DEVELOPMENT OF THE PROCESS PLANNING FOR MACHINING PRISMATIC PARTS

SHAZAREL SHAMSUDIN

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By

SHAZAREL BIN SHAMSUDIN

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In dedication to:

My dear parents, for their affectionate caring;

my beloved family for theirs understanding and encouragement; and

my supportive friends who have made my life happier.

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Chairman : P.M. Dr. Napsiah Ismail

Faculty : Engineering

Machining of the complicated parts of high accuracy in large quantities has been an increasing demand since sophisticated technological equipment and machinery rapidly developed. These complicated components can be machined by employing NC machine tools. The motion commands for NC machine tool are determined by the path of the cutter. Obtaining optimal cutter path length is vital important in reducing the machining time. Nevertheless, another factor which has also influenced over machining time is the sequence of the machining operation. Hence, this project has presented the development of the process planning for machining diaphragm valve with Y – valve body (prismatic parts) with regard an optimum machining time. An effective process planning was developed with considering two major influences over machining time which are cutter path and machining operation sequence. Tool paths planning and simulation have been done by Unigraphics CAD/CAM Software. The machining operation is assumed to be carried out by 3-axis CNC vertical milling machine and has five setups for machining completion. The process planning developed comprises of six phases. They are feature recognition, machining operation selection, machine selection, cutting tool selection, cutting parameters selection and finally sequencing of the machining operation. The study results revealed that the total shortest machining time was 99.81 minutes resulted from an optimum tool path and machining sequence. The results also revealed that two types of cut paths have contributed to higher machining time which are zig and zig with contour cut type. Both cut types were not suggested for machining of the diaphragm valve with Y-valve body.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

PEMBANGUNAN PERANCANGAN PROCES BAGI PEMESINAN KOMPONEN PRISMATIK

Oleh

SHAZAREL BIN SHAMSUDIN

November 2005

Pengerusi : P.M. Dr. Napsiah Ismail

Fakulti : Kejuruteraan

Pemesinan komponen-komponen komplek dengan ketepatan tinggi pada kuantiti yang banyak telah mendapat keutamaan semenjak peralatan dan komponen mesin yang berteknologi canggih dibangunkan dengan pantasnya. Komponen-komponen komplek tersebut dapat dimesin dengan menggunakan peralatan mesin kawalan berangka. Arahan gerakan bagi perkakasan mesin kawalan berangka ini dapat ditentukan oleh laluan mata pemotong. Masa bagi sesuatu pemesinan dapat dikurangkan dengan mendapatkan panjang laluan mata pemotong yang paling optimum. Namun demikian, faktor lain yang turut juga mempengaruhi masa pemesinan ialah urutan operasi pemesinan. Oleh itu, kajian ini telah mempersembahkan pembangunan perancangan proses bagi pemesinan injap berdiafragma dengan badan berbentuk Y (sebagai komponen prismatik) dengan mengambil kira masa pemesinan yang optimum. Satu proses perancangan yang terbaik telah berjaya dibangunkan dengan mempertimbangkan dua faktor utama yang mempengaruhi masa pemesinan iaitu laluan mata pemotong dan urutan operasi pemesinan. Simulasi dan perancangan laluan mata pemotong telah dilakukan oleh program komputer Unigraphics CAD/CAM. Operasi pemesinan dianggap akan dilaksanakan oleh mesin pengisaran menegak kawalan komputer berangka yang mempunyai tiga paksi pemesinan dan lima 'setup' diperlukan untuk menyempurnakan operasi pemesinan tersebut. Perancangan proses yang telah dibangunkan terdiri daripada enam fasa iaitu pengenalpastian ciri komponen, pemilihan operasi pemesinan, pemilihan mesin, pemilihan mata pemotong, pemilihan

parameter pemotongan dan pengurutan operasi pemesinan. Hasil kajian menunjukkan jumlah masa pemesinan tersingkat ialah 99.81 minit yang dihasilkan daripada laluan mata pemotong dan urutan pemesinan yang optimum. Hasil kajian juga mendapati terdapat dua jenis laluan potongan yang telah menyumbangkan kepada masa pemesinan yang tinggi iaitu 'zig' dan 'zig with contour'. Maka, kedua-dua jenis potongan ini tidak dicadangkan bagi pemesinan injap berdiafragma dengan badan berbentuk Y.

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Napsiah Ismail, PhD.
Associate Professor
Department of Mechanical and Manufacturing Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Main Supervisor)

A.M. Hamouda, PhD.
Professor
Department of Mechanical and Manufacturing Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Examiner)

DECLARATION

I hereby declare that the project paper is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

SHAZAREL SHAMSUDIN

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LIST OF ABBREVIATIONS/NOTATIONS/GLOSSARY OF TERMS

CAPP	-	Computer Aided Process Planning
NC	-	Numerical Control
CAD/CAM	-	Computer Aided Design/Computer Aided Manufacturing
CNC	-	Computer Numerical Control
AI	-	Artificial Intelligence
CL	-	Cutter-Location
PS	-	Point-Sequence
RPM	-	Round Per Minute
HSS	-	High Speed Steel
UG	-	Unigraphics
TPM	-	Technology Park Malaysia
WCS	-	Work Coordinate System
MCS	-	Machine Coordinate System

CHAPTER 1

INTRODUCTION

Process planning provides information to the shopfloor on how to produce the designed products. It addresses each part of the product separately and collectively. It defines the process, cost and production lead time under the constraints such as the designed geometry, material, quantity, machine and tooling availability, labour capacity and suitability, etc. In the past, process plans were often generated by human process planners who had plenty of manufacturing domain knowledge and worthy experience. In the recent decades, computer technologies have stimulated the advance towards computer-aided process planning CAPP and it useful to be utilised in the especially machining operation (Zhao et al., 2000).

Usually prior to machining operation, it is always advisable to make use of computers for planning an efficient path. Developing an actual part program and changing it at a later stage involves tedious calculations and results in an increased production cost. In view of the development of sophisticated technological equipment and machinery, there has been an increasing demand to manufacture complicated components of high accuracy in large quantities. To machine these complicated parts to the desired accuracy in a much shorter time, Numerical Control (NC) machine tools are employed. These NC machines require the commands to perform specific machining operations on the job. The motion commands for NC machines are determined by the path of the cutter. Hence, it is very essential to plan an efficient path such that the total length of cut and total time for machining are minimized. A computer program for generating an automated path prior to actual part programming on NC machine results in considerable saving of time, money and labour. It also allows for different possible path plans from which an optimal path could be selected for generating NC code (Kompalli et al., 1993).

1.1 Objective

The objectives of the project consist of several items as stated below:

i) To develop an effective process planning for machining diaphragm valve with Y-valve body (prismatic parts) with regard the optimum machining time.

ii) To simulate the machining operation of the designed part and analyse the optimal path by analytical modelling of tool path in order to get the optimum machining time.

1.2 Scope of the Project

The study will focus on the several aspects as follows:

i) Designing 3D model of diaphragm valve with Y- valve body (prismatic parts) using Unigraphics software.

ii) Development of the process planning for machining diaphragm valve with Y – valve body.

iii) Generating tool path and simulating the machining operation using Unigraphics CAD/CAM Software in order to generate G and M codes and also to obtain the optimum machining time.

iv) Choosing the best process planning for machining diaphragm valve with Y – valve body based on the total shortest machining time resulted from the optimum cutter path and machining operation sequence.

1.3 Problem Statement

A machining process generally involves many machine tools, operations, fixtures, and cutting tools. Its planning requires knowledge from diversified fields. Generally, a machining process planning includes the following parts:

- feature recognition;
- machining operation selection;
- machine selection;

- cutting tool selection;
- fixture selection and design;
- sequencing operation and cost estimate.

The feature recognition part identifies manufacturing features from the product design data. The machining operation selection part selects the relevant machining operation according to the feature characteristics and the manufacturing environment. The required machine equipment is selected for implementing the selected operations after considering the nature of the parts and the machine processing capabilities such as the working volume, accuracy, power, fixturing, and other functions. The fixture selection part chooses the fixtures according to the part geometric shapes and dimensions as well as manufacturing features. The main concerns of the cutting tool selection include the tool types, materials, shapes, and tool dimensions. The sequence of operation is also vital important and generally obtained to conform to particular objectives, such as, the shortest time and/or the minimum cost (Zhao et al., 2000). In this study, there is a need to machine the diaphragm valve with Y – valve body with regard the effective machining time. As a result a development of the process planning with follow the proper steps must be developed.

1.4 Significance of the Study

Obtaining optimal path by analytical modelling of tool path in machining diaphragm valve with - Y valve body is a major task in this study. Proper planning in the development of process planning as well as tool path will ensure saving of time, money and labour.

1.5 Limitations of the Study

i) The machining operation is assumed to be performed at 3-axis Okuma CNC vertical milling machine and the part has minimum five setups for machining completion;

ii) The types of milling operations involved are planar mill, fixed – contour, cavity – mill and point to point;

iii) Finishing process is assumed to be carried out one time for each machined part sections in the machining operation. The purpose is to save time in developing the best process planning and;

iv) The study did not cover the design of the specific fixture for clamping purposes and hence there will be no physical machining operation will be performed.

CHAPTER 2

LITERATURE REVIEW

This chapter will discuss briefly about the part that needs to be machined with its complete drawing, the capability of the machine used in the machining process and then followed by explanation of what are the process planning. Some tool path planning with algorithm also will be discussed and the purpose of this discussion are to identify what types of the tool path is appropriate whereby able to machine the part with minimum time, good surface quality without tool-marks and no gouge against boundary curves. Calculation of operation times and milling parameters together presented in this chapter. Finally, this chapter ended with explanation on selecting an Operation Type and types of cut that available in the Unigraphics CAD/CAM Software.

2.1 The Diaphragm Valves

Diaphragm valves are an essential part of bio-pharmaceutical flow processing. These products are developed not only to meet the customer's exact demands for system sterility and drainability but also improve the yield and ensure contamination free to the product. The manufacturer (SED Company) provide various valve configurations for isolation, flow control, diverting and sampling application.

The unique "flush through" bonnet and actuator ensure easy system cleaning and maintenance. Patented diaphragm designs prevent premature wear & tear. The encapsulation prevents the diaphragm material from cold flow and extrusion due to pressure, temperature cycling and steam sterilization. The valve body and weir was carefully engineered and precisely machine to provide leak tight shut off and true drainability when open. Figure 2.1 shows the complete part of diaphragm valve. The features and characteristics for the original product can be seen as follows:

- Valve body material: stainless steel
- Interior surface: Ra < 0.2 μm possible
- Working pressure max: depending on valve type and size
- Working temperature: 150°C (depending on actuator and diaphragm material)
- End connection standard: spigot
- Diaphragm material: EPDM - FDA, PTFE / EPDM - FDA, NBR