FRICTION BEHAVIOR ANALYSIS IN SURFACE ROUGHNESS FOR MACHINE TOOLS

This report is submitted in accordance with requirement of the University Teknikal Malaysia Melaka (UTeM) for bachelor's degree of Manufacturing Engineering (Hons.)

by

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I hereby, declared this report entitle "Friction Behavior Analysis in Surface Roughness for Machine Tools" is the results of my research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Hons). The member of the supervisor committee is as follow:

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ABSTRACT

This main purpose of this project is about friction behavior analysis in surface roughness for machine tools. The main objective of the modern machining industry nowadays is to improve the performance of the machine to produce the best quality of a product. The productivity of the machine tool and any machined part is decided by the quality of the surface produced by that machine. As a result, surface roughness usually uses as an indicator of the quality of produce that been produced. It influences by the machining parameter such as feed rate, and spindle speed. Friction is a highly nonlinear phenomenon, especially at velocity reversal. Quadrant glitches, characterized by spikes at quadrant locations during circular motion are a direct result of this highly nonlinear behavior. The objective of this study is to identify the relationship between friction behavior and surface roughness, to investigate the surface roughness of the machining process, and identify the best parameter to reduce surface roughness. The study only involves surface roughness and roundness measurement. Few samples were prepared by using a 5-axis CNC Milling Machine and tested by using roughness tests and roundness measuring machines in FKP metrology Lab. The surface location errors are used by analyzing the angle and the feed rate at each spindle speed that has been decided. Data form the surface location error will be used to generate a stability chart. The stability chart shows that as the feed rate increase it will affect the quadrant glitch. By increasing, the feed rate will result in a larger maximum contour error. Stick-slip friction behaviour could be observed from the contouring error in a circular test. As the amplitude of the quadrant glitch increase, it also will affect the surface roughness of the product. It has been shown that by using a lower feed rate and higher spindle speed will produce a better surface finish.

ABSTRAK

Tujuan utama projek ini adalah mengenai analisis tingkah laku geseran dalam kekasaran permukaan untuk peralatan mesin. Tujuan utama industri pemesinan moden adalah untuk meningkatkan prestasi mesin untuk menghasilkan kualiti produk yang terbaik. Produktiviti alat mesin dan mana-mana bahagian mesin ditentukan oleh kualiti permukaan yang dihasilkan oleh mesin itu. Oleh sebab itu, kekasaran Permukaan biasanya digunakan sebagai petunjuk untuk kualiti hasil yang telah dihasilkan. Ia dipengaruhi oleh parameter pemesinan seperti kadar suapan, dan kelajuan. Geseran adalah fenomena yang kerap berlaku pada keadan tidak linear, terutamanya pada pembalikan halaju. Gangguan kuadran, yang dicirikan oleh lonjakan pada lokasi kuadran semasa gerakan bulat adalah hasil langsung dari tingkah laku yang sangat tidak linear ini. Objektif kajian ini adalah untuk mengenal pasti hubungan antara tingkah laku geseran dan kekasaran permukaan, untuk mengkaji kekasaran permukaan proses pemesinan, dan mengenal pasti parameter terbaik untuk mengurangkan kekasaran permukaan. Kajian ini hanya melibatkan kekasaran permukaan dan ukuran bulat. Sedikit sampel disediakan dengan menggunakan Mesin CNC Milling 5-paksi dan diuji dengan menggunakan mesin ujian kekasaran dan kebulatan di Makmal metrologi FKP. SLE digunakan dengan menganalisis sudut dan kadar suapan pada setiap kelajuan g yang telah ditetapkan. Data dari SLE akan digunakan untuk menghasilkan carta kestabilan. Carta kestabilan menunjukkan bahawa apabila kadar

suapan meningkat, ia akan mempengaruhi sudut “Glic”. Dengan meningkat, kadar suapan akan menghasilkan ralat kontur maksimum yang lebih besar. geseran “stick-slip” dapat dilihat dari kesalahan kontur dalam ujian bulat. Seiring peningkatan amplitud sudut “Glic”, ia juga akan mempengaruhi kekasaran permukaan produk. Dengan menggunakan kadar umpan yang lebih rendah dan kelajuan gelendong yang lebih tinggi akan menghasilkan kemasan permukaan yang lebih baik.

DEDICATION

To my,

Beloved father, Sahrir Bin Zulkifli

Beloved mother, Rusiah Binti Ismail

Appreciated brother and sister, Arif Shafiq, Syazwani, and Syahmin Aiman

For giving me the best of moral support, money, cooperation and also understanding

Thank you for the whole encouragement and love you all.

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CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, the main motive of the industrial machining industry is to enhance the machine's performance to produce the best quality of a product. This is usually defined as a method of removing material from the workpiece in the form of chips. To manufacture high-quality product manufacturing factories invest in a lot in research and development funding to boost the machine's performance. The researcher has invested a lot of work into finding the right method to improve machine performance.

The machine tool performance, and any machined part, is decided by the surface quality produced by the machine. Thus it is of great importance for the good functional behavior of any mechanical components to achieve good surface quality. As a result, roughness of the surface usually used as an indicator of the quality of the finished product. It is influenced by the parameter of machinings, such as feed rate, speed, cutting depth, tool geometry, chip geometry, cutting fluid, vibration, and chatter. According to Svahn et. al (2003), friction was found to depend on surface roughness where the rougher surfaces gave a higher friction coefficient. The smoother surfaces give a lower friction coefficient. Highly accurate positioning and tracking are the primary requirements for any machine tool application. They are compromised by disturbances such as friction and cutting forces (Van Brussel et. al, 2008).

Generally, this study was intended to investigate the surface roughness with milling operation in CNC. The study also designs an investigation study by using CNC machining in FKP's lab and using roughness test measurement equipment to get the result.

Milling is a commonly used method of removing material for various products. It is defined by a high rate of removal of material. Machining results in elevated friction between the instrument and the workpiece and can lead to elevated temperature, impairing product dimension precision, and surface quality.

According to Sreenivasulu et. al (2014), it is well known that the final geometry of surface roughness is influenced by various machining conditions such as spindle speed, feed rate and depth of cut

Thus, a topic for parameters such as feed rate, speed, depth of cut, tool geometry, the geometry of chip formation, cutting fluid, vibration, and chatter will be explained in detail in the next chapter. Overall this project will cover the frictional behavior analysis on surface roughness of workpiece that machined by the milling process.

1.2 Problem Statement

Finishing a product in the sector of the industry is one of the quality controls that must be taken into account. CNC milling has recently become one of the most common methods used in the industry. CNC milling is used to attain a good surface finish for aluminum alloy in a short period and is far more cost-effective. (Koli & Yuvaraj, 2018).

According to Benardos et. al (2003), The productivity of any machine tool and any machined part depends on the quality of the surface produced. The production of a good surface finish is therefore greatly important. Then the roughness of the surface used as an indicator to determine the quality of every product.

Surface roughness has a major impact on the performance and service life of machinery and instruments. The surface roughness of mechanical parts affects not only the actual effects of parts cooperation, working accuracy, but also the physical properties and chemical properties such as thermal conductivity, electrical conductivity, stress, fatigue, and corrosion. (Shen et al., 2019)

Continuously growing demands for better mechanical parts reliability and efficiency, minimized friction losses, and above all higher power density contribute to higher tribological loads of contact surfaces. This is why the properties of the contact surfaces are becoming particularly crucial (Sedlaček, Podgornik, & Vižintin, 2009)

So it is necessary to investigate the surface roughness of the surface finish by determining the best parameter for CNC machining and what is the relationship between friction behavior and surface roughness. To be great for production quality, the error in the machining process must be reduced, and the manufacturer must be satisfied with the product.

1.3 Objective

The objective of this research are :

a) To identify the relationship between friction behavior and surface roughness.
b) To investigate the surface roughness of the machining process.
c) To identify the best parameter to reduce surface roughness.

1.4 Scope

Essentially, the progress of activities and expected outcome will be well described in further detail in the continuing chapter. In this report, the surface roughness of aluminum alloy will be measured by using roughness tester in FKP Metrology Lab. Meanwhile, Roundness Measuring Machine (RMM) is used to get a roundness measurement of the workpiece. The material will be cut in a cylindrical shape by using milling operation in CNC at FKP Lab. The Taguchi method has also been used to decide the best parameter for machining using CNC Milling.

1.5 Significant Of Study

From this report, in terms of the sustainability aspect, this research will contribute to the performance of machining. The Taguchi method was used to determine the best parameter that will give the best performance for machining. By achieving the objective of this study will give a significant impact on the overall machining performance. By improving the machining performance the defect of the product could be reduced. Thus, reduce the material usage of the product. Additional machining for surface finish can be eliminated. It will also reduce energy usage for machining. Therefore it will reduce the impact of it on the environment.

Besides that, identifying the relationship between friction behavior and surface roughness would also give a significant impact on machining. Then from analyzing data and accurate result would reduce the cost or project management, by maintaining the production. Thus, eliminating the waste by using Lean Manufacturing will give benefit to the company by maintaining or increase the profit.

The Industrial Revolution 4.0 empowering the association of individuals with the machine. In the future, any error in the machining process could be monitored online system where either the engineer or technician can check the performance of a machine in real-time as well as detecting defects instantly.

The result obtains from the experiment can be used to recommend machining practices for cycle time reduction while maintaining quality requirements such as precision, accuracy, and the quality surface of the product. Highly accurate positioning and tracking are the primary requirements for any machine tool application.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This section would discuss the topic of frictional behavior analysis in surface roughness for the machining tool which is milling. In this chapter, the machining parameter on surface roughness would be further discussed. Besides, the method for prediction of surface roughness and frictional behavior would also be included in this chapter.

2.2 Milling Operation

According to Boljanovic et. al. (2009), Milling is a process of machining in which metal can be removed by rotating the cutting tool being direct to the surface roughing or surface finishing material. The cutting tool used in the milling process is known as a cutter, which is considered as the cutting edge "teeth.". The workpiece is fed to a rotational cutter in a direction perpendicular to the axis of the cutting tool. End milling is one of the commonly used in the industry.

Milling operations can be classified into four categories, some of them having many variations, as follows:

- Peripheral or plane milling
- Face milling
- Angular milling
- Form milling.

End milling is one of the operations in face milling. Face milling is the milling of surfaces that are perpendicular to the cutter axis.

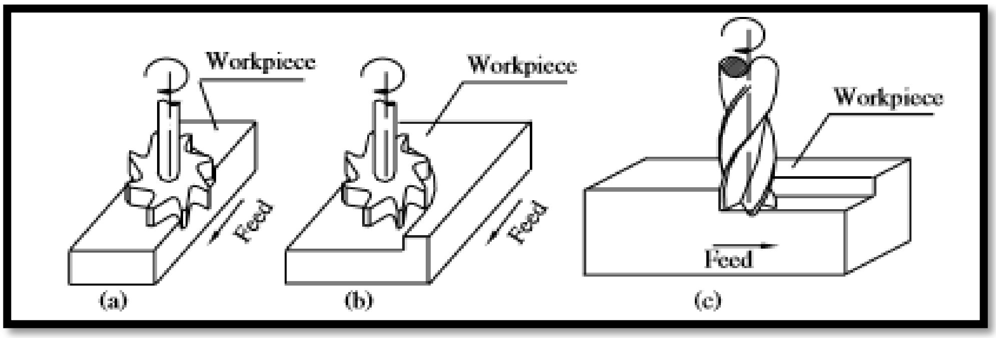

Figure 2.1 Face milling: a) conventional face milling b) partial face milling c) end milling (Boljanovic et. al., 2009)

Conventional face milling. When the diameter of the cutter is greater than the width of the workpiece conventional face milling will be used, so that the cutter overhangs the workpiece on both sides (Fig. 2.1 a). Partial face milling. This process is in which the cutter extends the workpiece on only one side (Fig. 2.1 b). End milling. End milling is a multipoint cutting for removing material from the workpiece by a rotating tool. Usually, the material removed by both the end and the periphery of the tool (Fig. 2.1 c).

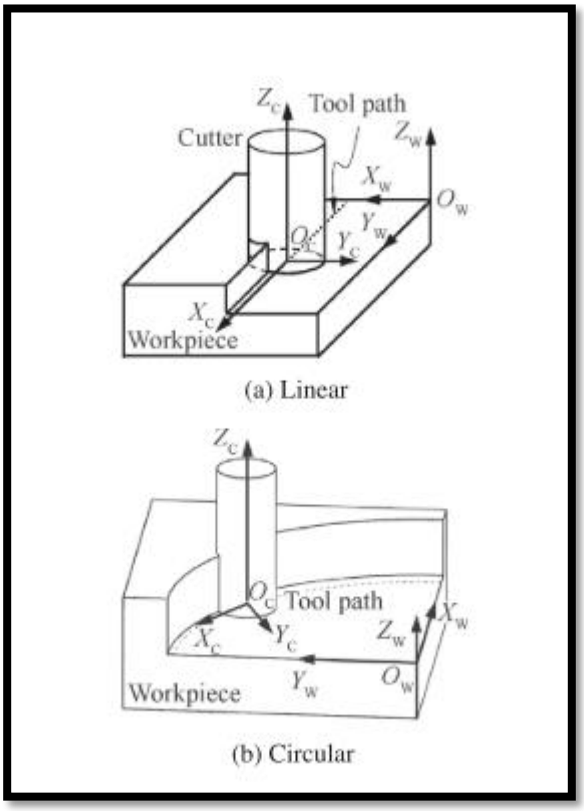

Figure 2.2: Geometry of linear and circular end milling process
(Wu, Yan, Luo, & Gao, 2013)

To evaluate the geometry of the circular end milling process, a series of plane Cartesian coordinate systems is needed to be determined first. As shown in Fig. 2.2, a plane Cartesian coordinate system Ow, Xw, Yw, and Zw is set on the workpiece. For the circular milling process, coordinate origin Ow coincides with the arc center of a finished workpiece. Meanwhile, directions of the Xw axis and Yw axis depend on the cutting force measuring device. Coordinate system Oc, Xc, Yc, Zc is fixed with the cutter center and has a synchronous motion in Xw, Yw plane

It is corresponding to the direction of the cutter along a tool path. Its Xc axis is always oriented in the instantaneous feed direction, the Yc axis locates on the line of the current cutter center and Ow of global coordinate, and Zc axis coincides with the cutter axis.

2.3 Surface Roughness

According to Kuttolamadom, Hamzehlouia, & Mears (2010), surface roughness is a measured surface characteristic that evaluates high-frequency deviations from an ideal surface. It is a qualitative property typically calculated in micrometers (μm) which integrates appearance, smoothness, etc. The arithmetic means value (Ra) is normally illustrated based on the mean of the normal deviations from a nominal surface over a specified 'cutoff' length and is given in Equation (1).

$$R_a = \frac{1}{n}\sum_{i=1}^{n} y_i$$

Eq. (1)

Where 'Ra' is the surface roughness, 'n' is the number of measurement points and 'yi' is the surface deviation at measurement point 'i'.

Another common surface roughness measurement that can be used is the root mean square average (Rq) given by Equation (2) and the Peak-to- valley roughness (Rt) (PV or the height from the deepest trough to the highest peak) given by Equation (3).

$$R_q = \sqrt{\frac{1}{n}\sum_{i=1}^{n} y_i^2}$$

Eq. (2)

$$R_t = y_{\max} - y_{\min}$$

Eq. (3)

However, surface roughness cannot be adequately described by its Ra or Rq value alone, as these are averages. Surface roughness measurement can be observed using either optical, scanning-electron, atomic-force microscopy, or interferometry. But, diamond stylus traveling over a surface is the most common feature.

Typically surface roughness unwanted to happen to the product. However, when manufacturing decides to reduce the roughness of the surface or keep it within range, it may increase its cost. This also leads to a trade-off between a component's manufacturing costs and its performance in an application. The formation of micro-cracks, undesirable changes in microstructure, and residual stress caused by plastic deformation and localized heating in the altered material zone (AMZ) will cause premature failure of a component during service. The surface integrity of a part can be defined as the degree of soundness, wholeness, or unbroken topography of the surface and microstructure resulting from a given manufacturing process. (Sambet Samantaray, 2015)

2.3.1 Surface Roughness Measurement

Surface roughness can be measured using two types of methods. These are known as contact and non-contact methods. For contact methods, the interaction between the measuring tool and a workpiece surface is involved. A stylus will be dragged across the surface of the workpiece to measure the deviation. Profilometers are one of these instruments. Non-contact methods include Interferometry, Confocal microscopy, Focus variation, structured light, and electrical capacitance. (Sambet Samantaray, 2015)