharge Machining

CHAPTER 1

INTRODUCTION

This chapter will explain the overview and the purpose of thesis study. The induction chapter includes the background of the study, problem statement, objectives and the scope of the research work.

1.1 RESEARCH BACKGROUND

Surface texture to examine friction and wear has been the focus of several studies in the last few decades. Surface texture is the characteristic or consistency of a surface. It is also known as surface topography which consist three characteristic such as roughness. Furthermore, surface topography is defined by surface orientation and roughness as well as topical deviations and inaccurate tendency of a surface from verity plane that appears like absolutely flat by naked eyes. Something like glasses it can looks glossy and smooth for their surface but practically there are variety numerous distortions on the surface under a magnifying glass using magnifying equipment. When we studied in physics, there is resistance force in between two surfaces that is in wrong way to the motion. This resistance is affected or controlled by the varied roughness of surface texture, (Gajrani, Suresh, & Sankar, 2018). In other word, we can hold a glass bottle strongly without slipping.

As can be seen from the discussion above, many forms of surface texturing can be used for enhancing tribological performance. However, laser surface texturing is the one of the method that easy to use, easy to control, fast and clean to the environment. (Saeidi, Parlinska-Wojtan, Hoffmann, & Wasmer, 2017)

Generally, different laser surface texturing result in different designs for a surface. Build regular micro-structure can be obtained in the form of micro-dimples on the outward appearances. Both hypothetically and the theoretically can be describe the micro-dimples by using laser surface texturing. As in reservoir for lubricant of starved lubricant surrounding, the microhydrodynamic behaviour in discussion can serve each micro-dimple. The surface texture on cutting tools affects the precision of the machining process too, and yet the microstructure of the work piece being cut provides to the final surface roughness.

At the end pf this process, to produce different dimensions and patterns of surface texture on cutting tools, there are various manufacturing methods for improving tribological performance by using laser surfaces texturing.

1.2 PROBLEM STATEMENT

There are a few problems in this experiment to improve the performances. Firstly, laser is a process used for finishing process. Laser process without undergo finishing process cannot accomplish great quality. Laser is a process to maintain quality but this process cannot get constant surface. Problem always occur during laser process when carbide is burning. It is contribution from the excessive temperature of the work piece during laser. Due to this problem, this investigation cannot get the desire surface finish and accurate dimensional. Further study will be required how the laser can be textured to take care of this issue. (Su, Zhou, Zhang, et al., 2018)

Other than laser, design also one of the problem that affects improvement of the performance in this experiment. This is because every design has their adhesion. The design on the carbide insert will be investigated as one of the critical issue to result different textures. Different designs will be fabricate on the carbide insert by using laser surface textured. This method allows us to enhance the strength of adhesively bonded joints and may reduce stress concentration problem. (F. Moronia, L. Romolia, & Khan, 2016)

1.3 OBJECTIVES

The objectives of this project are:

I. To investigate cutting performance of the laser textured on the carbide insert.
II. To compare the behaviour in different parameter textured design of the carbide insert.

1.4 PROJECT SCOPE

The scope of this project includes the investigation of surface textures on cemented carbide insert to the aluminium alloy through laser surface texturing. Before the investigation the carbide insert should be fabricate first. Laser surfaces texturing process is selected to be approach for fabricating textures on the turning carbide insert in order to give micro-scale transformations to the rake surface texture without making important change to the geometric dimensions, (Obeidi, McCarthy, Kailas, & Brabazon, 2018) .

This research will investigate and compare the designs of grinding to the rake surface texture fabricated on the turning carbide insert. The rake surfaces of turning carbide insert will be laser using the laser surface texturing with different design. According to (Rong Meng, Jianxin Deng, Yayun Liu, Ran Duan, & Zhang, 2017) different design in laser will generate surface texture which is micro-grids, micro-dimples and micro-grooves. The surface textures after laser process will be investigated using laser surface texturing. The impact of the surface textures on the turning carbide insert will then be investigated by managing the turning process with aluminium alloy. After turning process, the condition of the carbide insert rake surface will be investigated using laser surfaces texturing. The adhesion of the aluminium alloy material will be investigated too. Any wear and the percentage of the total area of design with adhesion on the rake surface of carbide inserts will be the results for this paper. This result should be estimated to complete the objectives of this research.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The essential point of this chapter is to investigate and provide relating knowledge to this project by reviewing different definition and process. All the researches prepared by the researches were reviewed. This literature review find out academic articles, journals, books, papers, and other decent articles which are relevant to the research of this project. It contribute to this paper by distinguishing past research. This chapter also helps to discover and to identified the proper technique which applicable to this project. Additionally, the design of surface texture, hardness of material, surface texture on carbide insert manufactured by laser surface texturing, surface finish on aluminium alloy after turning process, and tool wear of finished carbide insert after turning process were assessed in this chapter.

2.2 MECHANICS OF METAL CUTTING

In this section, fundamental of metal cutting will be overviewed as well as the theories and previous works related to finite-element analysis on cutting process will be explained. In the metal cutting analysis, there are two types of cutting model commonly utilized, which are called as orthogonal and oblique cutting. During the orthogonal cutting, the chip is removed by the cutting edge which is parallel to the uncut surface in Figure 2.1. Meanwhile, in the oblique cutting, the chip is removed by cutting edge that is inclined with an inclination angle in the direction of the tool feed and the work feed Figure 2.2.

Most of conventional machining process is considered as oblique cutting, but, orthogonal cutting has been extensively utilized during analysis due to its simplicity and easier to be understood, when equivalent chip formation is taken into assumption for both cutting model.

The continuity from metal cutting may be associated with surface roughness to improve tribological performance on the work piece and tools. The roughness is the most important role in determining how real the object interacts with environment. Also, the value of angle give effect on surface roughness. The metal cutting process can cause vibrate and changeable forces produced by the tool. Besides, roughness is an essential factor in tribology as it determines the quality of the outer layer and evaluates the cutting process. (Gachot, Rosenkranz, Hsu, & Costa, 2017)

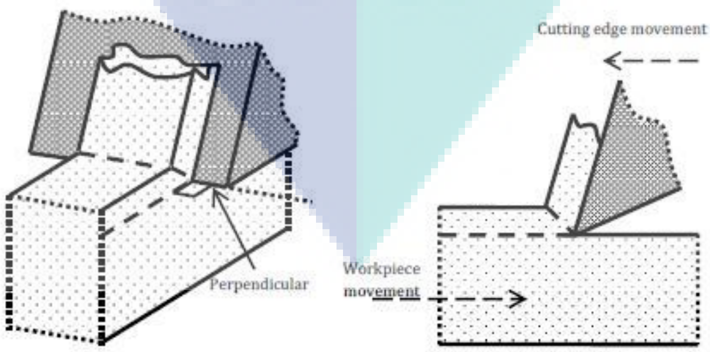


Fig. 2.1 Orthogonal cutting

Source: Minimum Quantity Lubricant (2017)

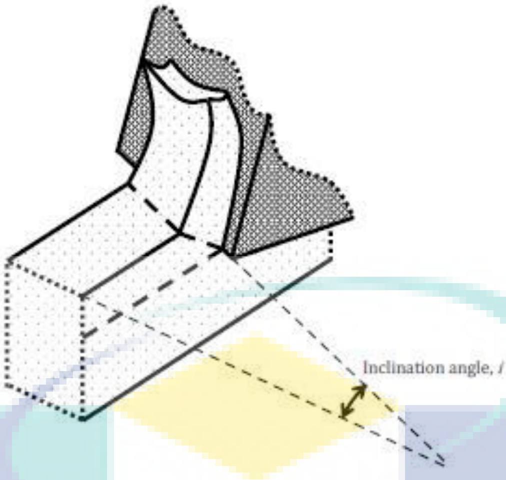


Fig. 2.2 Oblique cutting

Source: Minimum Quantity Lubricant (2017)

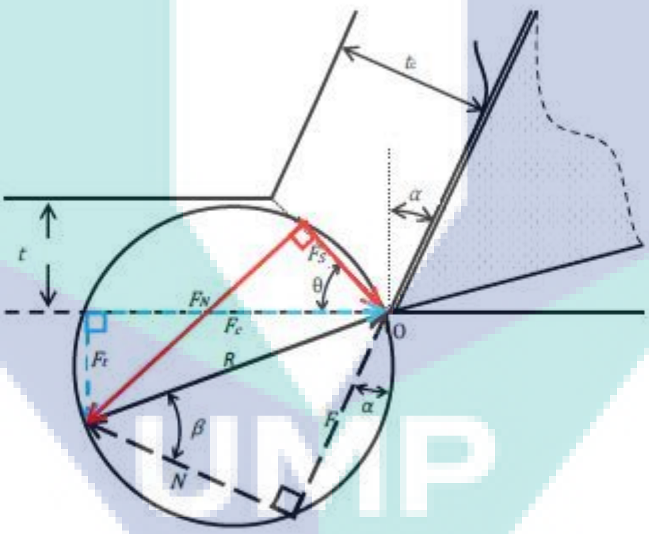


Fig. 2.3 Merchant thin zone model and force diagram

Source: Minimum Quantity Lubricant (2017)

2.3 TRIBOLOGICAL PERFORMANCE BETWEEN TOOL AND WORKPIECE

It is well known that surface finishing method can be used in improving tribological performance of manufactured parts for decades. Much research and analysis were done to study tribology performance, and a number of different techniques are proposed, such as etching method, electron beam texturing, and laser texturing. Several studies had proven that the existence of micro-asperities had a significant effect onto micro-hydrodynamic over the material surface. This phenomenon is supported by the considerable improvement observed on an aluminium component surface with micro dimples that was produced through the laser surface textured (LST). There are several method and techniques to produce surface texture, such as surface grinding, turning, etching, etc. However, laser surface texture (LST) method offers the foremost encouraging results. This is due to, texturing by laser excessively fast, clean, and easy to control the micro-dimples' shape and size. In contrast, more study is needed to enhance the application of LST in improving tribological performance between tool and work piece, (Rong Meng et al., 2017).

2.4 GRINDING PROCESS ON CARBIDE INSERT

Recently, researchers were investigated and finding out regarding one of the critical problems, which is definitely sustainable machining. Machining operations are wide used for cutting fluids or lubricants to counteract the friction and heat produced throughout the operations which are not encouraged to be used because of its chemical properties. These chemical properties not only increase the overall operations costs, and yet bring negative environmental effects. These are terribly harmful substances that required to avoid from destroying the environment during the operations, (Xu et al., 2017).

To date, several studies have investigated that the surface cutting has been textured in micro scale by using grinding process in order to improve the tribological performance at the tool-work piece surfaces and therefore, the machining performance. According to (Sedlaček, Podgornik, Ramalho, & Česnik, 2017) and (Su, Zhou, Sui, et al., 2018) have utilized an uncoated cemented carbide insert to be grinded with micro-depth on its rake surface using diamond grinding wheel. Additionally, the grit size of grinding wheel is one of the essential elements in grinding process to affect the surface roughness and texture. If the higher surface roughness was increased which up to 2.035 µm, a lower grit size of grinding wheel is produced, but it is possible to be create by using a small grit size. This method has been used to cut the edge of carbide insert, which located in a direction of parallel in grinding wheel inside a tolerance angle of ± 10˚. After all, the grinding depth of cut and grinding wheel speed not have a parameter in any analysis.

(Sui, Cui, Lin, & Zhang, 2018) and (Mao, Siddaiah, Menezes, & Liao, 2018) stated several ways currently exist for the cutting speed and feed rate for the investigation which is considered as parameters when using the same type of inserts. A five-axis grinding machine with maximum rotational speed of 1625 rpm has been used that required to predict and influence of an experiment. Moreover, different size of grinding wheel was investigated by controlling the grinding parameters with surface quality, which is the lower grain size of grinding wheel. The great surface quality of insert would be manufactured this technique and method was same with another research that evaluated the surface quality of inserts by measuring the average surface roughness.

In addition, feed speed increased the single-chip thickness and found the small when the cutting speed increases as well as the feed speed and cutting speed also slightly influenced the edge chipping. To be conclude, the feed speed and cutting speed not only respect for the magnitude of grain wear, but also to the kinematic relationship. Their variations in the surface quality of insert are affected during these techniques.

Besides, (Speidel et al., 2016) and here is another factor in grinding process that evaluated to influence the surface integrity of hard metals like WC-Co cemented carbide cutting tools. It altered the surface of cemented carbide within a micro scale-thickness by phase transforming, micro-cracking, and residual stresses. The rough grains at the wheel surface can act as cutting tools when the grinding wheel was rotating at high speed to touch and rubbed the surface of cemented carbide. From the rough grains to cemented carbide grains, it will lead both the tensile stresses and compressive residual stresses. Besides, the friction between the wheel surface and cemented carbide surfaces will increase due to the heat was emerged. The surface of cemented carbide will deform plastically or crack with these three critical factors that may be observed in a focused ion beam (FIB).

2.5 LASER SURFACE TEXTURING IN CARBIDE INSERT

For the time being, laser surface texturing is that the one in every of the difficult problems that researchers are work incessantly. Chemical properties that wide used for machining operations to counteract the friction and warmth can made throughout the operations such as cutting fluid or any lubricants that not aided to be used.

Based on (Etsion, 2004), plenty of in-depth theoretical and experimental studies were followed the experiments of Laser Surface Texturing in carbide insert were followed by the experiments of Laser Surface Texturing in carbide insert. The LST measure the dimples diameter, depth and are density is the three characterize in the LST. One of the dimple diameter is of the order of 100 is shown in figure, the density is about 20% and therefore the depth is of the order of 10 . Reynolds equation was established on resolution the modelling for the hydrodynamics pressure and find the common pressure at intervals the sealing dam for diverse operational conditions. Additionally, bulges area shaped round the dimples rim and must be discharged by final covering throughout the laser surface texturing process. For the ideal performance is that the allocation of the dimple depth over diameter was found the foremost import parameter. From the observation a high stiffness of the fluid film is determined below a clearance of 1 is an awfully sensible agreement between theory and experiment was obtained. It must do any testing of actual seals in water at 3600 rpm by one in every of the most important seal makers, energy consumption and energy consumption to point out dramatic reduction in friction force.

Figure 2.4: Micro-dimples structures in micro-surfaces structures

Source: (Etsion, 2004)

A specific experiment was advance that increase hydrostatic result in high-pressure adhesives or aggressive adhesive to defeat the poor performance at high-pressure. One in every of this treatment also is exploit treatment remaining portion non-textured and better density laser surface texturing over a little of the sealing dam adjacent to the high-pressure side. The various between the complete laser surface texturing treatment was demonstrates in figure shown. The partial Laser Surface Texturing manufactures sturdy lower friction torque compared to the non-textured seals can be seen. (Ye, Wu, Ren, Zhou, & Li, 2018) .

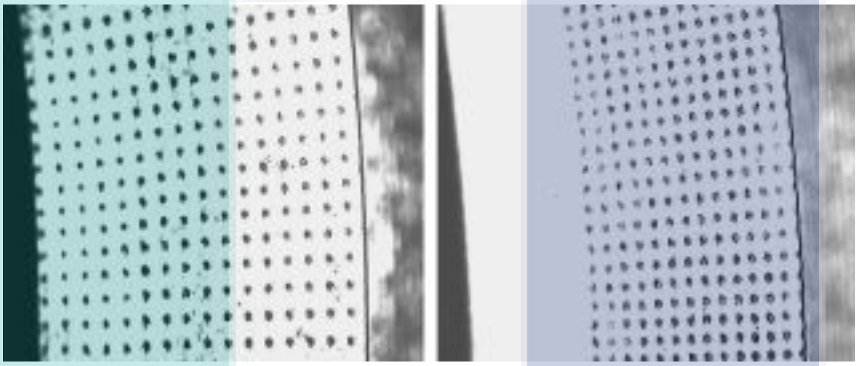


Figure 2.5: Seal ring partial (right) and full (left) face laser texturing

Source:(Etsion, 2004)

As may be seen, liquid lubricants solely and dry gas seals will advance from LST likewise which is the one of the advantages of Laser Surface Texture that are not finite. During a gas application is way smaller than in a liquid application, the most distinction is that the perfect dimple depth over diameter ratio. Moreover, completely different design of carbide insert was investigated by surface quality of insert which is controlling the laser parameters. The result of texturing on tribological performance micro-grooves, micro-grids and micro-dimples was resemble and analyse by fabricate laser surface texturing. The texture parameters of the laser surface and the characteristic are shown.

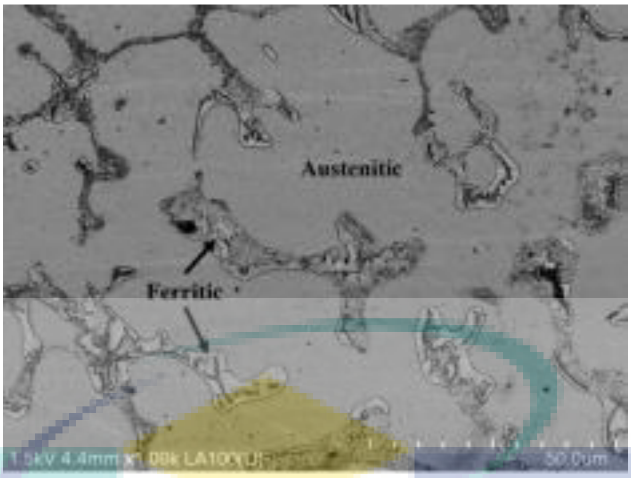


Figure 2.6: Microstructure of the as-received specimen

Source: (Lu, Zhang, Guan, & Zheng, 2018)

Additionally, micro-grooves, micro-grids and micro dimples may be observed by mistreatment micro dimples with the diameter of and spacing of that are classified often on the surface in (Lu et al., 2018) and (Qu, Gong, Yang, Cai, & Sun, 2018). The depth of textures is about for all the laser-textured.

The first stage, lower friction coefficient of laser surfaces at textured sample in tungsten carbide. Around the micro-grooves, micro grids and micro dimples there seems bulges, which lead to the rough surface, then the friction coefficient of laser textured surface has been bigger than tungsten carbide that clearly smaller. When the initial stage throughout slippery methods the friction constant of the textures are slowly a decrease as the bulges wear out. It has no ability of stable gear wear trash as a result of COF increase rapidly for the carbide tungsten surface. To resistance during the sliding process for the laser-textured surfaces which leads the contact area is decreased.

Thus, by using this equation the wear and tear resistance of the tungsten carbide, laser surface textured and the wear rate was calculated:

$$K = \frac{V}{0.002 \times t \times f \times L \times F} \longrightarrow \quad 1$$

Where L is length of stroke, V is the wear volume (mm^3), f is oscillating frequency (Hz), F is the normal load (N) and t is the temporal variable. (Lu et al., 2018).

According to (F. Moronia et al., 2016) laser surface texture was strongly established as an abrasive machining process. Cutting tools authentically was computed to influence the surface integrity of hard metals such as Wc-Co tungsten carbide. Within a micro scale-thickness by phase transforming, micro- cracking and residual stresses was transformed the surface of tungsten carbide. From the abrasive grains to the tungsten carbide grains it led both the tensile stresses and compressive residual stresses. In addition, heat will be turned up as the friction between the laser and tungsten carbide surface increase. The surface of tungsten carbide will distort plastically or crack with these three critical factors. The comparatively laser may overspread the surface with the pulverized tungsten carbide grains or partially removed from the surface as tungsten carbide grain fragments.

Relevant improvement in load capability, wear resistance and friction coefficient is some of characteristic tribological mechanical elements. By designing a regular micro-surfaces arrangement may be obtained to form the micro-dimples on their surfaces which might be depicted by laser surface texturing technique to supply micro-dimples. On improving the tribological performance the depth, shape, pattern and density of dimples will rely on accomplish of surface texturing. The very important role by managing those conditions is speed, lubricants controls and load. Supported the geometrical features to complete maximum triblogical performance, the adjustment of the basic texture shapes is commonly applied, (Uddin & Liu, 2016) and (Obeidi et al., 2018). As an example, the foremost distinguished geometrical parameter was the dimple space density, followed by the dimple diameter and therefor the dimple depth that urged.

2.6 LASER SURFACE TEXTURING ON WORK PIECE

Besides cutting tools such as carbide insert, metal work pieces can be laser surface texturing in order to create surface textures. These surface textures were generated to enhance the tribological properties of frictional surfaces. An investigate was conducted by (Qiu & Khonsari, 2011) to improve and compare the analytical and simulation effects of textures via laser surface texture on the surface of AISI 1045 normalized steel work pieces.

Another assumption. (Pardal et al., 2017) and (Saeidi et al., 2017), make a research with the point to enlargement best tensile shear. This looks enabled a rise of the bonding area of the joints because in the gaps of the texture was filled with the molten aluminium, usually leads to the growth of the intermetallic compound that while not the extremity of the increasing the process energy. (Pardal et al., 2017) It said the bonding are between the Al make laser surface changed the behaviors, but also treated on the aluminium not aluminium not only adjusted the thermal field beyond the samples. The aluminium after laser surface texture was measured the fracture surfaces.

Bonding area was determined in the research. The fracture surfaces displayed a black area part, two distinct and a bright surface part. Laser in AISI 1045 aluminium can be commented in resistance. The surface of the aluminium embraced an expressive amount of Al can be founded, where the black area in the centre was perceived in Al. The fracture produced over the aluminium located on a surface region was recommended.

Figure 2.7: Black area part, two distinct and a bright surface part Al after laser surface texturing.

Source: (Pardal et al., 2017)

2.7 DEVELOPMENT OF SURFACE TEXTURES ON CARBIDE INSERT

(Tatsuya Sugihara, 2016) states that methodology intensified the tribological properties of cemented carbide insert surface has accepted much abundant attention by surface texturing. However, it has been troublesome to search out effective texture's patterns and dimensions on a tool surface. Even though, sufficient texture is obtained by trial and error. In such a way that to conquer all this problem, different dimensions and design, generated on the tool rake face will develop cutting tools with dimples-shaped textures.

According to (Bharatish, Harish, Bathe, Senthilselvan, & Soundarapandian, 2018), it extremely found result in creation of micro-dimples structure and grooves has great patterns among others by using impulse burnishing technique. Whereas, (Qiu & Khonsari, 2011) said that micro-dimples had great surface area other than parallel line and channels which might design with completely different density, depth and size. Nevertheless, it also said that operational speed affected the strong of micro-dimples in cemented carbide insert. Furthermore, (Qiu & Khonsari, 2011) proposed another analysis the dimple was created in cemented carbide insert has to provide load carrying support and lower surfaces wear and it can also trap the wear debris during operation.

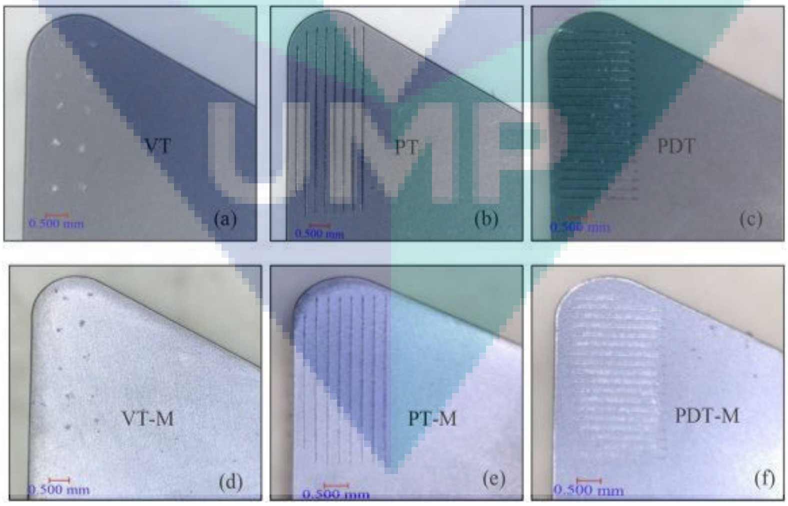


Figure 2.8: Comparison between micro-dimples, parallel line and channels.

Source: (Gajrani et al., 2018)

(Bhaduri et al., 2017) generated two different designs on cemented carbide insert that incorporated arrays of micro-dimples and channels by using laser surface at texturing. Several techniques that have been used before like abrasive machining, electromagnetic wave, reactive ion etching and electro discharge texturing but compared with laser surface texturing that has attracted over 20 years. Same with (Qiu & Khonsari, 2011) that has argued that micro-trap for wear debris and load carrying support is administered by micro-dimples on the cemented carbide insert. However, at the edge of the dimples, it recommended that the removal of bulges by lapping after laser surface texturing. Besides, different laser surface texturing designs, which is micro-dimples and channels were investigated by the authors on cemented carbide insert by using both ns and fs lasers. The result is that the micro-dimples has very great surface area than channels.

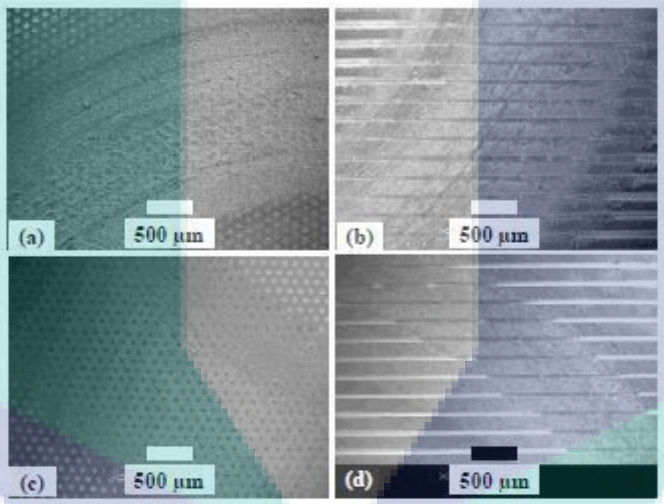


Figure 2.9: (a) dimples (b) channels produced using ns laser and (c) dimples (d) channels produced using fs laser

Source: (Bhaduri et al., 2017)

(Qiu & Khonsari, 2011) states that the result of dimple shape played a vital role in tribological performance of the texture surfaces. In the meantime, the explanation for this result is concerning the shape of the dimples which have an effect on the area of the hydrodynamic and cavitation in the dimple area. An author investigates the shape between elliptical dimpled and circular dimpled. The result is the elliptic dimpled specimens wear faster than circular dimpled specimens because of several factors like diameter, area ratio and depth. Comparable in (Tatsuya Sugihara, 2016) was investigated micro-grooves has same potential than the micro-dimples in cemented carbide insert due to the contact area at the tool-chip still remained.

(Xu et al., 2017) and (Obeidi et al., 2018) was discovered tribological behaviours on the surface textured by using laser surface texturing. Within with the same area concerning 10 times, dimples and groove's structure was created by using a laser beam velocity of 300 m/s to 400 m/s with a power of 5 W. Most of the researchers using this velocity to induce an ideal dimple or other design in femtosecond laser. During this experiment, the dimple geometry showed the best result in the suitable material and anti-wear properties. Contrast with this research, (Lu et al., 2018) authors investigate between three surfaces textured structures that is micro-dimples, micro-grooves and micro grids. The result showed that micro-grids is the best design to be chosen because of a few factors such as diameter and spacing, hardness and friction analysis. After make a laser surface texture the foremost changes that happen is hardness. Micro-grids had the highest hardness value which is 315 HV and hence the lowest value is micro-dimples, which is 241 HV. Therefore, micro-grids can absorb more energy than micro-dimples, and micro-grooves since has the highest hardness value.

Based on (J. Kümmel et al., 2015) used cemented carbide insert as a cutting tool within the turning process with a low cutting velocity and formation of built-up layers and edge was existed. This structure will build a deterioration of the work piece surface and rake face was protected by BUE. In addition, an author improvised the rake face with completely different design of textures by using laser surface texturing that can change the BUE adhesion tendency of the cutting tool.

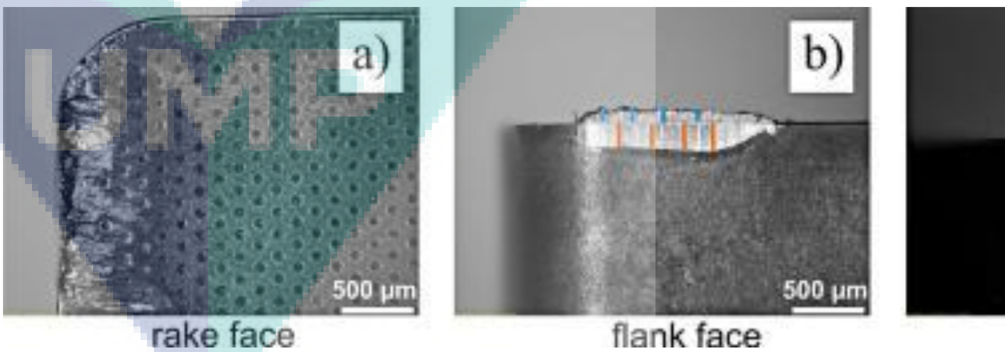


Figure 2.10: Example of rake face by using turning process

Source: (J. Kümmel et al., 2015)

There are three different design of textured was chosen by an author, which is dimples, channel in perpendicular and parallel on the rake surface BUE. During this experiment, dimple structure was fabricated the diameter of 50 µm with depth 20 µm whereas channel in perpendicular and parallel was fabricated width 50 µm and depth 20 µm. After investigation, the most effective design is dimple as a result of it stabizhangzed and got lower wear of cutting tool, however contrary for channel's design, which got destabilised BUE and increase wear of cutting tool.

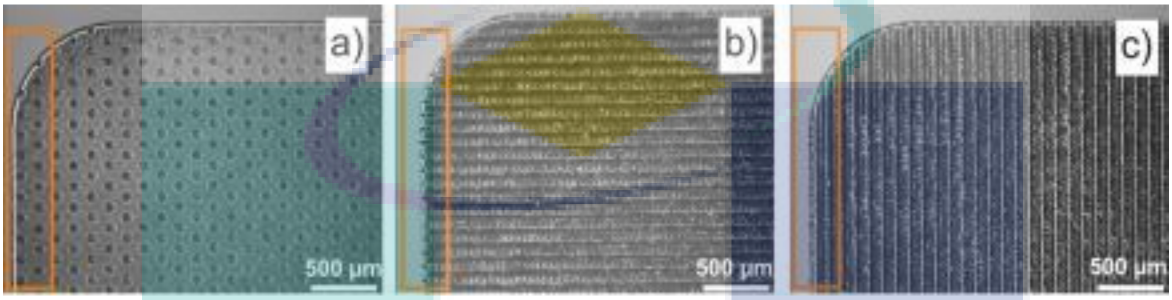


Figure 2.11: Uncoated cemented carbide insert (a) dimple structure (b) channel perpendicular cutting to edge (c) channel parallel cutting edge by using fibre-laser system.

Source: (J. Kümmel et al., 2015)

Other than laser surface texturing, rake face on cemented carbide cutting tools may be tested by applying electro-discharge machining (micro EDM). In this paper, (Li et al., 2016) and (Zhang, Hua, Dong, Zhang, & Chin, 2016) WC/8 % Co and WC/15 % TiC/6 %Co cemented carbide cutting tools were tested the rake face by shaping inclined and straight of linear grooves and micro holes that were constructed. Throughout this experiment, micro EDM was used high-frequency vibration machining to increase the dimension of the cutting tools. The result show that there was no adhesion existed on the cutting tool rake face and no debris also around the cavities. To avoid decreasing of mechanical strength of cutting tools, the depth of the linear grooves and micro holes determined to have an actual value. This research was proved that high-frequency vibration machining will assist on cutting tool and can be performed well on fabricating accurate and expected micro-scale textures.

Similar with (Gajrani et al., 2018) and (Sasi, Kanmani Subbu, & Palani, 2017), it were used electrical discharge machining to laser for various methods of surface texturing. Vickers hardness could fabricate micro-textures and was used to increase the tribological properties while drilling operations on cemented carbide cutting tool insert. During this analysis, to compare the conventional surface, it was used micro-grooved and micro-dimple and the reported said for the tool rake face have several surface textures on important effects. There have been existed reaction or discharged between the processing debris and also the side surface of structure.

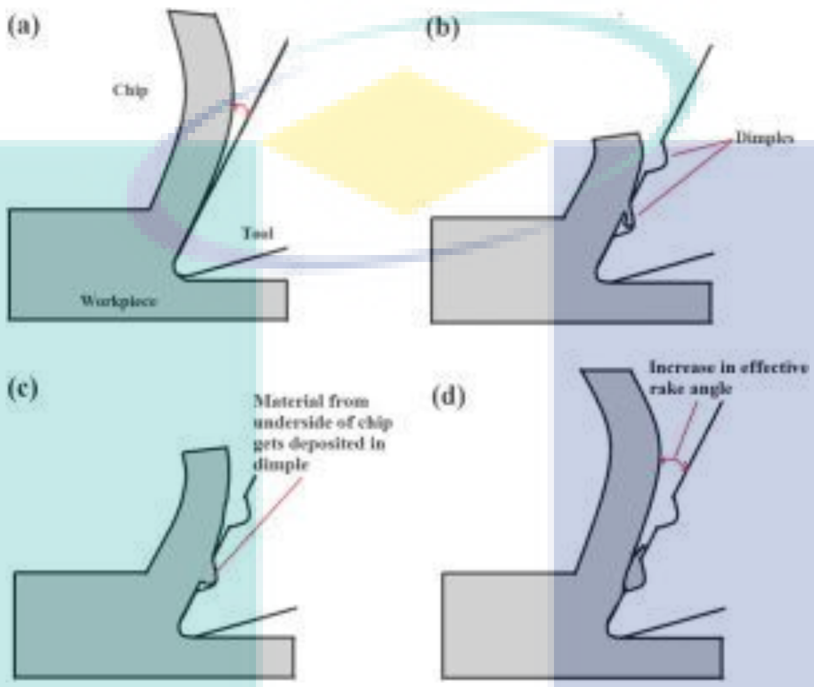


Figure 2.12: The cutting process by using (a) conventional tool, (b) cutting action at the dimple edges, (c) material deposition within dimple, (d) formation of a bump over dimple.

Source: (Sasi et al., 2017)

2.8 TURNING PROCESS WITH CARBIDE INSERT

Recently, some of the researcher found that high temperature during cutting process is a cause of the chipping and adhesive wear. The tool-chip contact can generate heat and friction that reducing the tool life by using the Gildemeister MD10S lathe machine during this experiment. Same with the previous research, cutting speed and feed rate was using as an important part which found the adhesion of aluminium alloy on cutting tool rake surface with the increasing cutting speed. However, a lower thermal conduction on the cutting tool can cause lower tool temperature. The cutting tools were adopted in this experiment to endure the turning process for 2.4 minutes. To get rid of the adhesion of aluminium alloy, the tool wear were investigated and compared in etching process, (Gajrani et al., 2018).

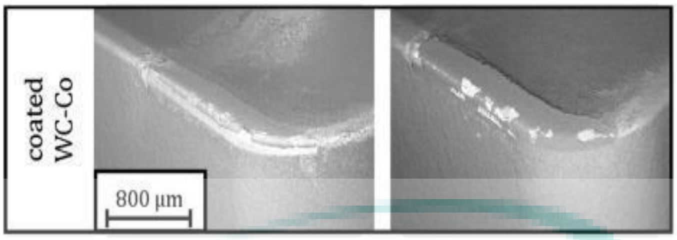


Figure 2.13: Etching process on carbide insert

2.9 TURNING PROCESS ON TEXTURED CARBIDE INSERT

According to (J. Kümmel et al., 2015) uncoated cemented carbide cutting tool was conducted in turning process to cut carbon steel work-piece during dry condition. In this research also found that to avoid application of coolant or lubricants, dry cutting process was used in it. This is because that BUE must be stabilised on the rake face which can strongly affect the local wear rates as well as used as to protect layer of the cutting tool. But some of the researchers opinion surface texturing must be considered in dry contact conditions. The cutting depth of dry turning process 1.0 mm, feed rate is 0.05 mm/rev and the cutting velocity around 100 m/mm was selected to do this process.

However, (Kedong Zhanga, Jianxin Dengb, Zeliang Dingc, Xuhong Guoa, & Sun, 2017) had same opinion about improvement of cement carbide insert which used dry machining to modified surface as well as to improve the tribological performance. Turning process was successfully used to improve the cement carbide insert cutting tools with the cutting depth 0.3 mm, cutting speed 40-200 m/min and the feed rate is 0.1 mm/rev. These operations also can maintained the duration of the tool life by maintain the lubricants and poor thermal conductivity.

As mentioned in (Gajrani et al., 2018) and (Bhardwaj & Shukla, 2018) before, the un-textured cutting tool was compared to reduce the cutting force and interface friction of the tool chip in the turning process. These process was conducted with the feed rate 0.28 mm/rev and the cutting speed of the cemented carbide cutting tools is 125 m/min to get the great rake face area. There are a few advantages of the turning process which is due to reduce the contact length of the cemented carbide cutting tool, and reduce the friction was to increase the improve in machining performance

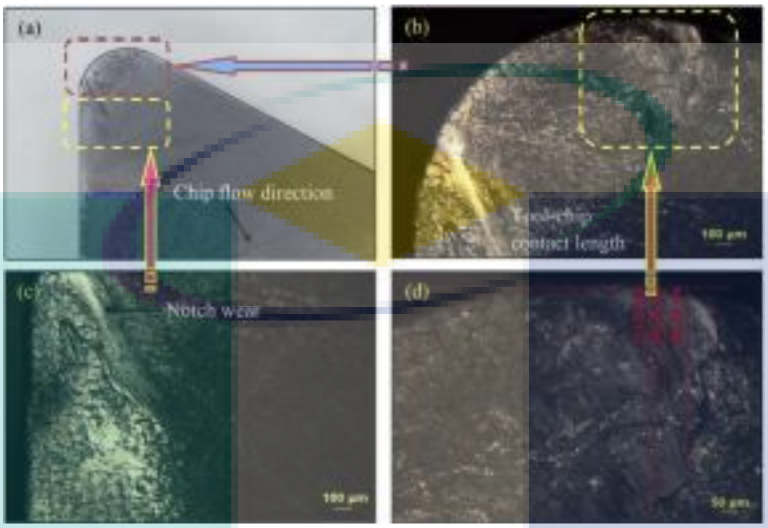


Figure 2.14: The un-textured cutting tool rake face in the turning process

Source: (Gajrani et al., 2018)

2.10 MEASUREMENT METHODS FOR SURFACE ROUGHNESS

(Bhardwaj & Shukla, 2018) and said after fabricating micro textures on the cutting tool rake surface, by using a Mitutoyo SJ-410 the surface roughness of the cutting tool and work piece was measured. These operation to make sure the preparation accuracy and characterize the surface fabricated parts.

According to (J. Kümmel et al., 2015) and (Saeidi et al., 2017) surface roughness must be determined after fabricating micro textures on the cutting tool rake surface and machining work piece using the textured cutting tool. It was determined by using focused ion beam (FIB) in order to the recorded the changes of microstructural in textured surface. By using the electron microscope (SEM) the surface layer of insert and work piece was examined. In this article also, during the cutting process the BUE formation was used by using a high-speed Motion Blitz

Cube with a magnification. Hence, the BUE formation tendency increased with the surface roughness increased by applying stylus instrument.

In (Lu et al., 2018) and (Obeidi et al., 2018) to investigate the surface roughness by using cleaned ultrasonically in acetone and different grit SiC papers before the laser surface texturing. Besides, 3D laser scanning microscope (VK100, Keyence) was used to determine the surface roughness and profiles of wear track after doing the laser surface texturing. While in (F. Moronia et al., 2016) the surface roughness was measured by using the Nd:YOV4 by insert the scanning speed, hatch distance and laser power.

Meanwhile, in the (Bhaduri et al., 2017) the method to measure the surface roughness of cutting tools were using the Alicona microscope. (Li et al., 2016) state that scanning electron microscope (SEM) was used to investigate the surface roughness in order to utilize and observed the wear tracks. These SEM also to investigate the condition and measure the dimension of micro holes and linear grooves on the cutting tool rake face surface. Microgroove on the rake surface of the cemented carbide cutting tools was measured using an electron microscope. (S-3400N) in (Lu et al., 2018).

In conclusions, the great and effective method to measure the surface roughness was the scanning electron microscope (SEM) which not used for surface roughness but can see the changes of the wear tracks in the rake surface of the cutting tool. However, to receive and achieve the same result data it may be used metallurgical microscopes as a suitable method.

2.11 SUMMARY

From this literature review, fabricating micro texture on cutting tool will not damage due to the high dimension accuracy and technique's efficiency laser technologies. This laser surface texturing is very expensive in Malaysia which in nano or micro scale laser texturing like femtosecond laser. Thus, a greater design will be chosen and investigate in this project by using laser surface texturing on the cemented carbide insert cutting tools.

The experiments can improve the hardness and performance of different designs and its wear around the cemented carbide insert by using laser surface texturing. In this project, there are a few designs that will be tested which micro-dimples, micro-grooves and micro grids to know its condition. From the experiment in research, micro-grids has a higher percentage of hardness and has been chosen as a greater design. However, it can improve the performance by using laser surface texturing.

Besides, not only designs as a part but still the methods to get the hardness of cemented carbide insert such as a grinding process, turning process and etching process. These three methods require to be determined to get a higher hardness. In a grinding process, the optimized parameters and depth are the major factor to grind the cutting tools. To fabricate a stronger surface quality, a greater grit size of grinding wheel requires to be identified. For turning process, to increase the cutting performance the cutting speed, feed rate and cutting depth need to be analysed. Lastly, the design between grids and dimple has been compared. It is confirmed that grids design had great spacing and friction. It is clearly express that the changes of hardness compared to the dimple design. Thus, since it has greatest hardness, the grid design can absorb energy.

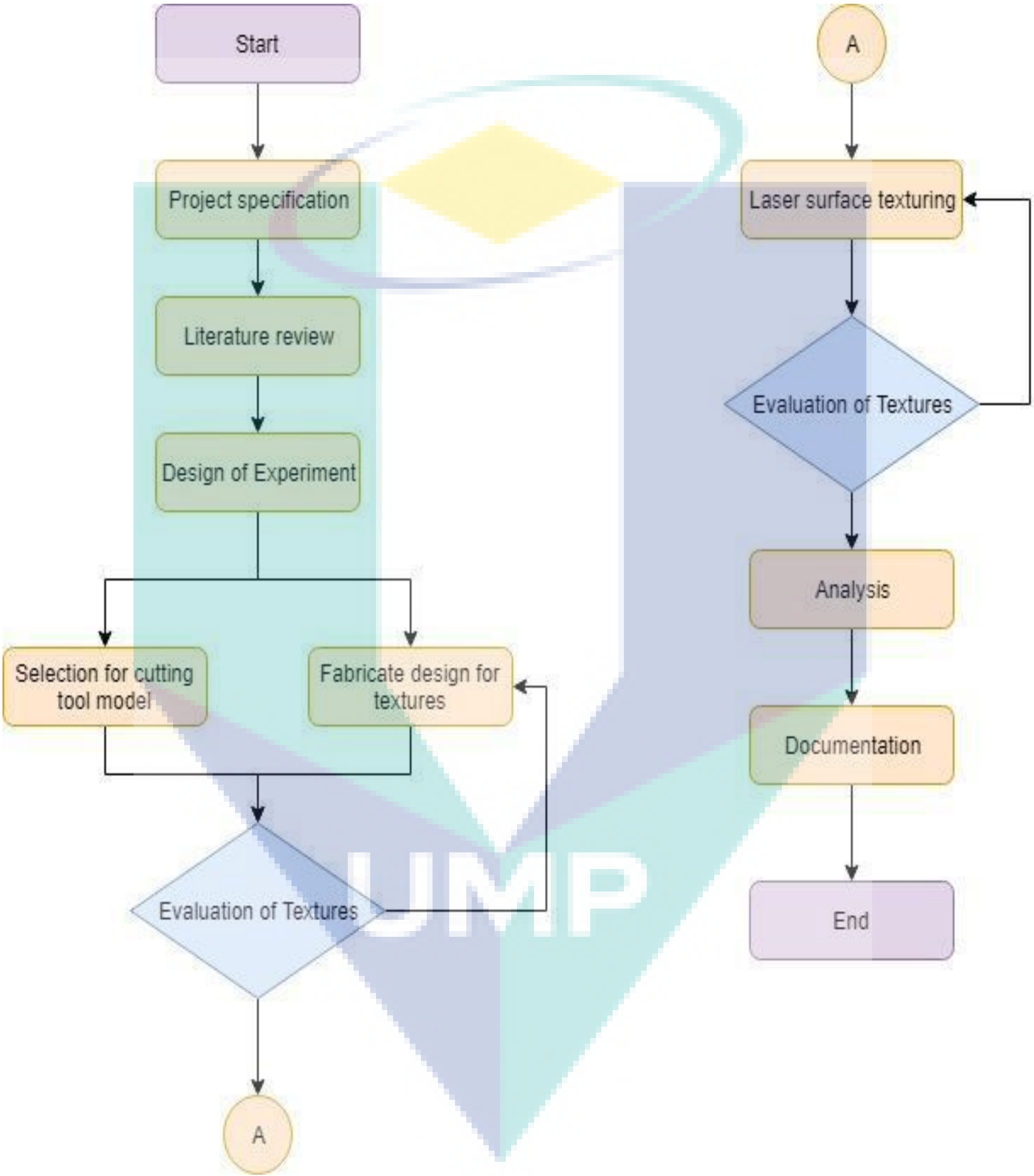
CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In this chapter, the most objectives is to supply associate insight into the analysis ways applied throughout this project. To conduct the experiments during this project are used scientific techniques and any procedures to explain during this chapter to increase the validity and dependability of this study. To express this project, a flow chart are going to be show the flow of this project. Besides, to illustrate how the project can run, a Gantt chart will be used to demonstrate the general timeline of this project. To be adopted in fabricating textures on cutting tool and machining work piece, the scientific techniques has been utilized in this chapter. The analysis outcome from the literature review of the previous chapter are also used these methods. To fabricate textures on cutting tool rake surface was used the selected method for grinding process. The work piece with the textured cutting tool, turning process is chosen for the machining. In addition, in this project will be introduced briefly about the equipment, machines and software in this chapter.

3.2 FLOW CHART



3.3 PROJECT DESCRIPTIONS

From the flow chart, there are two main methods and techniques that were distributed, which is texture fabricating process by using laser surface texturing and cutting process. The specification and experiment to planning to do the design of both projects can be determined by reviewing different literatures done by researchers.

First, in grinding process the carbide insert cutting tool has been chosen to undergo surface texturing. Coated cemented carbide insert with model DNMA 150608 was selected was selected because it is protected properties, which are suitable for turning process with lower surface roughness in. In (J. Kümmel et al., 2015) journal, the statement state has been agreed. For turning process this carbide insert was into the machine non-ferrous primarily. In this process, this model of carbide insert will perform ordinarily without any textures and chip breakers on the rake surface on metals like aluminium alloy. However, grinding process chose to generate certain textures on the carbide insert rake surface in this project. Throughout turning process, the cutting performance of the work-piece will give influence on those textures. Once the turning process, the rake surfaces are going to be verified the significant of the textures to generate on the carbide insert.

Okamoto ACC52ST surface grinding machine has been used to control the grinding process, which is known as a horizontal spindle surface grinder. The carbide insert was clamp by using magnetic vice clamp. To determine the optimized grinding parameters, this grinding process was recommended as the advance experiment to be used for the turning process later. Thus, the qualifying result will be investigated on the rake surface of the carbide insert in the condition of the surface texture and surface roughness.

After procuring the grinding parameters, the turning process was carried out to have an appropriate surface roughness of the carbide insert. ROMI C420 lathe machine has been used to control the turning process from this project. The foremost reason for choosing turning process is because the material will spin on the mandrel while the cutting tool will not be rotated. Instead of main reason, this process just to secure in the tool posts during the cutting operation. By rotating the work piece instead of spinning the cutting tool, this will give a result on consistent and reliable surface finish or surface roughness on the work-piece.

For the preliminary results, the hardness on the surface of carbide insert were investigated and evaluated. Appropriate facilities were applied to investigate and evaluate the results in order to enhance the reliability of the results. Vickers hardness test were utilized in this project to validate the hardness.

Turning process was carried out after receiving the optimized grinding parameters to have accurate surface roughness of the carbide insert. In this project, the turning process was controlled by utilizing ROMI C420 lathe machine. The major reason for choosing turning process is that the material will rotate on the mandrel while the cutting tool will not be rotated but just be secured on the tool post throughout the cutting operation. It will produce a steady and strong surface finish or surface roughness on the work piece by rotating the work piece instead of spinning the cutting tool.

Overall, after the concluding evaluation of surface texture, this project was undertaken to analysis and documentation of this project were done condition on cutting tool. The analysis has been done completely, which consists of the initial evaluation. The first evaluation was completed in Final Year Project 1 while for the final evaluation was finished in Final Year Project 2. For the documentation, it was done properly in all the chapters of this project report.

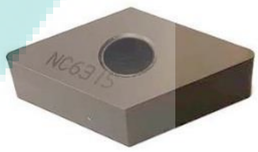
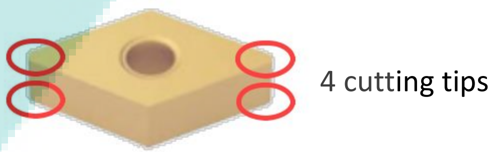
3.4 DESIGN OF EXPERIMENT (DOE)

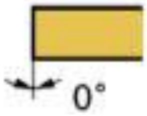
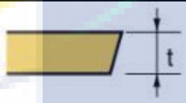
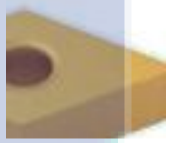
To increase the reliability for a project, the design of experiment is an essential tool which is also needed to develop an experiment strategy by using a minimal of resources. From this project, there are five basic important rules to facilitate the process and methods which are planning, screening, optimization, robustness testing, and verification. Besides, by determining a relationship between causes and effects and also providing an understanding of interactions among of these factors will help in minimizing experimental error.

3.4.1 Carbide Insert

Basically, in the grinding process the coated cemented carbide inserts DNMG 150608 were used for the preliminary experiment instead of a model DNMA 150608 which need to order from the foreign country. As illustrate in table, it can be seen that both carbide inserts have the same characteristics, for example, they have an insert shape of 55˚, a relief angle of 0˚, 6.35 mm and 15.5 mm of cutting-edge height and length and 0.8 mm of the nose radius. However, there has one difference between these two models which is the first one possesses chip breaker on its rake surface for general cutting purpose while the latter one possesses a completely flat rake surface without any pattern of chip breaker. Both carbide insert possesses will be no difference in the grinded surface texture but have the same features except the chip breaker. Therefore, it was expected to have a longer duration for grinding the DNMG 150608 carbide insert in order to grind the uneven rake surface until flat. There are four cutting tips on the carbide insert which are capable of be grinded for fabricating textures.

Table 3.1: Similarities and differences of features between model DNMG 150608 and DNMA 150608 carbide insert

FEATURES	DNMG 150608	DNMA 150608
Image		
Cutting tip		
Insert shape		

FEATURES	DNMG 150608	DNMA 150608
Relief angle		
Length of cutting edge	 l = 15.5	
Height of cutting edge	 t = 6.35	
Nose radius	 r = 0.8	
Chip breaker	Present 	Absent (Flat top) 

3.4.2 Laser Surface Texture Tester

Laser surface was carried out in preliminary experiment to obtain preliminary result in the Final Year Project 1. As illustrated in Figure 3.2, CK-FB3D 30W Fiber Laser Marker was applied to fabricate textures on the carbide insert rake surface. This machine specially designed for marking parameter can easily be selected for the material and content being marked. Furthermore, it is also have auto focus which can automatic adjustment of the focal distance. This is not reduce only production cost, but also contributes to improvement in production quality.

First and foremost, the carbide insert was first being clamp firmly on a vice which is electromagnetically to be held on the magnetic work table. The machine was the being setup and ready to be laser. There were two constant variables in this laser test, which is overlap and scanning speed. Besides the controlled variables or parameters adopted in this experiment were the frequency and the number of repetition on the carbide insert. There are two frequency that has been used in this experiment.

Table 3.2: Constant variables of the laser test at frequency 100Hz and 400Hz

Constant Variable	Overlap, mm	0.1
	Scanning speed, m/s	5

Table 3.3: Controlled variables of the laser test at frequency 100Hz and 400Hz

		No. of Experiment	
Controlled Variables	Frequency, Hz	9-12	100
		10-16	400
	Repetition	9, 13	1x
		10, 14	2x
		11, 15	3x
		12, 16	4x

On the next experiment, the constant variables are frequency and the scanning speed while the controlled variables are overlap and number of repetition.

Table 3.4: Constant variable of the laser test for the overlap 0.40mm and 0.05mm

Constant Variable	Frequency, Hz	100
	Scanning speed, m/s	20

Table 3.5: Controlled variables of the laser test for the overlap 0.40mm and 0.05mm

		No. of Experiment	
Controlled Variables	Overlap, mm	21-22	0.40
		23-24	0.05
	Repetition	21, 23	1x
		22, 24	4x

3.4.3 Evaluation of Depth of Surface Texture

After completed ten experiments of laser surface texture, the depth of the carbide insert were investigated using metallurgical microscope and video measuring system. The condition of carbide insert on the rake surface were inspected using the metallurgical microscope as shown in Figure 3.2. The video measuring system and Motic Image Plus 3.0 software was applied to observe the depth of carbide insert and the condition of textures on the rake surface of each carbide insert as illustrated in Figure 3.1. The results were determined in the next chapter.

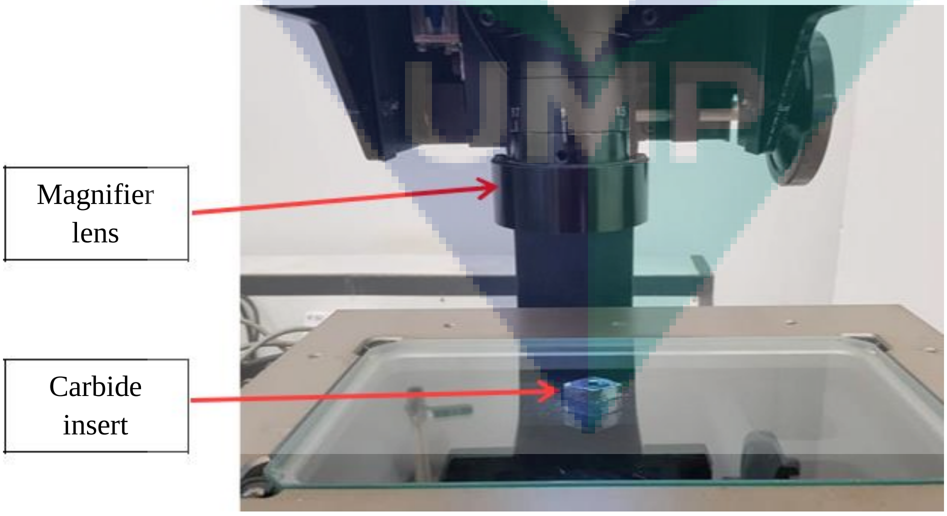


Figure 3.1: Experiment setup for depth inspection

3.4.4 Evaluation of Surface Roughness of Surface Texture

After completed all of the laser experiments, the rake surface of the carbide inserts were investigated using metallurgical microscope and surface roughness tester. The condition of the rake surface and the textures fabricated on the rake surface were inspected using the metallurgical microscope. The surface roughness tester was applied to measure the average surface roughness of the textures fabricated on the rake surface of each carbide insert. The results were determined in the next chapter.

As illustrated in Figure 3.2, the textured carbide insert was located properly by pasting on the plasticine with the textures facing upwards. It was then put on the work table and ready to be inspected using the microscope. The condition of the textures on the carbide insert rake surface was inspected and captured by using the 20x lens of microscope software.

From Figure 3.3, the carbide insert was clamped properly with a vice and the textured surface to be measured was facing upwards with contacting to the stylus. The surface roughness of the textures was measured by the contacting of the stylus to the texture area on the carbide insert rake surface. The measurement of the average surface roughness was displayed on the LCD of the machine. The average surface roughness of the experiments was discussed in the next chapter.

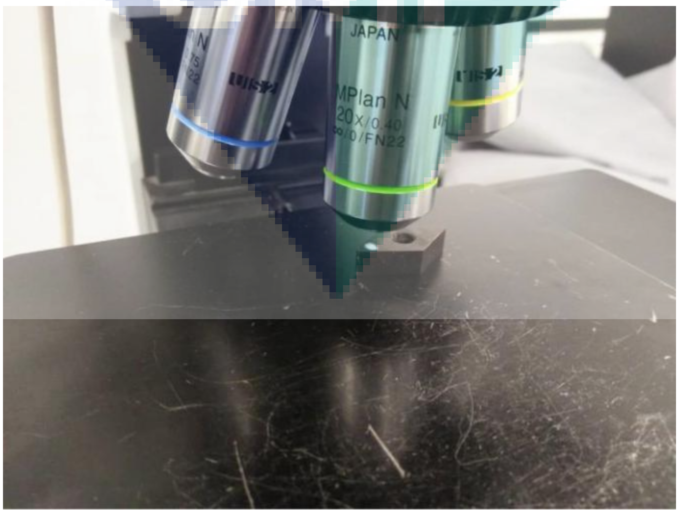


Figure 3.2: Experiment setup for texture inspection

Figure 3.3: Experiment setup for surface roughness measurement

3.5 HARDWARE AND SOFTWARE APPLICATION

Hardware is known as facility or equipment while programming is considered as the working data utilized by a computer. Both were used in this venture, for example, the surface carbide insert, metallurgical microscope, surface roughness tester, video measuring system, and Motic Image Plus 3.0 software. The majority of the hardware and software were examined altogether in the following section.

3.5.1 3D Fiber Laser Marker

During undergoes this project, CK-FB3D 30W Fiber Laser Marker was used to do a pattern on the carbide insert. This machine has 3-Axis Control which perfect ability engraving and unique technology to program complex shapes and allow for reliable consistency on every mark. This machine also can automatic adjustment of the focal distance which easy to control.

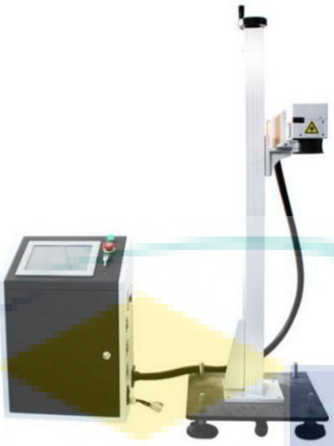


Figure 3.4.: CK-FB3D 3-Axis Control Fiber Laser Marker

Source: IDI Laser Website

Technical Parameters							
Laser	Model	CK-FB3D30		CK-FB3D50		CK-FB3D100	
	Power	30W		50W		100W	
	Pulse Energy	1mJ		1mJ		1mJ	
	Frequency	30K-200KHZ		50K-200KHZ		5k-200KHZ	
	Wavelength	1064nm					
Arts and Crafts	Guide Laser	Red Light /Wavelength:655nm,Output:1.0mW(Class 2 laser Product;)					
	Marking Range	Standard Area	Optional Area	Standard Area	Optional Area	Standard Area	Optional Area
		Upto 1000x1000mm		Upto 1000x1000mm		Upto 1000x1000mm	
	Focus Adjust Range	±20mm	±20mm	±20mm	±20mm	±20mm	±20mm
	Marking Mode	XYZ 3-Axis Dynamic Focus					
	Minimum Linewidth	0.03mm	0.03mm	0.03mm	0.03mm	0.03mm	0.06mm
Software	Marking Speed	≤10000 mm/s	≤10000 mm/s	≤10000 mm/s	≤10000 mm/s	≤10000 mm/s	≤10000 mm/s
	OS&GUI	Win Xp/Win 7					
	Supported Font	True Type Font/AUTOCAD Mongline Font,Customise the Font					
	1D Barcode	Code 39/Code 128/ITF/CODABAR/EAN/UPC and so on					
	2D Barcode	QR/PDF417/Datamatrix(ECC 200) and so on					
	Import Files	PLT/DXF/DWG/SVG/STL/BMP/JPG/JPEG/PNG/TIFF and so on					
Machine	Ambient Environment	Temperature: 10 °C~35 °C Humidity: 5%~75%					
	Power Supply	Single phase 110/220V optional/50~60Hz		Single phase 110/220V optional/50~60Hz		Single phase 110/220V optional/50~60Hz	
	Power Consumption	≤750W		≤1200W		≤1500W	
	Cooling Mode	Air Cooling		Air Cooling		Air Cooling	
	Machine Dimension	1400mm*850mm*1699mm		1400mm*850mm*1699mm		1400mm*850mm*1699mm	
	Control Interface	PCI-Express/USB-2.0 optional		PCI-Express/USB-2.0 optional		PCI-Express/USB-2.0 optional	

Figure 3.5.: Laser Surface Texture Specification

Source: IDI Laser Website

3.5.2 Metallurgical Microscope

In this project, an Olympus BX51M metallurgical microscope is utilized for inspecting the condition of the textures on the carbide insert rake surface. It is displayed as in Figure 3.6. This model of microscope provides reflected light illumination only, transmitted light illumination is not offered. It possesses a magnifying power within a range of 5x to 100x. It also has an illuminator that can reduce the complicated steps which are always required as working a microscope. Furthermore, it offers conformability for a diverse range of material science and yet industrial applications. The specifications of this model of microscope are illustrated in Figure 3.7.

Figure 3.6: Olympus BX51M metallurgical microscope

Optical system		UIS2 optical system (infinity-corrected system)
Microscope stand	Illumination	Reflected/transmitted: built-in 12V100W light source, light preset switch, LED voltage indicator, reflected/transmitted changeover switch (BX51) Reflected: built-in 12V100W light source, light preset switch, LED voltage indicator (BX51M)
	Focus	Stroke: 25mm, fine stroke per rotation: 100µm minimum graduation: 1µm, with upper limit stopper, torque adjustment for coarse handle
	Maximum specimen height	25mm (without spacer: BX51), 65mm (without spacer: BX51M)
Reflected light illuminator	BF etc.	BX-RLA2: 100W halogen (high intensity burner, fiber illuminator mountable), BF/DF/DIC/KPO, with FS, AS (with centering mechanism, BF/DF interlocking ND filter)
	Reflected fluorescence	BX-URA2: 100 Hg lamp, 75W Xe lamp, 50W metal halide lamp, 6 position mirror unit turret (standard: WB, WG, WU+BF etc), with FS, AS (with centering mechanism), with shutter mechanism
Transmitted light		100W halogen, Abbe/long working distance condensers, built-in transmitted light filters (LBD,ND25, ND6) (BX51)
Observation tube	Widefield (F.N. 22)	Inverted: binocular, trinocular, tilting binocular Erect: trinocular, tilting binocular
	Super widefield (F.N. 26.5)	Inverted: trinocular Erect: trinocular, tilting trinocular
Revolving nosepiece	For BF	Sextuple, centering sextuple, septuple (motorized septuple: optional)
	For BF/DF	Quintuple, centering quintuple, sextuple (motorized quintuple optional)
Stage		Coaxial left (right) handle stage: 76(X) X 52(Y)mm, with torque adjustment, large-size coaxial left (right) handle stage: 110(X) X 105(Y)mm, with lock mechanism in Y axis

Figure 3.7: Microscope specifications

Source: Microscope Central (2018)

3.5.3 Motic Image Plus 3.0 Software

Motic Image Plus 3.0 is a software utilized to measure the depth of surface of carbide insert through the microscope onto a computer screen. It enhances the digital microscope use with live measurements, intuitive and customizable. This software basically transforms the image of the work piece which is magnified under microscope onto the computer screen with supporting extra features. It benefits various fields of customer with its affordable price, especially to students, as well as doctors and quality control staffs. The main page of this software illustrated in computer is displayed on Figure 3.8. In addition, this software is capable to differentiate the area of various materials in composite elements.

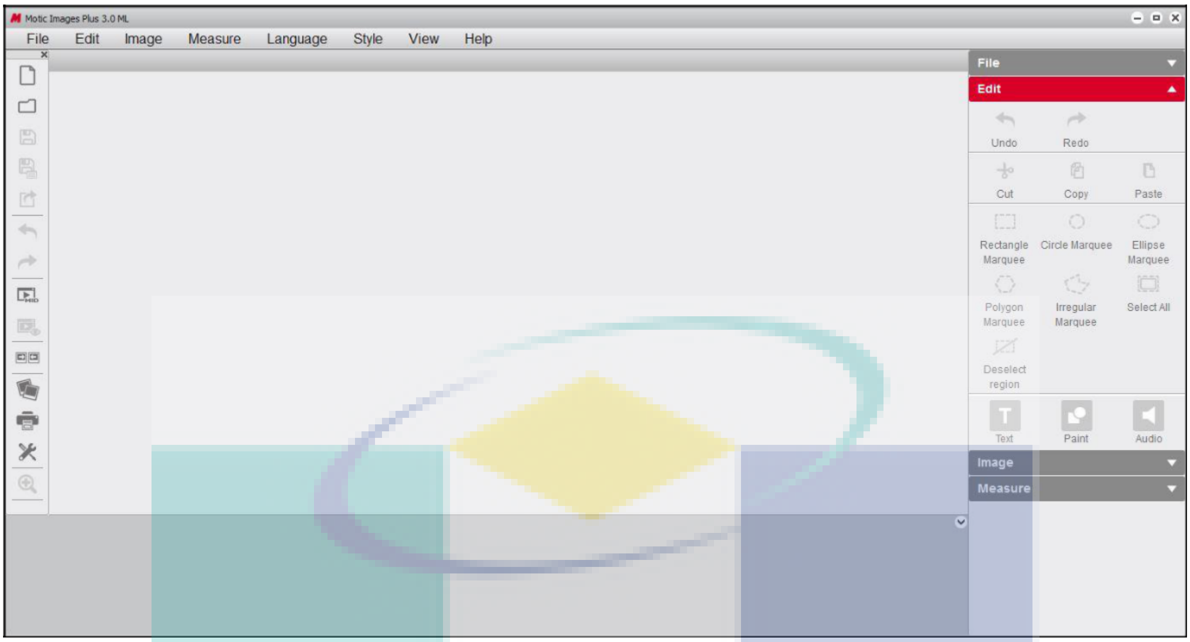


Figure 3.8: Main page of Motic Image Plus 3.0 Software

3.4.5 Surface Roughness Tester

SURFCOM 130A is the model of surface roughness tester used in this project as illustrated in Figure 3.9. It is typically a compact surface texture measuring instrument which offers easy and convenient operation. It involves a stylus tip of radius 5 µm in order to give a high accuracy measurement performance. It also provides evaluation range setting for instance the measurement length, measurement speed, cut off value, 34 types of roughness parameters (, ,) and 32 types of waviness parameters.

Besides, a proper calibration should be conducted attentively by using a calibration plate before the surface roughness measurement started. Without doing calibration, the accuracy of the results will be unreliable.

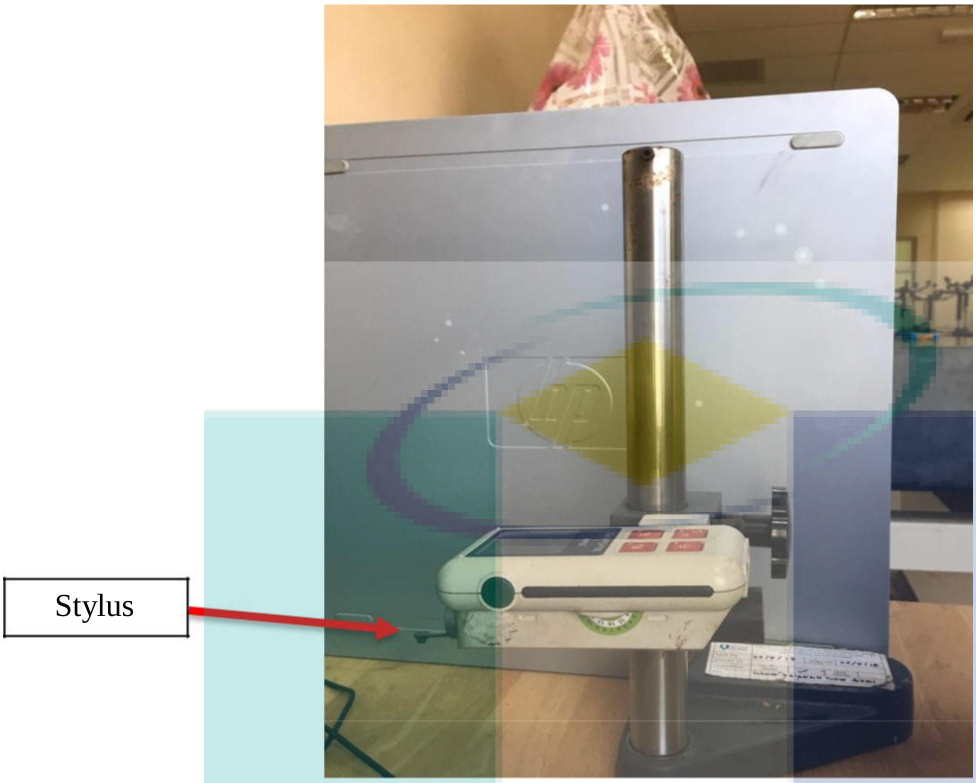


Figure 3.9: Surface roughness tester with a stylus

3.4.6 Video Measuring System

As illustrated in Figure 3.24, it is an optical or video measuring system calibration. It is also one kind of reliable vision equipment which offers good accuracy with long term performance. This video measuring system calibration includes the table flatness to optical axis, focus squareness to optical axis, edge detection accuracy, X / Y axis stage squareness, and also Z axis linear calibration. It also offers microscope calibration that involving reticle scale magnification accuracy and the crosshair rotation and centerline.

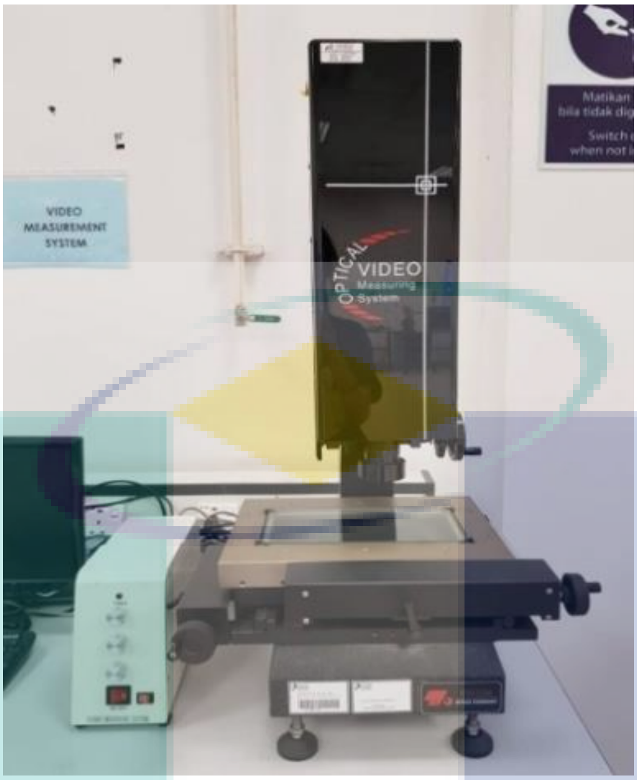


Figure 3.10: Video Measuring System

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 INTRODUCTION

This chapter introduces about the overall relevant results of the experiments in this project. The findings or problems found during conducting the experiments will be presented too. The essentialness of results will be translated in figure, diagram, graph, and table with further description of written text in this chapter.

The outcomes at the state of surface texture on the carbide insert rake surface will be shown in this part. And yet the measurements of surface roughness of the carbide insert will be demonstrated here. The condition and surface roughness of carbide insert rake surface after the grinding test is categorized as the preliminary results. On the other hand, the adhesion of work piece material and the state of carbide insert rake surface after the turning test is classified as the terminal exploratory outcomes. The preliminary results and the last trial results will be characterized and showed in Final Year Project 1 and Final Year Project 2 respectively.

The performance of surface roughness for the carbide inserts applied with different experiment parameters during the laser test will be examined. The condition of work piece material with different experiment parameters during the laser test will be compared. Furthermore, the design on the carbide insert by using laser surface textured will be researched as well. These investigations will then be interpreted as the results in this chapter.

4.2 CONDITION OF CARBIDE INSERT RAKE SURFACE

The condition of textured carbide insert rake surface for the two grinding experiments was illustrated in the following section. All the images were investigated and roughly captured by camera.

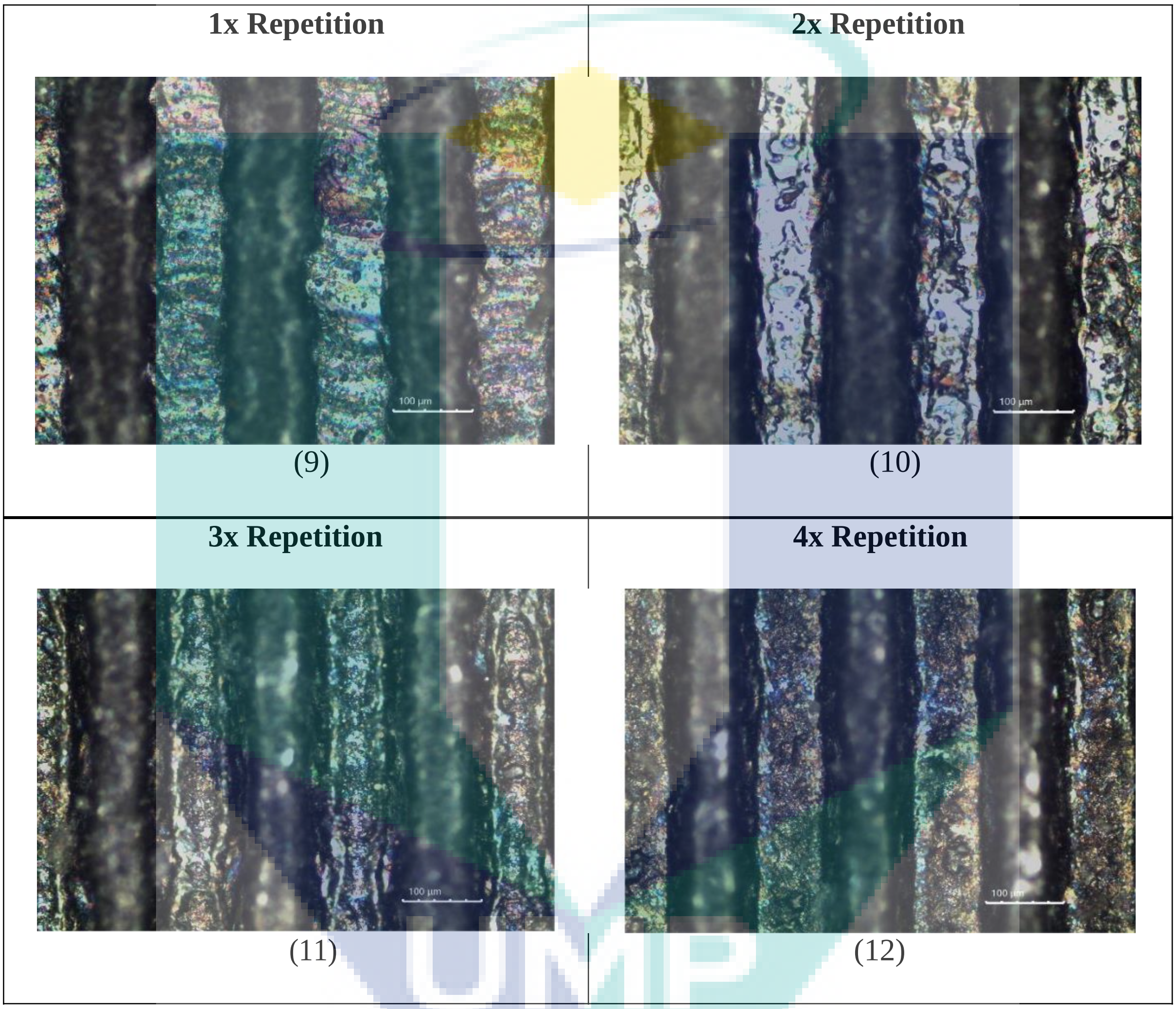


Figure 4.1: Number of experiment of carbide insert rake surface at frequency 100Hz

The figure above shows that the surface of experiment of carbide insert which were fabricated via laser surface technology at 100Hz. The surface of carbide insert has been investigated through the metallurgical microscope. As can be seen Experiment 9 shows the highest built-up-edge (BUE) due to the number of repetition while Experiment 12 shows the lowest BUE.

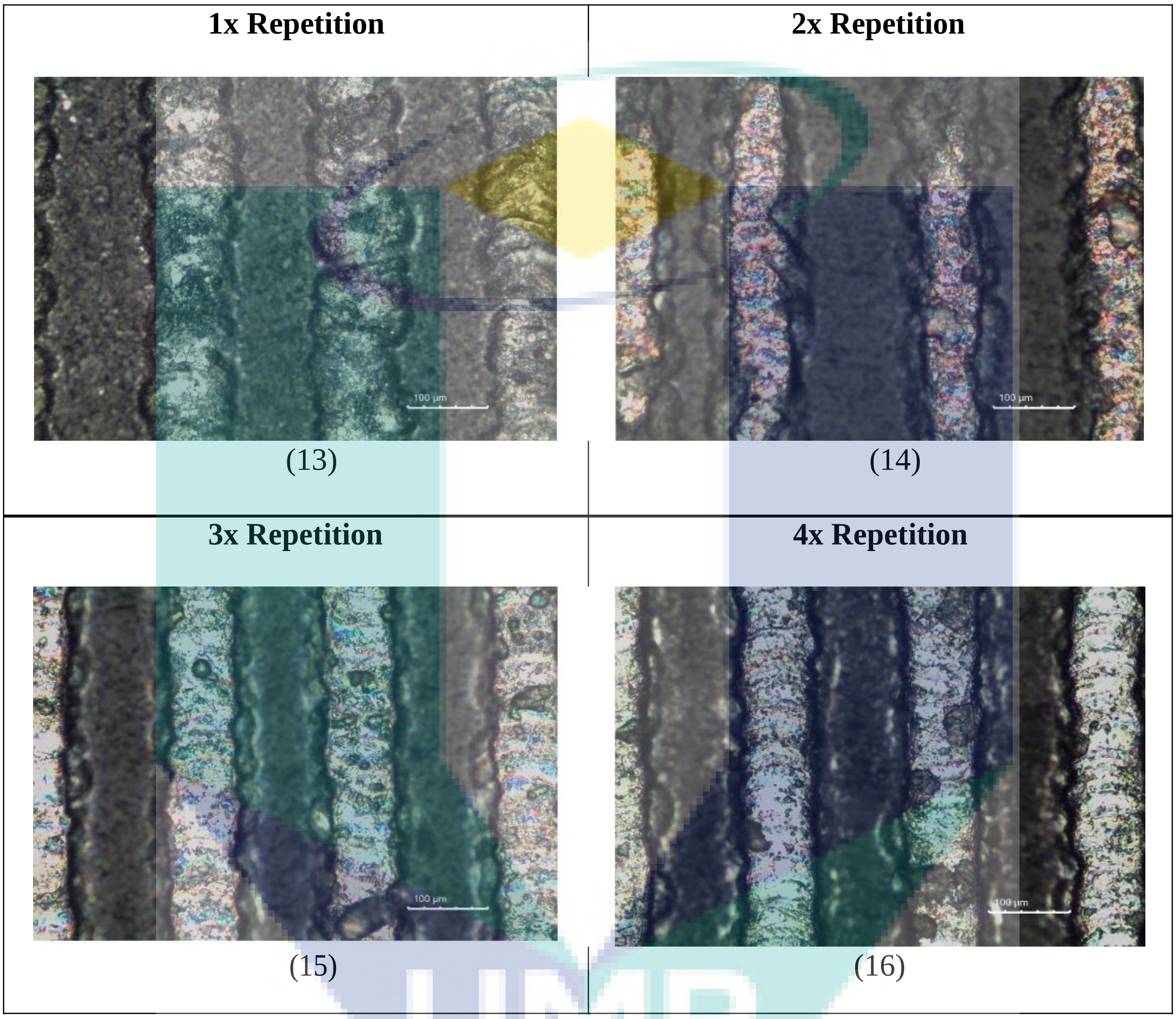
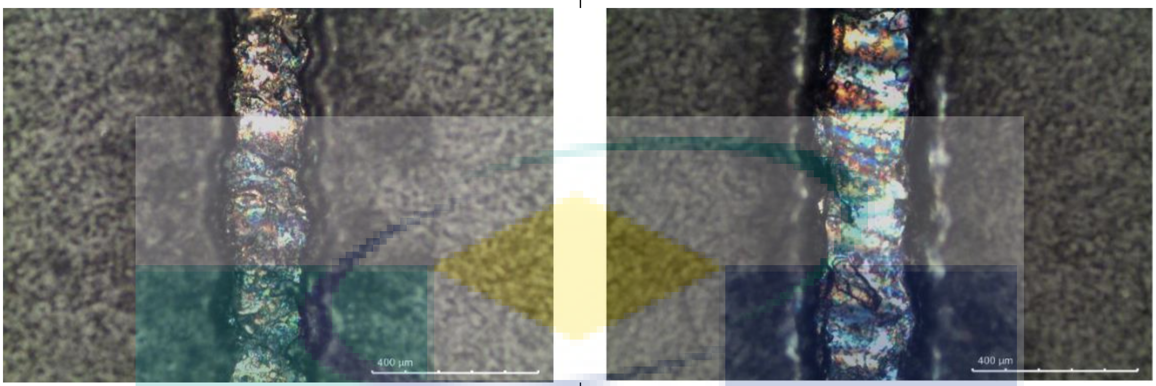


Figure 4.2: Number of experiment of carbide insert rake surface at frequency 400Hz

However, in the Experiment 13 to 16 are using similar method to investigate the surface of carbide insert but using different frequency which is 400Hz. It shows that Experiment 14 has the highest BUE compared to the Experiment 16. This is because of composition in the carbide insert was changed during using the laser due to the frequency are too higher compared to the previous experiment in Figure 4.1**.** Since the overlap and scanning speed were kept constant throughout the experiments, they had no much affected to the textures fabricated.

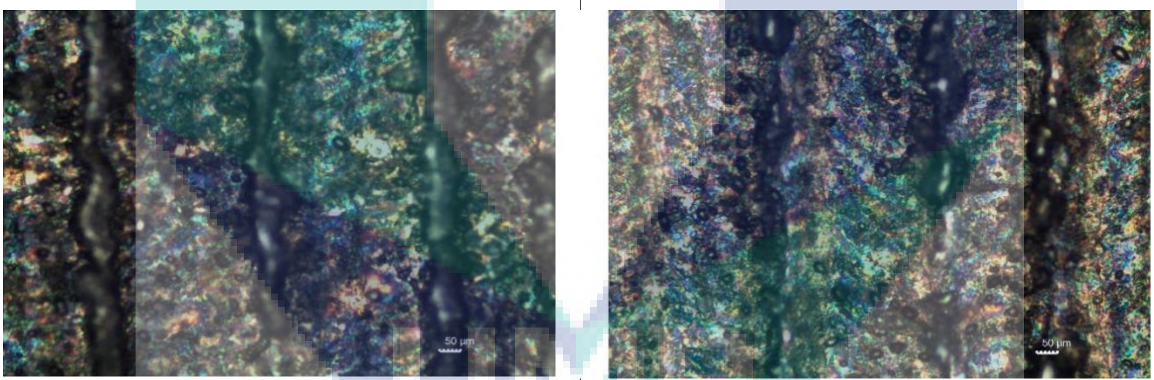
1x Repetition	4x Repetition



(21) (22)

Figure 4.3: Number of experiment of carbide insert rake surface with overlap 0.40 mm

1x Repetition	4x Repetition



(23) (24)

Figure 4.4: Number of experiment of carbide insert rake surface with overlap 0.05 mm

On the other hand, the Figure 4.3 and Figure 4.4 shows the rake surface of carbide insert by using the different constant variable which is frequency and scanning speed while the controlled variable is overlap and number of repetition. It can be seen experiment 21 has low BUE and experiment 22 has high BUE due to the number of repetition. Even so, both experiment 23 and 24 has highest BUE rake surface because of the smaller overlap which make the lines redundant.

All things considered, from all the experiment the texture of carbide insert rake surface from experiment 12 and 16 showed better evenness as compared to others. This is because, the low BUE on the rake surface, the higher hardness of the of the carbide insert.

4.3 AVERAGE DEPTH OF CARBIDE INSERT SURFACE

As describe in the previous chapter, the depth of the carbide insert, mm was measured. The result was taken by using the readings and was determined as shown in Table 4.1.

Table 4.1: Average depth for 4 sets of experiments at frequency 100Hz

Number of Experiment	**Depth of Experiment, mm**					**Average Depth, mm**
9	0.0425	0.0419	0.0431	0.0398	0.0428	0.0420
10	0.0525	0.0515	0.0534	0.0542	0.0527	0.0529
11	0.0675	0.0668	0.0672	0.0660	0.0661	0.0667
12	0.0822	0.0839	0.0832	0.0774	0.0723	0.0776

According to figure above, the rake surface of carbide insert was capable of be laser into textures, which were parallel to the cutting edge as expected. However, the width and depth of the textures obtained were basically irregular compared to those textures which were fabricated via laser technology. The largest depth of texture was determined for each experiments 9 to 12 which was 0.0776 mm at frequency 100 Hz.

Table 4.2: Average depth for 4 sets of experiments at frequency 100Hz

Number of Experiment	**Depth of Experiment, mm**					**Average Depth, mm**
13	0.0635	0.0690	0.0718	0.0685	0.0699	0.0549
14	0.0885	0.0872	0.0905	0.0879	0.087	0.0714
15	0.0875	0.0859	0.0919	0.085	0.0879	0.0876
16	0.1018	0.1024	0.01032	0.1011	0.1030	0.1045

It can be concluded that Experiment 16 have the largest depth of texture while Experiment 9 gave the smallest depth of texture as compared to the rest of 16 experiments. The depth of texture was affected by the experiment parameters which were scanning speed and frequency. The number of repetition also affected the outcome of the textures. Since the scanning speed and the frequency were keep constant throughout the experiments, they had no much influences to the textures.

Table 4.3: Average depth for 2 sets of experiments with overlap 0.40 mm

Number of Experiment	**Depth of Experiment, mm**					**Average Depth, mm**
21	0.0483	0.0495	0.0482	0.0498	0.0505	0.0493
22	0.0749	0.0753	0.0759	0.0742	0.0735	0.0748

Table 4.3 and Table 4.4 compares the results average depth of rake surface of carbide insert with overlap 0.40 mm and 0.05 mm. It can be seen experiment 21 has the low average depth compared to the experiment 22. Same goes to experiment 23 and 24.

By considering the results of average depth in graph as illustrated on Figure 4.5 and 4.6, we are prepared to clarify the relationship between the variables. From the first figure, the relation between the average depth of insert and the eight laser experiments. Experiment 9 gave the lowest average depth evidently while experiment 16 gave the largest.

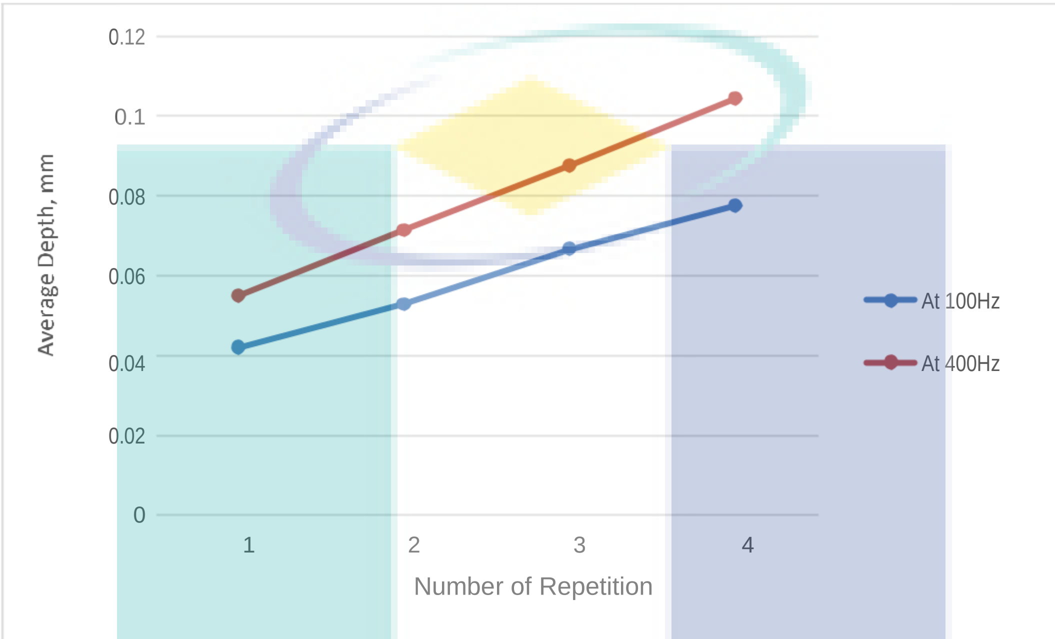


Figure 4.5: Graph of average depth against number of repetition at 100Hz and 400Hz

Figure 4.6: Graph of average depth against number of repetition with overlap 0.40 mm and 0.05 mm

From Figure 4.5, it points out the relationship between the average depth at 100Hz and 400Hz depth of cut with number of repetition in the laser experiments. Depth of cut at 100Hz resulted in the lowest average depth with the lowest number of repetition. On the other hand, the depth of cut with 400Hz resulted in the highest average depth with the medium number of repetition. The only similarity of these two depths of cut was that both of them resulted in the largest average depth with the highest number of repetition. In other words, the larger the number of repetition, the larger the average depth of insert will be fabricated.

According to Figure 4.6, it shows the relation between the average depths with overlap 0.40 mm and 0.05 mm while the constant variable are frequency and scanning speed. Depth of cut at both overlap resulted in the lowest average depth with the lowest number of repetition.

4.4 SURFACE ROUGHNESS OF CARBIDE INSERT SURFACE

As described in the previous methodology section, the surface roughness of the carbide insert textured rake surface, was measured. An average measurement was taken by using three preliminary readings. A preliminary result for the surface roughness of textured carbide insert was determined successfully as shown in Table 4.1. The measurement setting was given to be measurement length = 5.16 mm.

Table 4.5: Average surface roughness for 4 sets of experiment at 100Hz

Number of Experiment	**Surface Roughness, µm**			**Average Surface Roughness, µm**
	1st	**2nd**	**3rd**	
9	0.753	0.734	0.737	0.741
10	0.659	0.623	0.631	0.638
11	0.557	0.551	0.525	0.544
12	0.409	0.407	0.415	0.410

Table 4.6: Average surface roughness for 4 sets of experiment at 400Hz

Number of Experiment	**Surface Roughness, µm**			**Average Surface Roughness, µm**
	1st	**2nd**	**3rd**	
13	0.835	0.833	0.895	0.854
14	0.741	0.726	0.76	0.742
15	0.652	0.678	0.655	0.662
16	0.574	0.563	0.578	0.571

According to the result from Table 4.5 and Table 4.6, it was mentioned that the average surface roughness of textured carbide insert for experiment 12 was lowest, which was 0.410

μm. On the contrary, it showed that the average surface roughness of textured carbide insert for experiment 13 was the largest, which was 0.854 μm. Generally, experiment 9 and 14 was quietly close value.

Table 4.7: Average surface roughness for 2 sets of experiment with overlap 0.40 mm

Number of Pattern	Surface Roughness, µm			Average Surface Roughness, µm
	1st	2nd	3rd	
21	0.667	0.688	0.678	0.678
22	0.426	0.419	0.422	0.422

Table 4.8: Average surface roughness for 2 sets of experiment with overlap 0.05 mm

Number of Pattern	Surface Roughness, µm			Average Surface Roughness, µm
	1st	2nd	3rd	
23	0.546	0.534	0.549	0.543
24	0.786	0.778	0.781	0.782

Turning now to the experimental evidence on average surface roughness with different overlap which is 0.40 mm and 0.05 mm. As we can see both Table 4.7 and 4.8 using same constant variables which is frequency 100Hz and scanning speed 5m/s. Surface roughness at experiment 22 was the low average surface roughness compared experiment 21 with the . In experiment 23 has the low average surface roughness while experiment 24 has high surface roughness.

By analyzing the results of surface roughness in graph as displayed on Figure 4.7 and 4.8, we are able to interpret the relationship between the variables. From the first figure, the relation between the average surface roughness of insert and the eight grinding experiments. Experiment 12 gave the lowest average surface roughness evidently while experiment 13 gave the largest.

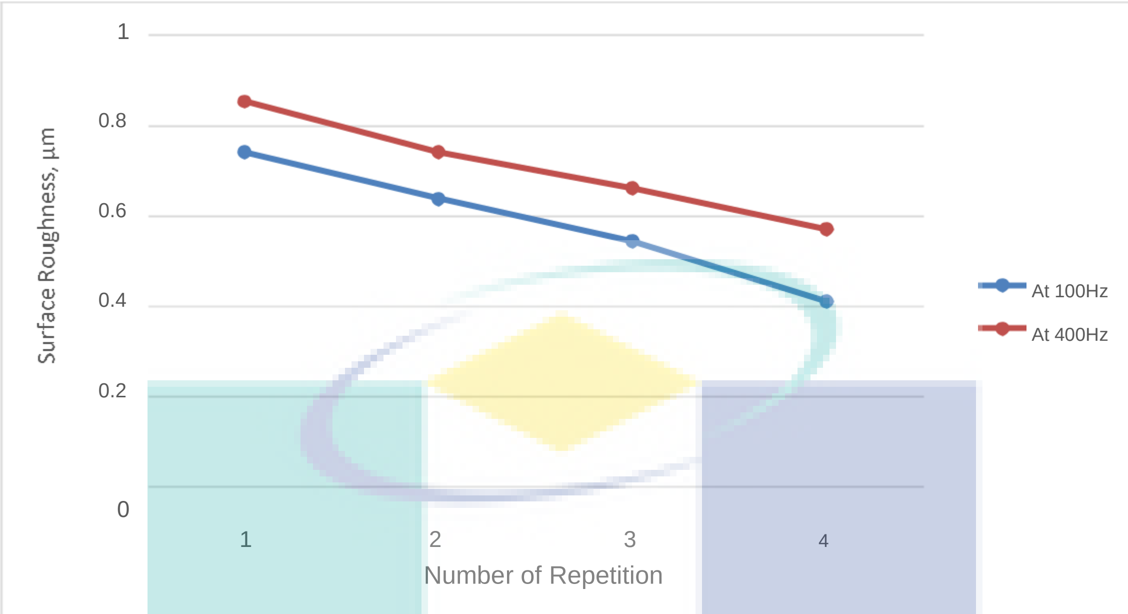


Figure 4.7: Graph of average surface roughness against number of repetition at 100Hz and 400Hz

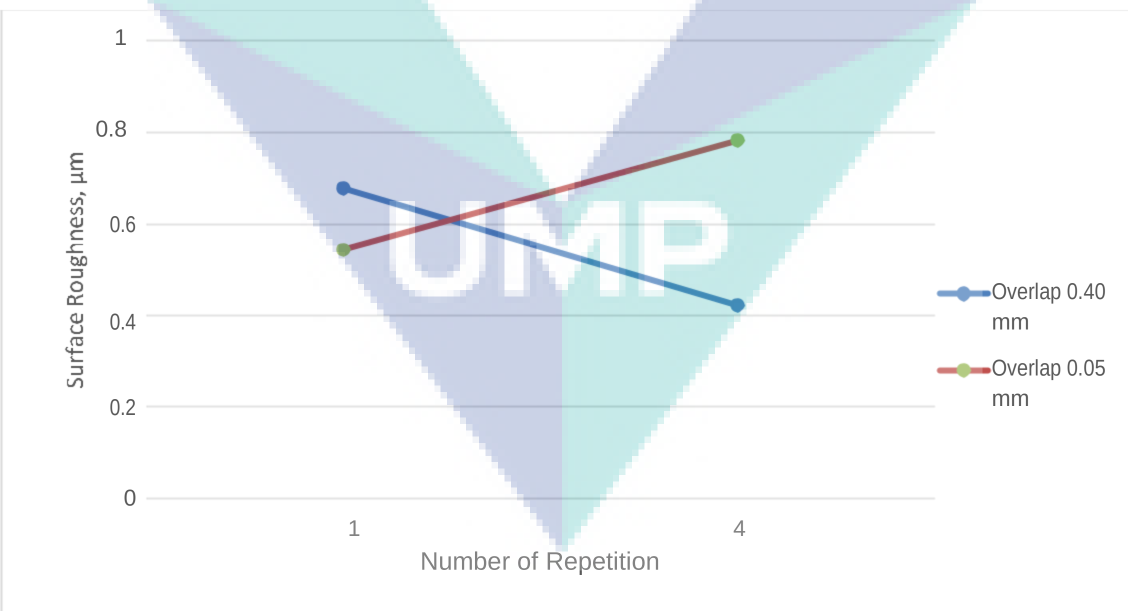


Figure 4.8: Graph of average surface roughness against number of repetition with overlap 0.40 mm and 0.05 mm

From Figure 4.7, it indicates the relationship between the average surface roughness at frequency 100Hz and 400Hz with the number of repetition in the laser experiments. The roughness at 100Hz resulted in the lowest average surface roughness with the number of repetition at experiment 12. However, the roughness at 400Hz resulted in the lowest average surface roughness with the medium number of repetition. The only similarity of these experiments was resulted in the largest average surface roughness with the highest number of repetition. In other words, the larger number of repetition, the larger the average surface roughness of insert will be fabricated.

While in Figure 4.8 shows the overlap not only affected the surface roughness but also the frequency. In fact, the smaller the overlap, the larger the surface roughness as well as the larger frequency used, the larger surface roughness. This is because of the frequency can relate to the vibration appear during the laser experiment. As a result, the higher frequency use can make the stronger vibration appear which can make the composition in the carbide insert collide. (D. Kümmel, Hamann-Schroer, Hetzner, & Schneider, 2019)

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter will conclude the findings, limitations and recommendations acquired throughout the project. Findings which were related to the project objectives as stated in the first chapter will be interpreted. Limitations found in this project will be discussed and then appropriate recommendations will be proposed to improve this project in the future.

5.2 INTERPRETATION OF FINDINGS

By comparing and modifying the previous research studied by (Etsion, 2004), we can state that the laser process is capable to fabricate certain textures on the rake surface of carbide insert even though the textures are generally irregular and inconsistent. These textures are still possesses depth and surface roughness in order to improve the mechanical seals. These then are effective to minify the cutting force and reduce the tool wear for a cutting process. This is also one of the objectives that researchers are pursuing recently.

Based on the results acquired from laser test, we found that a higher depth of cut rake surface of carbide insert and a lower frequency will contribute to a lower surface roughness on the carbide insert rake surface. It is beneficial for the cutting process to diminish the cutting friction and cutting force and thus tool wear.

Furthermore, depth, surface roughness and overlap are discovered to result in different constant variables and controlled variables in laser process. In frequency 100Hz will produced high depth of cut due to the number of repetition of the laser and low surface roughness appeared compared to frequency 400Hz which is contrast from other experiments.

Last but not least, pattern for carbide insert was determined successfully via laser test in experiment 12. The carbide inserts perform better in those condition without causing any tool wear. However, in n controlled the overlap, the textured of carbide insert become high surface roughness as well as high the built-up-edge (BUE) due to the number of repetitions.

5.3 LIMITATIONS

After conducting the experiments, there were certain limitations discovered in this project. These limitations were affected by several weaknesses and should be eliminated by alternative methods in the experiments in order to enhance the reliability of the results. The relevant limitations or weaknesses were described in the following section.

During the laser test for the carbide insert, there were several problems found. The laser marking machine indicator is not bright which no laser output because of the signal cable not connect well. Besides, the high frequency of the laser can cause the strong vibration on surface carbide insert as well as can break the carbide insert. Those problem would be interrupt the experiments make the pattern became rough. By reviewing the literatures in previous chapter, it can be explained with some reasons. Because of that, the depth of the carbide insert unable to be measured properly due to the limitation equipment.

Lastly, there was another limitation found when collecting the result data. The surface roughness tester which is a contact-type measuring instrument used in this project performed with a medium accuracy for collecting the surface roughness data. Sometimes, the stylus tip of the tester is incapable to fit into or measure smaller textures on the carbide insert due to its large radius. It may lead to inaccuracy and imprecision of data collection when measuring and yet comparing the surface roughness of textured carbide inserts with different laser parameters.

5.4 RECOMMENDATIONS

In order to deal with the first limitations as stated in the previous section, and appropriate modification of the laser experiments should be taken. We need to reconnect the signal line or check the machine before use it. Besides, we must follow the Standard Operating Procedure (SOP). In addition, the frequency need to adjust to not give the carbide insert vibrate and break. Thus, the accurate readings can be taken and utilize in this experiments.

For the last limitation, appropriate equipment can be used to improve the reliability of data collection when measuring the surface roughness of carbide insert. Non-contact surface roughness and profile measuring instruments are recommended such as 3D laser scanning microscope. As comparing to the contact-type measuring instrument, the 3D laser scanning microscope provides higher measurement accuracy by measuring smaller asperity on the surface. It uses the confocal principle and a laser as the light source, to measure the asperity of the target's surface. It also offers quick measurement without damaging the sample surface. Another method to be applied to improve the reliability of surface roughness measurement is to collect more readings. With more readings collected, the accuracy of the average surface roughness will be improved and yet the standard deviation will be closer to the mean or average data. Therefore, eight readings should be taken instead of three in the further experiments.

In a nutshell, these recommended solutions or alternative methods are suggested for improving the accuracy of result in this project. In future work, simulation results can also be included or compared to this project since the scope of this project only includes the experimental results.

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Table 4.3 and Table 4.4 compares the results average depth of rake surface of carbide insert with overlap 0.40 mm and 0.05 mm. It can be seen experiment 21 has the low average depth compared to the experiment 22. Same goes to experiment 23 and 24.

By considering the results of average depth in graph as illustrated on Figure 4.5 and 4.6, we are prepared to clarify the relationship between the variables. From the first figure, the relation between the average depth of insert and the eight laser experiments. Experiment 9 gave the lowest average depth evidently while experiment 16 gave the largest.

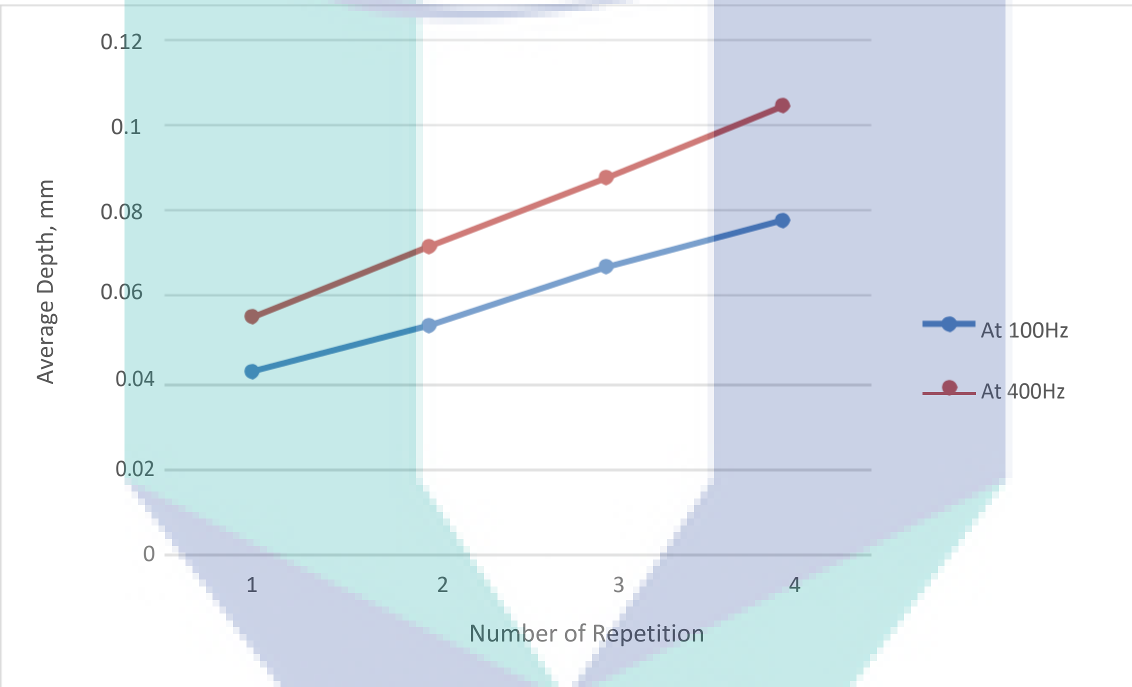

Figure 4.5: Graph of average depth against number of repetition at 100Hz and 400Hz

Figure 4.6: Graph of average depth against number of repetition with overlap 0.40 mm and 0.05 mm

From Figure 4.5, it points out the relationship between the average depth at 100Hz and 400Hz depth of cut with number of repetition in the laser experiments. Depth of cut at 100Hz resulted in the lowest average depth with the lowest number of repetition. On the other hand, the depth of cut with 400Hz resulted in the highest average depth with the medium number of repetition. The only similarity of these two depths of cut was that both of them resulted in the largest average depth with the highest number of repetition. In other words, the larger the number of repetition, the larger the average depth of insert will be fabricated.

According to Figure 4.6, it shows the relation between the average depths with overlap 0.40 mm and 0.05 mm while the constant variable are frequency and scanning speed. Depth of cut at both overlap resulted in the lowest average depth with the lowest number of repetition.

4.4 SURFACE ROUGHNESS OF CARBIDE INSERT SURFACE

As described in the previous methodology section, the surface roughness of the carbide insert textured rake surface, was measured. An average measurement was taken by using three preliminary readings. A preliminary result for the surface roughness of textured carbide insert was determined successfully as shown in Table 4.1. The measurement setting was given to be measurement length = 5.16 mm.

Table 4.5: Average surface roughness for 4 sets of experiment at 100Hz

Number of Experiment	Surface Roughness, µm			Average Surface Roughness, µm
	1st	2nd	3rd	
9	0.753	0.734	0.737	0.741
10	0.659	0.623	0.631	0.638
11	0.557	0.551	0.525	0.544
12	0.409	0.407	0.415	0.410

Table 4.6: Average surface roughness for 4 sets of experiment at 400Hz

Number of Experiment	Surface Roughness, µm			Average Surface Roughness, µm
	1st	2nd	3rd	
13	0.835	0.833	0.895	0.854
14	0.741	0.726	0.76	0.742
15	0.652	0.678	0.655	0.662
16	0.574	0.563	0.578	0.571

According to the result from Table 4.5 and Table 4.6, it was mentioned that the average surface roughness of textured carbide insert for experiment 12 was lowest, which was 0.410

μm. On the contrary, it showed that the average surface roughness of textured carbide insert for experiment 13 was the largest, which was 0.854 μm. Generally, experiment 9 and 14 was quietly close value.

Table 4.7: Average surface roughness for 2 sets of experiment with overlap 0.40 mm

Number of Pattern	**Surface Roughness, μm**			**Average Surface Roughness, μm**
	1st	**2nd**	**3rd**	
21	0.667	0.688	0.678	0.678
22	0.426	0.419	0.422	0.422

Table 4.8: Average surface roughness for 2 sets of experiment with overlap 0.05 mm

Number of Pattern	**Surface Roughness, μm**			**Average Surface Roughness, μm**
	1st	**2nd**	**3rd**	
23	0.546	0.534	0.549	0.543
24	0.786	0.778	0.781	0.782

Turning now to the experimental evidence on average surface roughness with different overlap which is 0.40 mm and 0.05 mm. As we can see both Table 4.7 and 4.8 using same constant variables which is frequency 100Hz and scanning speed 5m/s. Surface roughness at experiment 22 was the low average surface roughness compared experiment 21 with the . In experiment 23 has the low average surface roughness while experiment 24 has high surface roughness.

By analyzing the results of surface roughness in graph as displayed on Figure 4.7 and 4.8, we are able to interpret the relationship between the variables. From the first figure, the relation between the average surface roughness of insert and the eight grinding experiments. Experiment 12 gave the lowest average surface roughness evidently while experiment 13 gave the largest.

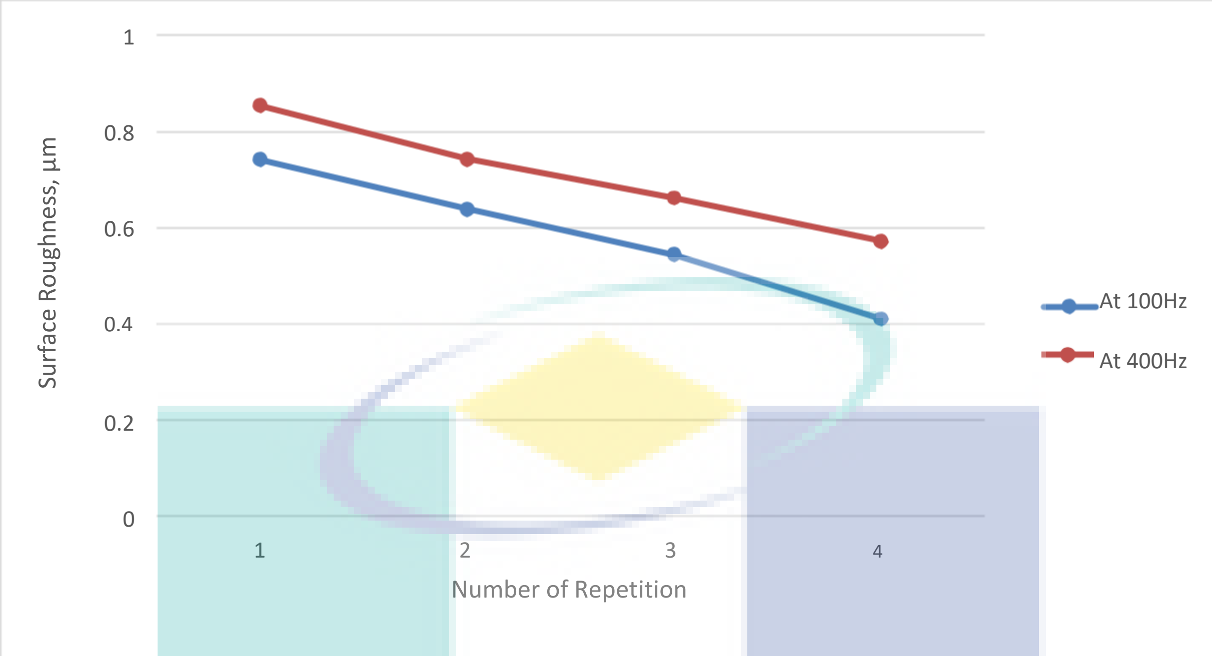

Figure 4.7: Graph of average surface roughness against number of repetition at 100Hz and 400Hz

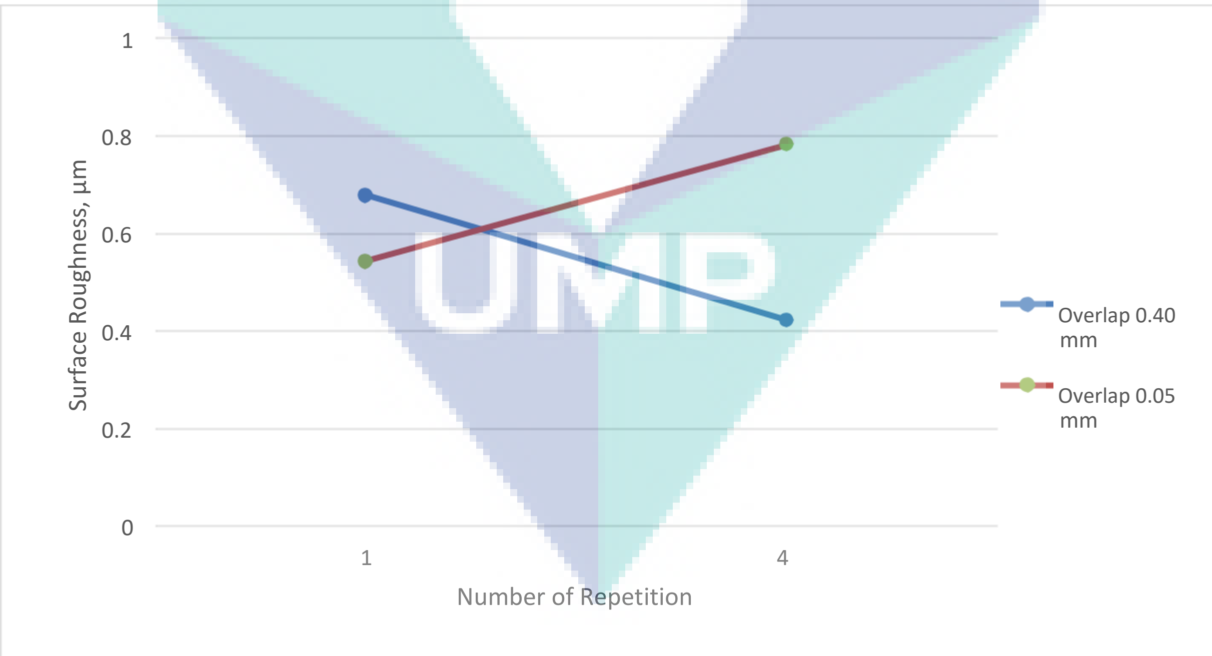

Figure 4.8: Graph of average surface roughness against number of repetition with overlap 0.40 mm and 0.05 mm

From Figure 4.7, it indicates the relationship between the average surface roughness at frequency 100Hz and 400Hz with the number of repetition in the laser experiments. The roughness at 100Hz resulted in the lowest average surface roughness with the number of repetition at experiment 12. However, the roughness at 400Hz resulted in the lowest average surface roughness with the medium number of repetition. The only similarity of these experiments was resulted in the largest average surface roughness with the highest number of repetition. In other words, the larger number of repetition, the larger the average surface roughness of insert will be fabricated.

While in Figure 4.8 shows the overlap not only affected the surface roughness but also the frequency. In fact, the smaller the overlap, the larger the surface roughness as well as the larger frequency used, the larger surface roughness. This is because of the frequency can relate to the vibration appear during the laser experiment. As a result, the higher frequency use can make the stronger vibration appear which can make the composition in the carbide insert collide. (D. Kümmel, Hamann-Schroer, Hetzner, & Schneider, 2019)

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter will conclude the findings, limitations and recommendations acquired throughout the project. Findings which were related to the project objectives as stated in the first chapter will be interpreted. Limitations found in this project will be discussed and then appropriate recommendations will be proposed to improve this project in the future.

5.2 INTERPRETATION OF FINDINGS

By comparing and modifying the previous research studied by (Etsion, 2004), we can state that the laser process is capable to fabricate certain textures on the rake surface of carbide insert even though the textures are generally irregular and inconsistent. These textures are still possesses depth and surface roughness in order to improve the mechanical seals. These then are effective to minify the cutting force and reduce the tool wear for a cutting process. This is also one of the objectives that researchers are pursuing recently.

Based on the results acquired from laser test, we found that a higher depth of cut rake surface of carbide insert and a lower frequency will contribute to a lower surface roughness on the carbide insert rake surface. It is beneficial for the cutting process to diminish the cutting friction and cutting force and thus tool wear.

Furthermore, depth, surface roughness and overlap are discovered to result in different constant variables and controlled variables in laser process. In frequency 100Hz will produced high depth of cut due to the number of repetition of the laser and low surface roughness appeared compared to frequency 400Hz which is contrast from other experiments.

Last but not least, pattern for carbide insert was determined successfully via laser test in experiment 12. The carbide inserts perform better in those condition without causing any tool wear. However, in n controlled the overlap, the textured of carbide insert become high surface roughness as well as high the built-up-edge (BUE) due to the number of repetitions.

5.3 LIMITATIONS

After conducting the experiments, there were certain limitations discovered in this project. These limitations were affected by several weaknesses and should be eliminated by alternative methods in the experiments in order to enhance the reliability of the results. The relevant limitations or weaknesses were described in the following section.

During the laser test for the carbide insert, there were several problems found. The laser marking machine indicator is not bright which no laser output because of the signal cable not connect well. Besides, the high frequency of the laser can cause the strong vibration on surface carbide insert as well as can break the carbide insert. Those problem would be interrupt the experiments make the pattern became rough. By reviewing the literatures in previous chapter, it can be explained with some reasons. Because of that, the depth of the carbide insert unable to be measured properly due to the limitation equipment.

Lastly, there was another limitation found when collecting the result data. The surface roughness tester which is a contact-type measuring instrument used in this project performed with a medium accuracy for collecting the surface roughness data. Sometimes, the stylus tip of the tester is incapable to fit into or measure smaller textures on the carbide insert due to its large radius. It may lead to inaccuracy and imprecision of data collection when measuring and yet comparing the surface roughness of textured carbide inserts with different laser parameters.

5.4 RECOMMENDATIONS

In order to deal with the first limitations as stated in the previous section, and appropriate modification of the laser experiments should be taken. We need to reconnect the signal line or check the machine before use it. Besides, we must follow the Standard Operating Procedure (SOP). In addition, the frequency need to adjust to not give the carbide insert vibrate and break. Thus, the accurate readings can be taken and utilize in this experiments.

For the last limitation, appropriate equipment can be used to improve the reliability of data collection when measuring the surface roughness of carbide insert. Non-contact surface roughness and profile measuring instruments are recommended such as 3D laser scanning microscope. As comparing to the contact-type measuring instrument, the 3D laser scanning microscope provides higher measurement accuracy by measuring smaller asperity on the surface. It uses the confocal principle and a laser as the light source, to measure the asperity of the target's surface. It also offers quick measurement without damaging the sample surface. Another method to be applied to improve the reliability of surface roughness measurement is to collect more readings. With more readings collected, the accuracy of the average surface roughness will be improved and yet the standard deviation will be closer to the mean or average data. Therefore, eight readings should be taken instead of three in the further experiments.

In a nutshell, these recommended solutions or alternative methods are suggested for improving the accuracy of result in this project. In future work, simulation results can also be included or compared to this project since the scope of this project only includes the experimental results.

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Appendics

A GANTT CHART

GANTT CHART FOR FINAL YEAR PROJECT 1																
TASK	STATUS	YEAR 2018														
		SEPTEMBER				OCTOBER				NOVEMBER				DECEMBER		
		Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15
Project Introduction Decide project title with supervisor Discuss problem statement, objective and scope of project	Plan															
	Actual															
Review Literature Work Review journals and books Find additional knowledge about the project	Plan															
	Actual															
Drafting of Introduction	Plan															
	Actual															
Drafting of Literature Review	Plan															
	Actual															
Methodology Discuss design of experiment with supervisor Decide experiment plans	Plan															
	Actual															
Drafting of Methodology	Plan															
	Actual															
Preliminary Results and Discussion Analyze data with written text	Plan															
	Actual															
Drafting of Results and Discussion	Plan															
	Actual															
Submission of Final Year Project Proposal to supervisor	Plan															
	Actual															
Final Year Project Proposal Presentation	Plan															
	Actual															
Submission of Final Year Project Proposal to faculty	Plan															
	Actual															
Preparation for Final Year Project in the following semester	Plan															
	Actual															

GANTT CHART FOR FINAL YEAR PROJECT 2																
TASK	STATUS	YEAR 2018														
		FEBRUARY			MARCH				APRIL			MAY				
		Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15
Discussion with Supervisor	**Plan**															
Decide the following progress	**Actual**															
Final Textures Fabrication	**Plan**															
Fabricate design on carbide	**Actual**															
Evaluation of Textures	**Plan**															
Inspect textures via equipment	**Actual**															
Investigation of Carbide Insert	**Plan**															
Rake Surface	**Actual**															
Final Evaluation Test A	**Plan**															
Evaluation of Depth	**Actual**															
Drafting of Results and Discussion	**Plan**															
	Actual															
Final Evaluation Test B	**Plan**															
Evaluation of Surface Roughness	**Actual**															
Drafting of Results and Discussion	**Plan**															
	Actual															
Conclusion Writing	**Plan**															
	Actual															
Poster Drafting	**Plan**															
	Actual															
Thesis Writing	**Plan**															
	Actual															
Poster Presentation	**Plan**															
	Actual															
Thesis Submission	**Plan**															
	Actual															

B 6-PAGE PAPER

EFFECT OF SURFACE TEXTURES ON CARBIDE INSERT TO THE FRICTION BEHAVIOR OF ALUMINUM ALLOY IN TURNING PROCESS

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ABSTRACT - This thesis introduces the effect of textures on carbide insert rake surface to the surface roughness on using laser surface texturing. Surface texturing is one of the techniques for enhancing tribological properties of mechanical components. This is also widely used which contributes a lot in numerous engineering applications. Various parameters of pattern have been used to improve tribological performance. Parallel grooves has been used because able to trap wear debris, change stress distribution and low surface roughness. The fabrication of textures on carbide insert surface is one of the predominant methods to enhance the sustainability of laser process with cemented carbide insert. Laser process was utilized using CK-FB3D 3-Axis Control fiber laser marker to fabricate textures that were effective use to cut the tool. Olympus BX51M metallurgical microscope was using to check condition of the rake surface carbide insert. After that, depth of cut of the laser on the carbide insert was investigate using video measuring system. Furthermore, the surface roughness was utilized using surface roughness tester. Carbide insert has been tested using four parameters and found that relatively low scanning speed and frequency resulted in less surface roughness for textured carbide insert. Low surface roughness was discovered because high hardness of the carbide insert would make the less friction when cutting the tool.

Keywords Surface textures; Carbide insert; Surface roughness; Comparison design.

INTRODUCTION

Surface texture is to examine friction and wear has been the focus of several studies in the last few decades. Surface texture is the characteristic or consistency of a surface. It is also known as surface topography which consist three characteristic such as roughness. Furthermore, surface topography is defined by surface orientation and roughness as well as topical deviations and inaccurate tendency of a surface from verity plane that appears like absolutely flat by naked eyes. Surface roughness is known as roughness or surface finish which comprises of finely spaced micro surface irregularities resulted from different machining operations.

A cemented tungsten carbide insert was capable to be laser with a micro-depth on its rake surface using fibre laser marker [1]. At first, canning speed and overlap can be maintained constant as we are using different frequency and number of repetition of the carbide insert for the investigation. On the next experiment, scanning speed and frequency are considered as parameters when we are using overlap and number of repetition as manipulated variables for the experiment [2].

In addition, another research was proposed in cutting laser using fibre laser technology to develop textures on the rake surface of cemented carbide insert in a structure of nano or micro scale periodic groove. A linear polarized femtosecond laser of energies was able to generate nano or micro grooves periodically and precisely. Milling process was introduced in cutting of aluminum alloy and a larger friction was produced as the grooves on the insert rake surface were perpendicular to the cutting edge. It led to a worse damage and stronger adhesion on the cutting edge of insert apparently too. It concluded that a parallel grooves on the insert rake surface to the main cutting edge will improve the anti-adhesive effect strongly by using fibre laser marker [3].

Recently, another study generated three types of textured on the rake surface of cemented carbide insert using laser technology. Parallel grooves, circular dimples and rectangular dimples were generated respectively on the cemented carbide insert. The cutting performance was examined and compared by analysing the scanning speed, cutting force, insert adhesion, friction coefficient, and the machined surface quality. A low scanning speed was found to result in a good cutting performance as using textured inserts especially the insert which was textured with parallel grooves. However, the investigation of depths of groove and dimple are undefined in the research even though it is possible to affect the cutting performance [4].

Laser surface texturing was discovered triblogical behaviors on the surface textured. Within with the same area concerning 10 times, dimples and groove's structure was created by using low scanning speed. Most of the researchers using low scanning speed to induce an ideal parallel grooves or other design in femtosecond laser. During this experiment, the dimple geometry showed the best result in the suitable material and anti-wear properties [5]. Besides, to investigate between three surfaces textured structures that is micro-dimples, micro-grooves and micro grids. The result showed that micro-grids is the best design to be chosen because of a few factors such as diameter and spacing, hardness and friction analysis. After make a laser surface texture the foremost changes that happen is hardness. Therefore micro grooves can absorb more energy than micro dimples and micro-grids since has the highest hardness value [6].

In order to improve the rake face on cemented carbide cutting tools may be tested by applying electro-discharge machining (micro EDM). Throughout this experiment, micro EDM was used high-frequency vibration machining to increase the dimension of the cutting tools. The result show that there was no adhesion existed on the cutting tool rake face and no debris also around the cavities. To avoid decreasing of mechanical strength of cutting tools, the depth of the linear grooves and micro holes determined to have an actual value. This research was proved that high-frequency vibration machining will assist on cutting tool and can be performed well on fabricating accurate and expected micro-scale textures [7]. Turning experiments in both dry and cryogenic minimum quantity lubrication (CMQL) conditions were conducted using textured cemented carbide cutting tool and lathe machine. Lubricant oil was applied in the CMQL condition. Titanium alloy was used as the work piece in this experiment. It was concluded that the cutting tool with microgroove arrays gave better cutting performance in CMQL condition compared to dry condition. It is because the microgroove preserves the lubricants on the rake surface which is capable to reduce the friction at the tool and chip interface during cutting process [8].

Besides, the carbide insert behaviour can be improved laser surface texturing. The micro grooves textured surface was developed on cutting tool to effectively diminish the adhesive behaviour [9]. The micro-textures acted as reservoir to store lubricant and reduce the contact area during cutting [10].

This paper is conducted to deliver the effect of laser surface textured of carbide insert to the by undergoing laser process. The surface texture on the laser carbide insert will be fabricated. The depth of laser process will be investigated as one of the critical parameters to result different textures on the carbide insert rake surface. The surface textures fabricated on the rake surface of carbide insert will be investigated using metallurgical microscope and surface roughness tester. Then, the condition of carbide insert rake surface can be investigated after undergoing surface roughness test. This method allows us to enhance the sustainability of laser process by using textured cutting tool insert to improve the anti-adhesive. Furthermore, this paper also determines and compares the effects parameters carbide insert to the laser process. The surface of carbide insert was investigated to have textures in micro scale in order to alter the tribological performance and thus improve the overall machining performance.

METHODOLOGY

This paper was distributed to one main parts which were texture fabricating process and work piece cutting process. Texture fabricating process was conducted as laser test. Firstly, an appropriate model DNMA 150608 of carbide insert cutting tool was selected to undergo surface texturing fabrication via laser process. A preliminary laser test was conducted to acquire the largest roughness of textures on carbide insert. Such large roughness was discovered to retain lubricant and reduce adhesive behavior of carbide inser [10].

I. Laser test

CK-FB3D 30W Fiber Laser Marker was applied to fabricate textures on the carbide insert rake surface as illustrated in Figure 1. The carbide insert was first being clamped firmly on a vice which is electromagnetically to be held on the magnetic work table. The vise was then being setup on the magnetic work table and ready to be laser. The speed of reciprocating work table and the depth of cut for the carbide inserts were the controlled variables. The cutting tip of the carbide insert was laser in a direction parallel to the grinding wheel as illustrated in Figure 2. The laser direction for every depth of cut was designed to be only one single direction. It meant that the laser pointer will only move down every time it returned to its starting point at the right side of the carbide insert.

For preliminary laser test, the speed of reciprocating work table was tested 5 m/s and 20 m/s, frequency 100 Hz and 400 Hz while the overlap was tested with 0.1 mm, 0.40 mm and 0.05 mm. The number of repetition was from 1 time to 4 timed. Afterward, 5 m/s, 100 Hz, 0.1 mm and 4 times number of repetition were selected as the optimal speed of reciprocating work table and depth of cut in order to fabricate the lowest roughness of textures on carbide insert. The texture roughness was investigated using metallurgical microscope and surface roughness tester.

Figure 1. CK-FB3D 3-Axis Control Fiber Laser Marker

There were 12 experiments conducted in this laser test. From table 1 until table 3 displayed the experimental setting and parameters for the 12 experiments of laser test.

Table 1. Constant variables of the laser test at frequency 100Hz and 400Hz

Constant variable	Overlap, mm	0.1
	Scanning speed, m/s	5

Table 2. Controlled variables of the laser test at frequency 100Hz and 400Hz

Controlled Variable	Frequency, Hz	9-12	100
		10-16	400
	Repetition	9, 13	1x
		10, 14	2x
		11, 15	3x
		12, 16	4x

Table 3. Constant variable of the laser test for the overlap 0.40mm and 0.05mm

Constant variable	Frequency, Hz	100
	Scanning speed, m/s	20

Table 4. Controlled variables of the laser test for the overlap 0.40mm and 0.05mm

Controlled Variable	Overlap, mm	21-22	0.40
		23-24	0.05
	Repetition	21, 23	1x
		22, 24	4x

II. *Evaluation depth of surface texture test*

The video measuring system and Motic Image Plus 3.0 software was applied to observe the depth of carbide insert and the condition of textures on the rake surface of each carbide insert as illustrated in Figure 3. The textured rake surface of the carbide insert should be facing upwards when being secured on the cutting tool holder.

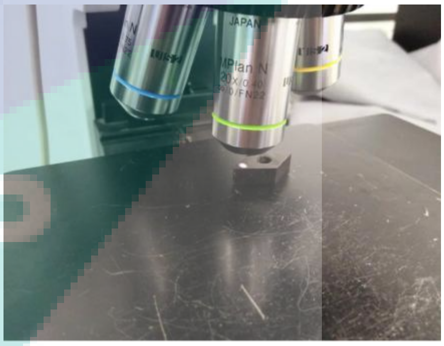

Figure 2. Experiment setup for depth test

III. *Evaluation of rake surface on carbide insert*

After completed laser test, the rake surfaces of the carbide insert were investigated using metallurgical microscope. The condition of the Built-Up-Edge (BUE) on the each rake surface were inspected using the metallurgical microscope as shown in Figure 4. The condition of the textures on the carbide insert rake surface was inspected and captured by using the 20x lens of microscope software.

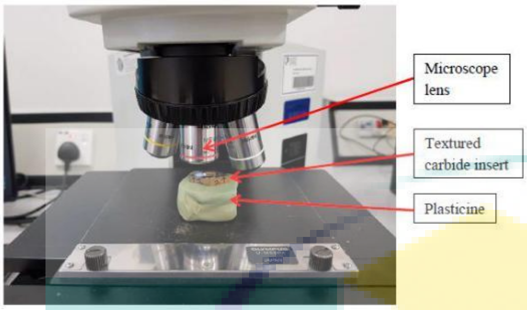

Figure 3. Experiment setup for texture evaluation

IV. Evaluation of surface roughness of surface texture

After completed all of the laser experiments, the surface roughness tester was applied to measure the average surface roughness of the textures fabricated on the rake surface of each carbide insert. The carbide insert was clamped properly with a vice and the textured surface to be measured was facing upwards with contacting to the stylus. The surface roughness of the textures was measured by the contacting of the stylus to the texture area on the carbide insert rake surface and was displayed on the machine.

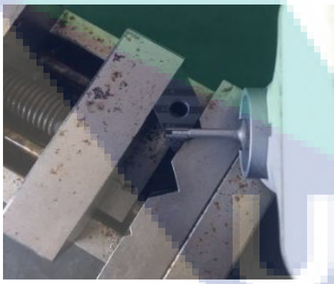

Figure 5. Experiment setup for surface roughness measurement

RESULTS AND DISCUSSION

I. Condition of carbide insert rake surface

The condition of textured carbide insert rake surface for the two grinding experiments was illustrated in the following section. All the images were investigated and roughly captured by camera.

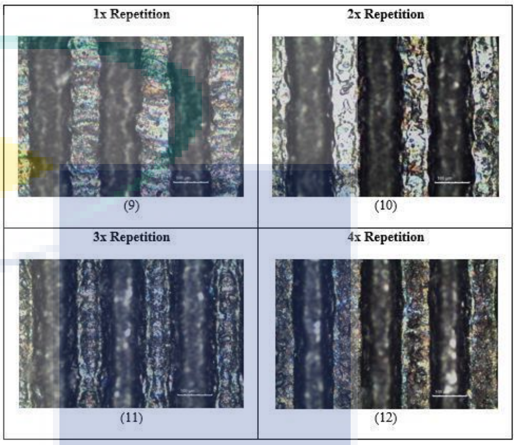

Figure 6. Number of experiment of carbide insert rake surface at frequency 100Hz

The figure above shows that the surface of experiment of carbide insert which were fabricated via laser surface technology at 100Hz. The surface of carbide insert has been investigated through the metallurgical microscope. As can be seen Experiment 9 shows the highest built-up-edge (BUE) due to the number of repetition while Experiment 12 shows the lowest BUE.

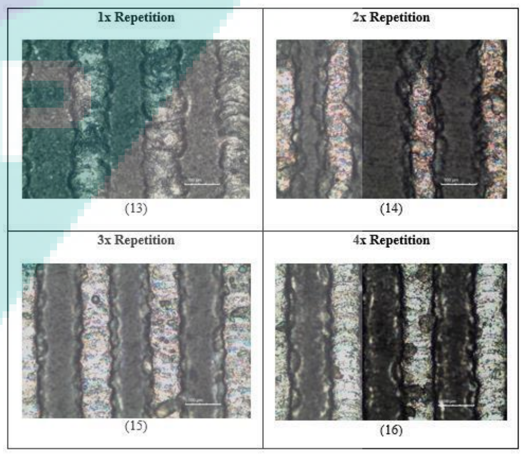

Figure 7. Number of experiment of carbide insert rake surface at frequency 400Hz

However, in the Experiment 13 to 16 are using similar method to investigate the surface of carbide insert but using different frequency which is 400Hz. It shows that Experiment 14 has the highest BUE compared to the Experiment 16. This is because of composition in the carbide insert was changed during using the laser due to the frequency are too higher compared to the previous experiment in Figure 6**.** Since the overlap and scanning speed were kept constant throughout the experiments, they had no much affected to the textures fabricated.

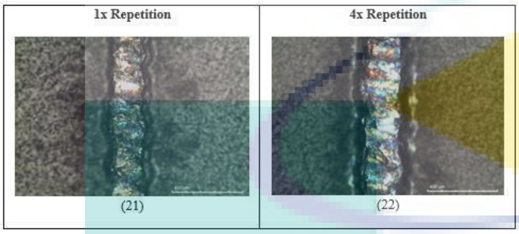

Figure 8. Number of experiment of carbide insert rake surface with overlap 0.40 mm

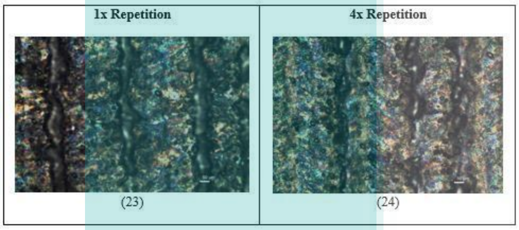

Figure 9. Number of experiment of carbide insert rake surface with overlap 0.05 mm

On the other hand, the Figure 8 and Figure 9 shows the rake surface of carbide insert by using the different constant variable which is frequency and scanning speed while the controlled variable is overlap and number of repetition. It can be seen experiment 21 has low BUE and experiment 22 has high BUE due to the number of repetition. Even so, both experiment 23 and 24 has highest BUE rake surface because of the smaller overlap which make the lines redundant.

All things considered, from all the experiment the texture of carbide insert rake surface from experiment 12 and 16 showed better evenness as compared to others. This is because, the low BUE on the rake surface, the higher hardness of the of the carbide insert.

II. Average depth of carbide insert surface

The depth of the carbide insert, mm was measured. The result was taken by using the readings and was determined as shown in Table 5.

Table 5. Average depth for 4 sets of experiments at frequency 100Hz

Number of Experiment	Average Depth, mm
9	0.0420
10	0.0529
11	0.0667
12	0.0776

According to figure above, the rake surface of carbide insert was capable of be laser into textures, which were parallel to the cutting edge as expected. However, the width and depth of the textures obtained were basically irregular compared to those textures which were fabricated via laser technology. The largest depth of texture was determined for each experiments 9 to 12 which was 0.0776 mm at frequency 100 Hz.

Table 6. Average depth for 4 sets of experiments at frequency 100Hz

Number of Experiment	Average Depth, mm
13	0.0549
14	0.0714
15	0.0876
16	0.1045

It can be concluded that Experiment 16 have the largest depth of texture while Experiment 9 gave the smallest depth of texture as compared to the rest of 16 experiments. The depth of texture was affected by the experiment parameters which were scanning speed and frequency. The number of repetition also affected the outcome of the textures. Since the scanning speed and the frequency were keep constant throughout the experiments, they had no much influences to the textures.

Table 7. Average depth for 2 sets of experiments with overlap 0.40 mm

Number of Experiment	Average Depth, mm
21	0.0493
22	0.0748

Table 8. Average depth for 2 sets of experiments with overlap 0.05 mm

Number of Experiment	Average Depth, mm
23	0.0366
24	0.0584

Table 7 and Table 8 compares the results average depth of rake surface of carbide insert with overlap 0.40 mm and 0.05 mm. It can be seen experiment 21 has the low average depth compared to the experiment 22. Same goes to experiment 23 and 24.

By considering the results of average depth in graph as illustrated on Figure 10 and 11, we are prepared to clarify the relationship between the variables. From the first figure, the relation between the average depth of insert and the eight laser experiments. Experiment 9 gave the lowest average depth evidently while experiment 16 gave the largest

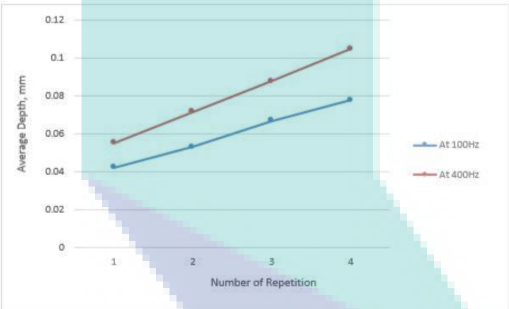

Figure 10. Graph of average depth against number of repetition at 100Hz and 400Hz

Figure 11. Graph of average depth against number of repetition with overlap 0.40 mm and 0.05 mm

From Figure 10, it points out the relationship between the average depth at 100Hz and 400Hz depth of cut with number of repetition in the laser experiments. Depth of cut at 100Hz resulted in the lowest average depth with the lowest number of repetition. On the other hand, the depth of cut with 400Hz resulted in the highest average depth with the medium number of repetition. The only similarity of these two depths of cut was that both of them resulted in the largest average depth with the highest number of repetition. In other words, the larger the number of repetition, the larger the average depth of insert will be fabricated.

According to Figure 11, it shows the relation between the average depths with overlap 0.40 mm and 0.05 mm while the constant variable are frequency and scanning speed. Depth of cut at both overlap resulted in the lowest average depth with the lowest number of repetition.

III. Surface roughness of carbide insert surface

The surface roughness of the carbide insert textured rake surface, was measured. An average measurement was taken by using three preliminary readings. A preliminary result for the surface roughness of textured carbide insert was determined successfully as shown in Table 4.1. The measurement setting was given to be measurement length = 5.16 mm.

Table 9. Average surface roughness for 4 sets of experiment at 100Hz

Number of Experiment	Average Surface Roughness, µm
9	0.741
10	0.638
11	0.544
12	0.410

Table 10. Average surface roughness for 4 sets of experiment at 400Hz

Number of Experiment	Average Surface Roughness, µm
13	0.854
14	0.742
15	0.662
16	0.571

According to the result from Table 9 and Table 10, it was mentioned that the average surface roughness of textured carbide insert for experiment 12 was lowest, which was 0.410 µm. On the contrary, it showed that the average surface roughness of textured carbide insert for experiment 13 was the largest, which was 0.854

μm. Generally, experiment 9 and 14 was quietly close value.

Table 11. Average surface roughness for 2 sets of experiment with overlap 0.40 mm

Number of Experiment	Average Surface Roughness, μm
21	0.678
22	0.422

Table 12. Average surface roughness for 2 sets of experiment with overlap 0.05 mm

Number of Experiment	Average Surface Roughness, μm
21	0.678
22	0.422

Turning now to the experimental evidence on average surface roughness with different overlap which is 0.40 mm and 0.05 mm. As we can see both Table 11 and 12 using same constant variables which is frequency 100Hz and scanning speed 5m/s. Surface roughness at experiment 22 was the low average surface roughness compared experiment 21 with the . In experiment 23 has the low average surface roughness while experiment 24 has high surface roughness.

By analyzing the results of surface roughness in graph as displayed on Figure 11 and 12, we are able to interpret the relationship between the variables. From the first figure, the relation between the average surface roughness of insert and the eight grinding experiments. Experiment 12 gave the lowest average surface roughness evidently while experiment 13 gave the largest.

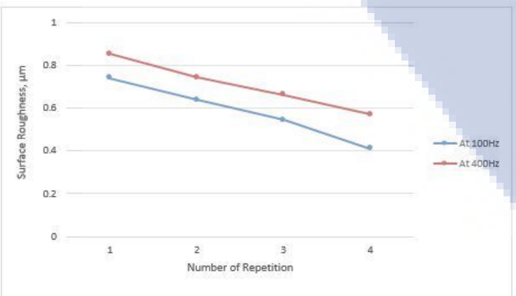

Figure 12. Graph of average surface roughness against number of repetition at 100Hz and 400Hz

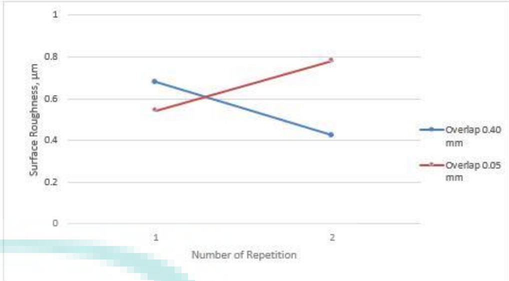

Figure 13. Graph of average surface roughness against number of repetition with overlap 0.40 mm and 0.05 mm

From Figure 12, it indicates the relationship between the average surface roughness at frequency 100Hz and 400Hz with the number of repetition in the laser experiments. The roughness at 100Hz resulted in the lowest average surface roughness with the number of repetition at experiment 12. However, the roughness at 400Hz resulted in the lowest average surface roughness with the medium number of repetition. The only similarity of these experiments was resulted in the largest average surface roughness with the highest number of repetition. In other words, the larger number of repetition, the larger the average surface roughness of insert will be fabricated.

While in Figure 13 shows the overlap not only affected the surface roughness but also the frequency. In fact, the smaller the overlap, the larger the surface roughness as well as the larger frequency used, the larger surface roughness. This is because of the frequency can relate to the vibration appear during the laser experiment. As a result, the higher frequency use can make the stronger vibration appear which can make the composition in the carbide insert collide.

CONCLUSION

This paper concluded that laser process was capable to fabricate textures on carbide insert which were then effective to improve anti-adhesive behavior of carbide insert. A lower scanning speed of laser and a lower frequency resulted in lower roughness of textures on carbide insert rake surface. This lower roughness of texture had higher possibility to tribological performance.

Additionally, the results clearly indicated that textured carbide insert performed relatively better on minifying the laser process. It is beneficial for the cutting process to diminish the cutting friction and cutting force and thus tool wear. Furthermore, depth, surface roughness and overlap are discovered to result in different constant variables and controlled variables in laser process. In frequency 100Hz will produced high depth of cut due to the number of repetition of the laser and low surface roughness appeared compared to frequency 400Hz which is contrast from other experiments. Last but not least, pattern for carbide insert was determined successfully via laser test in experiment 12. The carbide inserts perform better in those condition without causing any tool wear. However, in n controlled the overlap, the textured of carbide insert become high surface roughness as well as high the built-up-edge (BUE) due to the number of repetitions. These results were corresponding to the research studied by Etsion et al. (2004). Textured carbide insert was valid to reduce cutting force, friction force, and material adhesion during machining process especially when lubricant or coolant was being applied [6].

Acknowledgements

The authors gratefully acknowledge FKP UMP for offering experimental equipment in this work. The authors would also like to thank the staffs from FKP laboratories for their invaluable assistance, advice and technical support.

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Surface Texturing Potential on Carbide Insert in Reducing Aluminium Alloy Adhesiveness during Machining

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Articles Info:
Received **1 January 2019**
Received in revised form **5 March 2019**
Accepted **15 March 2019**
Available Online **26 March 2019**

Keywords:
Surface textures
Carbide insert
Adhesive behavior
Aluminum alloy
Wet cutting

ABSTRACT

Aluminum alloy is a widely used material which contributes greatly in numerous engineering applications. Aluminum alloy can be considered as having low strength and it is less likely to experience tooling difficulty. However, the complexity of machining aluminum alloy is related to its adhesive behavior, which capable to impede the machining operations where build-up-edge can be observed easily to occur. Since machining process generates a lot of energy due to friction and adhesive contact between tool and material, it is suggested to apply wet cutting method during machining of aluminum alloy to decrease the likeliness of aluminum alloy chip to adhere onto the tool surface. However, this method of machining is still having low effectiveness whereas the limitation of cutting fluid to enter the tool-chip sticking zone. Thus, the fabrication of textures on carbide insert rake surface is one of the predominant methods to enhance the sustainability of turning process with aluminum alloy workpiece. In this study, grinding process was utilized using Okamoto ACC52ST surface grinding machine to fabricate textures, where it is assumed that high effectiveness of lubricant can be retained and friction at tool-chip interface can be reduced. Turning process was conducted with the application of ROMI C420 lathe machine to investigate the adhesive behavior of aluminum alloy. It is observed that, the adhesive behavior of aluminum alloy was minimized with the application of textured carbide insert especially in wet cutting condition in general. Additionally, it can observed that, even at relatively high cutting speed and depth of cut, less adhesion behavior of aluminum alloy is obtained for textured carbide insert in wet cutting condition. This can be considered as a gain in productivity, whereas the adhesive behavior for non-textured carbide insert can only be reduced if only low cutting speed condition and wet cutting method are utilized.

INTRODUCTION

Surface texture is the characteristic or consistency of a surface, where it is known as surface topography, which constitutes all the small, topical deviations and erroneous tendency of a surface from the true plane that looks like perfectly flat by naked eyes. Meanwhile, surface roughness is known as roughness or surface finish, which comprises of finely spaced micro surface irregularities resulted from different machining operations. A study had shown that an uncoated cemented tungsten carbide insert was capable to be grinded with a micro-depth on its rake surface using diamond grinding wheel [1]. The cutting speed and feed rate were maintained constant as various structures or grain sizes of insert was utilized for the investigation. In addition, another research was proposed in machining steel materials using the pre-

Dip-coating methods for carbon membrane fabrication: Effects of coating-carbonization-cycles on Hydrogen separation prepared from BTDA-TDI/MDI (P-84) polyimide blends with Nanocrystalline cellulose (NCC)

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Abstract: In this paper depicts the manufacture and assessment of tubular carbon membrane equipped from BTDA-TDI/MDI (P-84) polyimide mixes with Nanocrystalline cellulose (NCC). Given earlier investigations, we planned the theory that tubular carbon membrane performance could impose constraints by controlling the carbonization conditions which directed with a heating rate of 3°C/min, a final temperature of 800°C and adjustment time of 300°C. The principal purpose of this examination is to acquaint successful dip-coating strategies with produce superior tubular carbon membrane. The coating-carbonization cycles (1, 2, 3, and 4 times) have been considered. This methodology empowers quick and straightforward assessment of dip-coating techniques to yields high separation performance. Gas separation performance of the carbon membranes was adequately carried out by a single gas permeation experiment of H_2, and N_2 to explore the transport component in the carbon membrane separation process. In this case, the most elevated selectivity of 434.68±1.39 for H_2/N_2; side by side with H_2 permeance of 1399.66±5.22 GPU shall accomplish by employing two coating-carbonization-cycles.

Keywords: Coating-carbonization-cycle, P84 co-polyimide, Nanocrystalline cellulose (NCC), Tubular carbon membrane, and Hydrogen.

1.0 Introduction

Membrane innovation has sociably attracted many reviews in consideration with the gas separation enterprises, for example, hydrogen recovery, air separation, olefin/paraffin separation, CO_2 capture, nature gas dehydration, and many other (1-4). Carbon membrane innovation is in the process of being created promptly for these reasons. The requests on inorganic membrane have expanded because of the reduced temperature and chemical resistance of natural membrane. The hand-selected molecular sieving system of carbon membrane is especially helpful to accomplish great separation which is smooth between gases with practically relative molecular size (5-7). Some other way, this approach turns out to be more energy conservation thus progressively efficient by contrasting with other gas separations technique. In this manner, a few specialists have participated in evolving new materials with a few manufacture techniques for carbon membrane (8-11). One method is to manufacture the carbon membrane as a tubular aided membrane to limit imperfection and manage the cost of high gas separation performance (2, 12). The fundamental focal point of this examination ponders to give better comprehension of the best dip-coating process parameters to control the

A comprehensive review and perception of carbon molecular sieve membranes for hydrogen production and purification

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Abstract

Hydrogen (H_2) as a high-quality and clean energy carrier has attracted renewed and ever-increasing attention around the world in recent years, mainly due to developments in fuel cells and environmental pressures including climate change issues. In thermochemical processes for H_2 production from fossil fuels, separation and purification is a critical technology. Where water–gas shift reaction is involved for converting the carbon monoxide to H_2, membrane reactors show great promises for shifting the equilibrium. Membranes are also important to the subsequent purification of H_2. For H_2 production and purification, there are generally two classes of membranes both being inorganic: dense phase metal and metal alloys, and porous ceramic membranes. Porous ceramic membranes are normally prepared by sol–gel or hydrothermal methods, and have high stability and durability in high temperature, harsh impurity and hydrothermal environments. In particular, microporous membranes show promises in water gas shift reaction at higher temperatures. In this

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RDU1703253

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Research Project Details	
Project ID	RDU1703253
Project Title	STUDY OF AN OPTIMAL SURFACE PROPERTY OF CARBIDE CUTTING TOOL BY SURFACE MODIFICATION METHOD
Project Category	Teknologi dan Kejuruteraan (Technology dan Engineering)
Project Status	Sedang Berjalan
Start Date	30/06/2017
End Date	29/06/2019
Extension Date	29/12/2019

Lists of Researcher for RDU1703253

No	Staff ID	Staff Name	Start Date	End Date	Position
1	01832	MOHD NIZAR BIN MHD RAZALI	30/06/2017	29/06/2019	Ketua
2	0671	ZAMZURI BIN HAMEDON	30/06/2017	29/06/2019	Ahli
3	0215	AHMAD RAZLAN BIN YUSOFF	30/06/2017	29/06/2019	Ahli
4	0306	SYARIFAH NUR AQIDA BINTI SYED AHMAD	30/06/2017	29/06/2019	Ahli
5	01838	AHMAD REDZA BIN AHMAD MOKHTAR	30/06/2017	29/06/2019	Ahli
6	01854	AHMAD SHAHIR BIN JAMALUDIN	05/10/2018	29/06/2019	Ahli

Lists of External Reseacher / Collaborator for RDU1703253

Research Project Financial Info

Vote	Approved (RM)	Received (RM)	Expenditure (RM)	Balance (RM)
11000 - SALARY & WAGES	5,000.00	5,000.00	4,968.00	32.00
21000 - TRAVEL & TRANSPORTATION	2,500.00	2,500.00	2,500.00	0.00
22000 - TRANSPORTATION OF GOODS	0.00	0.00	0.00	0.00
23000 - COMMUNICATION & UTILITIES	0.00	0.00	0.00	0.00
24000 - RENTAL	0.00	0.00	0.00	0.00
26000 - SUPPLY OF RAWS MATERIALS	0.00	0.00	0.00	0.00
27000 - RESEARCH MATERIALS & SUPPLIES	10,000.00	10,000.00	10,000.00	0.00
28000 - MAINTENANCE & MINOR REPAIR SERVICES	0.00	0.00	0.00	0.00
29000 - SPECIAL SERVICES (CONFERENCE FEES <= 2500)	2,500.00	2,500.00	2,500.00	0.00
35000 - SPECIAL EQUIPMENT (NOT MORE THAN <= 40%)	0.00	0.00	0.00	0.00
Total (RM)	**20,000.00**	**20,000.00**	**19,968.00**	**32.00**

RESEARCH OUTPUT

Research Exhibition & Award Winning List

Publication List

Journal List

Conference List

Paper Title	Conference Name	Venue	Organizer	Level	Year
Dip-coating methods for carbon membrane fabrication: Effects of coating-carbonization-cycles on Hydrogen separation prepared from BTDA-TDI/MDI (P-84) polyimide blends with	4TH INTERNATIONAL MANUFACTURING ENGINEERING CONFERENCE (IMEC) 2019	The Everly Hotel, Putrajaya	Universiti Malaysia Pahang and Institut Teknologi Bandung (ITB), Indonesia		2019

blends with Nanocrystalline cellulose (NCC)					
A comprehensive review and perception	ENERGY SECURITY AND CHEMICAL	Parkroyal Resort Penang,	Universiti Malaysia Pahang		2019