Faculty Engineering Technology of Mechanical and Manufacturing

A STUDY OF RELATIONSHIP BETWEEN SCALLOP HEIGHT AND SURFACE ROUGHNESS ON 5-AXIS CNC MACHINE

WAN ZARINALILA BINTI SANI
B071510233

Bachelor Degree of Manufacturing Engineering Technology (Process & Technology)

2019

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: A study of relationship between scallop height and surface roughness on 5-axis CNC machine

Sesi Pengajian: 2019

Saya **WAN ZARINALILA BINTI SANI** mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (X)

☐ SULIT* Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972.

☐ TERHAD* Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan.

☒ TIDAK TERHAD

Yang benar,

.....

WAN ZARINALILA BINTI SANI

Alamat Tetap:

No 298 Felda Selancar,

85070 Segamat,

Johor.

Tarikh:

Disahkan oleh penyelia:

.....

MOHD SYAFIK BIN JUMALI

Cop Rasmi Penyelia

Tarikh:

*Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini

DECLARATION

I hereby, declared this report entitled A study of relationship between scallop height and surface roughness on 5-axis CNC machine is the results of my own research except as cited in references.

Signature: ……

Author : WAN ZARINALILA BINTI SANI

Date:

APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Process & Technology) with Honours. The member of the supervisory is as follow:

Signature: …….

Supervisor : MOHD SYAFIK BIN JUMALI

ABSTRAK

Reka bentuk produk dan industri pengilangan dikenali sebagai salah satu industri penting di seluruh dunia. Banyak kerja penyelidikan telah dijalankan untuk memastikan ketersediaan tuntutan untuk memenuhi fokus dan sasaran mereka dalam mencapai kemampanan dan kecemerlangan setiap produk yang telah dihasilkan. Sayangnya, perkembangan teknologi semakin sukar untuk dikawal, dan menjaga kesinambungan produk-produk masa depan. Kehadiran teknologi komputer moden seperti Mesin Kawalan Numerik Komputer (CNC) yang mengejar perkembangan komputer yang hebat yang wujud dalam teknologi moden dipercayai memberi pelbagai faedah kepada pembuatan termasuk dalam reka bentuk produk. Walaupun kajian mengenai teknologi komputer ini telah dijalankan sejak beberapa tahun kebelakangan ini, pengetahuan tentang teknologi komputer seperti ini masih memerlukan lebih banyak penyelidikan dan penerokaan. Walau bagaimanapun, dengan penafsiran praktikal dan pakar terlebih dahulu, kajian dan keputusan yang lebih baik dapat diperolehi. Kertas kajian ini memberi tumpuan kepada hubungan ketinggian kerang dan kekasaran permukaan dalam mesin CNC 5 paksi. Kestabilan, fleksibiliti dan kecekapan laluan alat menghasilkan penamat permukaan bahagian itu akan diperhatikan dan direkodkan sebagai analisis data untuk kajian ini. Saiz pemusnahan alat pemotong (kilang bola-akhir) juga akan dikaji dengan nilai kerang yang dipilih.

ABSTRACT

Product design and manufacturing industry are known as one of the important industry around the world. Many research works have been conducted in ensuring the availability of the demands in order to fulfil their focus and target in achieving sustainability and excellence of every product that had been produced. Unfortunately, the advance the technology development the harder it needs to be controlled, and care to maintain its sustainability of the future products. The presence of modern computer technology such as Computer Numerical Control (CNC) machine which pursues great computer development that exists in modern technology is believed to give various benefits to manufacturing including in product design. Even though the study of these computer technologies has been conducted over this past few years, the knowledge of this kind of computer technology still needs more research and exploration. Nevertheless, with the advance practical and expert interpretation, better review and results can be obtained. This research paper focused on the relationship of the scallop height and surface roughness in 5-axis CNC machines. The stability, flexibility and the efficiency of the tool path generate on the surface finishing of the part will be observed and recorded as the data analyses for this study. The destruction size of cutting tools (ball-end mill) also will be studied with the selected scallop value. From this study, the surface roughness increases with the increases of scallop height parameter where irregular surface represent the tool path of cutting tool ball-end mill during machining operation (sweeping process).

DEDICATION

To my beloved father and my late mother.

ACKNOWLEDGEMENTS

I would like to express my sincere acknowledgment to my supervisor, Mr. Mohd Syafik Bin Jumali from Faculty Engineering Technology of Mechanical and Manufacturing, Universiti Teknikal Malaysia Melaka (UTeM) for his guidance along this study and his patiently essential supervision and assistance towards the completion of this project.

Next, I would also like to express my deepest gratitude to my father, sisters and brothers for their non-stop moral support along my studies in here. Lastly, my special thank you to all my friends, lecturers, and assistant laboratory who guide and helps me throughout this studies.

Thank you

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

CNC	Computer Numerical Controls
CAD	Computer-aided Design
CAM	Computer-aided Manufacturing
CL	Cutter location
CC	Cutter contacts

CHAPTER 1

INTRODUCTION

In this chapter, it generally explains the main purpose of this paperwork had been implemented into the experimental simulation as an act towards existing problem occurs after processes or operations work. This chapter has emphasized a few learning that might be helpful for this research purpose in Computer Numerical Control (CNC).

1.1 Background of study

Advancement in computer manufacturing technology that has led to the widespread development of various techniques and operation works, in order to improve the manufacturing production in term of its processes and design planning. The Computer Numerical Control (CNC) had brought a major development in the manufacturing industry called as CAD/CAM which is the merger of the computer-aided manufacturing (CAM) and computer aided designing (CAD). In the past few years, the efficiency of the computer manufacture process has played an important role to improve the productivity and the quality of the manufactured product itself. It is involved with the complicated product and crucial operations in design plans.

Scallop height is defined as the distance between the scallop curve and the design surface where the unfinished part is not fully removed from the surface part of the product. Scallop height is also known as cusp height that refers to a small amount ridge that's left behind on the surface of a part after each pass over the part. It causes the irregular surface

on the part of the product. Basically, scallop height determined by the combination of type and diameter of the tools used, and also the value of the step-over (the distance exist between each of the passes of the machines tool head). Type of the cutter diameter (ball-end mill) and the step-over distance will determine the scallop height between each step in the next pass.

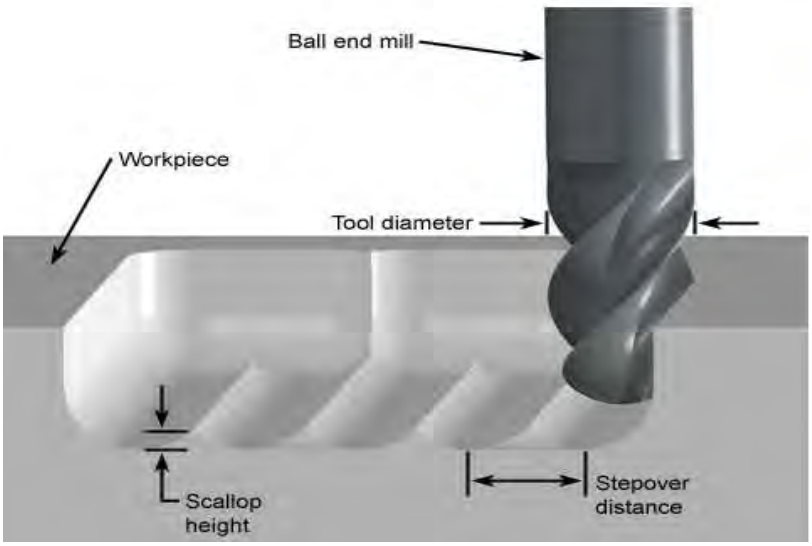

Figure 1: The geometrical tool-path generation of a cutter on the surface part

The scallop height is usually applied on the surface part of product especially the part of curve surface that required an angle. Since the ball end mill always leaves the small value of scallop, it will indirectly affect the tool path generation on the surface of the part. The cusp height that forms due to the tool-path style used in the manufacturing operation system from one feed to the next feed (helical, one way, zigzag, contour, and spiral) of the surface part including the depth distance taken to feed per time.

Without a doubt, most of the products produced require a higher quality of surface roughness or also knows as surface finish in a manufacturer. Even with the help of mathematical model that has been developed to ensure constant scallop height but the constancy is not always guaranteed by using CAM systems. The higher requirement of productivity leads to the machining time consuming to be increased. Due to the intricacy of the end or ball machining process that has been extensively used to manufacture.

It is important to estimate and predict the surface roughness of the product during the operation process. Much effort has been expended by different researchers in previous studies to generate tool paths with constant scallop. This is because to improve and estimate the right used of distance that can be applied to offer the best surface finish of the product surface. A few methods had been used with a different diameter of cutting tool that has applied with the constant scallop height as the simulation test.

1.2 Problem statement

In product design and manufacturing, the probability and chance to produce a good quality product or part in the first trial is quite difficult depending on the design, flow of process and operations used. Moreover, the operations that involved the free-form surface can be hard to handle and control to be as expected outcomes. This is because, most of the surface finish of the product that is obtained while running on the machine during operations has a high possibility to be affected with various factors like spindle run-out, temperature, a material chosen, vibration, the geometry of the tool itself, cross-feed, tool path and other parameters.

1.3 Objectives

This purpose of this project is:

I. To study the relationship between the scallop height and surface roughness of the product design.

II. To design sample and generate the tool path with different parameter of the scallop value on 5-axis CNC machine.

III. The possible defects on the surface finishing sample.

1.4 Scope of study

In product design and manufacturing, the probability and chance to produce a good quality product or part in the first trial is quite difficult depending on the design, flow of process and operations used. Moreover, the operations that involved the free-form surface can be hard to handle and control to be as expected outcomes. This is because, most of the surface finish of the product that is obtained while running on the machine during operations has a high possibility to be affected with various factors like spindle run-out, temperature, a material chosen, vibration, the geometry of the tool itself, cross-feed, tool path and other parameters.

In this study, the experimental had been developing to analyse the simulation result on the form surface finish product by carried out using the different scallop height parameter by using ball-end mill on CNC machine. The research also aims to provide an experimental explanation on the tool path generate of the cutting tools relations towards the result of the surface finish under different scallop value. In addition, the research study covers on the defects on the surface finish product after simulation experiment.

1.5 Important of study

Nowadays, the use of computer technology in product and design manufacturing bought a huge role in a production line. This kind of technology provides an easier way to manufacture a product in the meantime to increase the product quality in term design and production time. This study provided the fundamental of understanding of Computer Numerical Control (CNC) machining operation in a practical way along the simulation of the experimental process. Other than that, this paper can be used as references in the related future study regarding the CNC machining processes. Moreover, this study provides a theoretical explanation of tool path generation of a cutter in the product operation as a helps to improve the manufacture of a better product design.

CHAPTER 2

LITERATURE REVIEW

In this chapter, research and study were done by doing the study on the previous research paper. The previous research is about scallop height and surface roughness of Computer Numerical Control (CNC) machine by providing a relatedly theoretical explanation of the study that has been conducted for the past few years. Generally, this chapter focus on tribology of scallop height and the fundamental of CNC machine and its effect on surface finishing after operation work.

2.1 Introduction of Scallop Height

Generally, the used of the free-form sculptured surfaces in the complex design of the product are widely produced with the ball-end mill cutter by using Computer Numerical Control (CNC) machine. The current method providing for machining part surfaces need a determination of the precise interval between successive tool-paths generation especially when it comes to finding efficient tool-path of the entire sculptured surface. A larger of the tool path interval can result in a rough surface finish of the product. According to Feng and Li (2002) in their studies of an efficient tools paths generation method of iso-scallop height using 3-axis ball-end mill.

They stated that the scallop height is referred to the horizontal distance between the design surface and scallop curve. On the other words, it is referred to the unfinished surface process from the stepping over of X or Y axis during cutting the next pass. Basically, the scallop geometry is the common intersection curve of the two tool envelope surface of adjacent tool paths and the scallop surface.

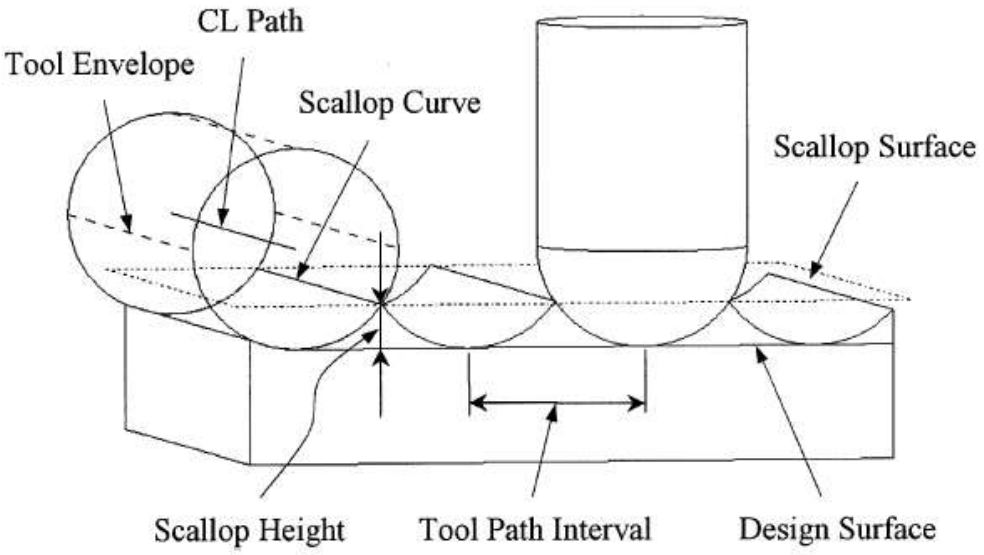

Figure 2: Geometric Elements of a machined surface.

The figure above represents the relevant geometric elements of a machined surface to the derivation in the present work that defined in the work section. The cutter location (CL) path shows the trajectory of the cutter center while the cutter contact (CC) path represents the tangential trajectory between the product surface and cutter radius of the ball-end mill. These studies represent the tool path interval of the result in the scallop surfaces thorough understanding of the machining geometry and iterative approaches.