UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MACHINABILITY STUDY ON VARIOUS FIVE AXIS MACHINING CENTRE CONFIGURATION

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Engineering Technology (BETP) with Honours

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DECLARATION

I hereby, declared this report entitled "Machinability Study On Various Five Axis Machining Centre Configuration" is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (BETP) (Hons.). The member of the supervisory is as follow:

………………………………

(**MUHAMMAD SYAFIK BIN JUMALI**)

ABSTRACT

Five axis CNC machine was firstly developed to made an aerospace part.This is because each an aerospace part or component required high accuracy in large production and ability the cutting tools to feed in any axes and smooth the surface according the contoured. This research investigated the effect on dimensional accuracy between one to another set of configurations when involving five axes and analyzed the effect on the surface finish of the part to be machine. Coordinate Measuring Machine (CMM) is used to measure the effect on the dimensional accuracy of the parts and also the Mitutoyo Surface Roughness SJ-410 implemented to test out the surface finish of various five axis configuration. Based on this two equipment of measurement, there have a greater different between set of configuration it contributed this research to overcome the problem. On the result in surface roughness analysis, BC configuration recorded more precise in Roughness Average values (Ra) compared to AC configuration. Meanwhile in dimensional accuracy analysis, AC configuration noted overcut between actual and theoretical part but the values of σ in dimensional accuracy on AC configuration more accurate compared to BC configuration.

ABSTRAK

Lima paksi mesin CNC mula dibangunkan untuk dibuat komponen aero angkasa.Ini adalah kerana, setiap bahagian komponen aero angkasa memerlukan kejituan tinggi didalam pengeluaran besar dan keupayaan alat pemotongan untuk momotong di mana-mana paksi dan permukaan yang baik mengikut kontur. Dalam penyelidikan ini menyiasat ketepatan dimensi serta kesan antara satu set konfigurasi dan yang lain bila melibatkan lima paksi pemotongan dan analisis kesan kekemasan permukaan bahagian yang telah dimesinkan dalam kedua-dua konfigurasi menggunakan Koordinat Berukuran Mesin (CMM) untuk mengukur kesan ketepatan dimensi setiap bahagian dan juga Mitutoyo Surface Roughness SJ 410 melaksanakan menguji kemasan permukaan lima paksi pelbagai konfigurasi. Berdasarkan peralatan dua ini ukuran terdapat perbezaan antara set konfigurasi ia menyumbang penyelidikan ini mengatasi masalah itu. Berdasarkan keputusan, dalam analisis kekemasan permukaan BC konfigurasi lebih tepat dalam nilai Purata Kekemasan (Ra) berbanding AC konfigurasi. Manakala dalam analisis ketepatan dimensi, AC konfigurasi menunjukkan pemotongan yang lebih diantara teori dan sebenar tetapi nilai σ didalam ketepatan dimensi keatas AC konfigurasi lebih tepat berbanding BC konfigurasi.

DEDICATION

Firstly, dissertation is dedicated to Universiti Teknikal Malaysia, whose give opportunity in order to complete my case study. Its very helpful with provided good facilities and services while research happened. Secondly, I would like to dedicated to Mr Muhammad Syafik Bin Jumali as supervisor and Mr Syahrul Azwan Bin Sundi @ Suandi as co-supervisor whose passion for teaching set a new knowledge that can be apply, not only in this research, also can be implement in daily routine. Other than that, technician in Faculty of Engineering Manufacturing (FKP) and Faculty of Engineering Technology (FTK) , those who always gave good co-operation and time in order to completed this research. Lastly this dedication to Head of Department Mr Engr. Hanizam Bin Hashim, whose approved this research and improvised on how to make this research more useful and helpful in industry.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

CMM	Coordinate Measuring Machine
$(xyz)_0$	Coordinate frame$(xyz)_0$ built in translating cam
^0S	Translating cam surface
^rS	Surface equation of meshing element of roller
^0n	Unit outward normal of translating cam
a_1	Length of float link
a_2	Length of crank link
a_3	Distance between z2 and z3 axes
b_4	Distance between x3 and x4 axes
b_{4a}	Displacement of roller-followers displacement of translating cam
N_i	ith point on nominal surface
P_i	ith actual measured point
S_i	ith nearest point to nominal surface
X,Y,Z	Required NC data values for CMM
λ	Distance between the design point and the set point along the normal vector
δ	Width of roller
θ_3	Rotation angle of crank
Al	Aluminum

CHAPTER 1

INTRODUCTION

1.0 Introduction

Nowadays , there are many five-axis machining centers configurations available in the market. Manufacturer build this machine to meet the market demands. The 5-axis machining center was developed to make complex parts on one machine, as opposed to several. A 5-axis machining center can cut part on multiple sides of a part simultaneously in one setup. In addition, the process reduces idle times, increases accuracy, and increases the overall speed of production.

Machinability can be defined as it is the property of a material which govern the ease or difficulty with which a material can be machined using the cutting tool. For various term can be define as different to another. Five axis machining is the ability to perform movement about different axis simultaneously. Most CNC manufacturers defines their machines movement starting with the three primary axis. X ,Y , and Z, with Z axis being parallel to the tool spindle, the other two axis are given by the machines ability to rotate about the X and Y axis.Axis Rx pivots or rotates parallel and about the X axis. Axis Ry pivots or rotate parallel to and about the Y axis. Axis Rz represents the rotation of the cutting tool installed into the machine spindle center.

Otherwise, center can be mean as the point from which an activity or process is directed, or on which it is focused. Configuration is computing the way in which all the equipment that makes up a computer system is set to operate.

Five-Axis Machining Centers do not just move in the linear axes X, Y and Z. Instead, these machines also move in two rotary axes. In this research, focusing on tools of configuration which is B-C and A-C . Figure below shows the type of orientation of axis tool configurations :

Figure 1.1 : B-C Machining Center

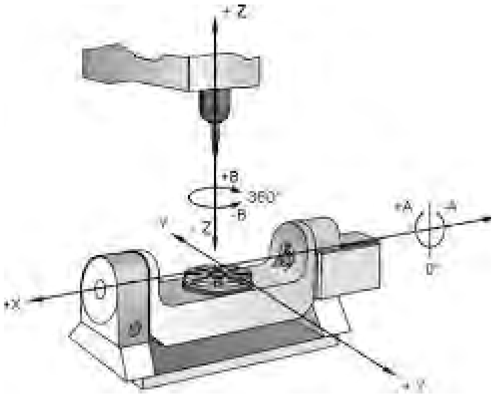

Figure 1.2 : A-C Machining Center

Figure 1.3 : A-B Machining Centre. (Mazakas, A.,2011)

True 5-axis machining refers to the ability to feed the tool through the cut using all axes to smoothly follow a contoured surface. After all, 5-axis machines were first developed for the aerospace industry. In this example of a blade, the rotary axes move continuously during the cut.

One of the most practical applications is called 3+2 machining. The part is rotated into position before the start of each cut and then a standard 3-axis tool path is run. This makes programming easy since rotary motion only occurs between operations. 3+2 machining also allows you to rotate the part into a position that allows shorter tools to reach deep areas. This technique is often used in mold making to prevent the problem of tool deflection. Another practical application is to lock only one of the axes, which is called 4+1 machining. The B-axis on a mill-turn is tilted and locked into position while still allowing the part to rotate during the cut. The B-axis spindle is more rigid when used in this configuration.

Benefits of using 5-axis machining saving time and money for the large production is at the top of the list. Loading a part on the machine only once saves on part handling because no one has to move the part from machine to machine or from one fixture to another. It also means that only one part-holding fixture needs to be built for multiple operations. Another big benefit is the improvement in accuracy between operations on multiple faces since the part does not need to be touched by human hands from the time it's loaded until it's unloaded. Otherwise, a company can deliver orders faster, with better quality, and reach more markets by expanding the range of part geometries that can be cut. A 5-axis machine can also help you streamline your machining processes by combining them on one machine.(Mazakas, A.,2011)

1.1 Problem Statement

The workpiece setup can be arranged in many ways in five axis machining center to work more efficiently. Nowadays, there are several kinds of machining center configuration that available in market. Machinability include the complexity of the part can be produce by the machine and also capability of the the difference of set of configuration to do the job well and also to control the precision of the part during machining. In process efficiency, it will count as the time taken of the operation take place without any parameter error occur during the part to be produce in a certain time. In previous study, many of researches explain the mechanism of this two type configuration. So that, in this research figured out about machining performance or machinability between one to another set of configuration when involving all the five axes , which is A-C and B-C machining centre configuration.

1.2 Objective

The aim that needs to be achieved in this research is stated below :

1. To investigate the effect on dimensional accuracy between one to another set of configurations when involving five axes.
2. To analyze the effect on the surface finish of the part to be machined.

1.3 Scopes

The scopes fixed as a border in this research. Hence, the scopes provides guideline for the area that have or have not cover. Scope in this research is stated below :

1. CATIA V5 software will be use to completing this research.
2. The part that will be machined are made up of Aluminum.
3. Final part will be analyze based on dimension accuracy and surface finish by using CMM and Mitutoyo Surface Roughness Tester SJ-410.

CHAPTER 2

LITERATURE REVIEW

In this section, some of previous studies was implemented to guide this research and relate to the finding current studies.

2.1 Numerical Control

Numerical control, popularly known as the NC is very commonly used in the machine tools. Numerical control is defined as the form of programmable automation, in which the process is controlled by the number, letters, and symbols. In case of the machine tools this programmable automation is used for the operation of the machines. Numerical Control widely used in variety of process like drafting, inspection, sheet metal working and etc. But is more significantly used for various machining like milling, turning, drilling and shaping(Khameni,H.,2009). All the functions of a NC machine tool are therefore controlled electronically, hydraulically or pneumatically. In NC machine tools, one or more of the following functions may be automatic.

i. Starting and stopping of machine tool spindle.
ii. Controlling the spindle speed.
iii. Positioning the tool tip at desired locations and guiding it along desired paths by automatic control of motion of slides.
iv. Controlling the rate of movement of tool tip (feed rate)
v. Changing of tools in the spindle.

2.1.1 Functions of a Machine Tool

The purpose of a machine tool is to move away excessive material, usually metal from the material supplied to let a work piece of the required shape and size, produced to an acceptable accuracy and surface finish. The machine tool should possess certain capabilities in order to fulfill these requirements. It must be :

i. Able to hold the work piece and cutting tool properly.
ii. Endowed the sufficient power to enable the tool to cut the work piece material at economical rates.
iii. Capable of displacing the tool and work piece relative to one another to produce the required work piece shape. The displacements must be controlled with a degree of precision which will ensure the desired accuracy of surface finish and size.

2.1.2 Advantages of NC machine tools

i. Reduced lead time.

Lead time includes the time needed for planning, design and manufacture of jigs, etc. This time may amount to several months. Since the need for special jigs and fixtures is often entirely eliminated, the whole time needed for their design and manufacture is saved.

ii. Elimination of operator errors.

The machine is controlled by instructions registered on the tape provided the tape is correct and machine and tool operate correctly, no errors will occur in the job. Fatigue, boredom, or inattention by operator will not affect the quality or duration of the machining. Responsibility is transferred from the operator to the tape, machine settings are achieved without the operator reading the dial.

iii. Operator activity.

The operator is relieved of tasks performed by the machine and is free to attend to matters for which his skills and ability are essential. Presetting of tools, setting of components and preparation and planning of future jobs fall into this category. It is possible for two work stations to be prepared on a single machine table, even with small batches. Two setting positions are used, and the operator can be setting one station while machining takes place at the other.

iv. Lower labor cost.

More time is actually spent on cutting the metal. Machine manipulation time ex Gear changing and often setting time are less with NC machines and help reduce the labor cost per job considerably.

v. Smaller batches.

By the use of preset tooling and presetting techniques downtime between batches is kept at a minimum. Large storage facilities for work in progress are not required. Machining centers eliminate some of the setups needed for a succession of operation on one job time spent in waiting until each of a succession of machine is free is also cut. The components circulate round the machine shop in a shorter period, inter department costs are saved and 'program chasing' is reduced.

vi. Longer tool life.

Tools can be used at optimum speeds and feeds because these functions are controlled by the program.

vii. Elimination of special jigs and fixtures.

Because standard locating fixtures are often sufficient of work on machines. the cost of special jigs and fixture is frequently eliminated. The capital cost of storage facilities is greatly reduced. The storage of a tape in a simple matter, it may be kept for many years and manufacturing of spare parts, repeat orders or replacements is made much more convenient.

viii. Flexibility in changes of component design.

The modification of component design can be readily accommodated by reprogramming and altering the tape. Savings are affected in time and cost.

ix. Reduced inspection.

The time spent on inspection and in waiting for inspection to begin is greatly reduced. Normally it is necessary to inspect the first component only once the tape is proved; the repetitive accuracy of the machine maintains a consistent product.

x. Reduced scrap.

Operator error is eliminated and a proven tape results in accurate component.

xi. Accurate costing and scheduling.

The time taken in machining is predictable, consistent and results in a greater accuracy in estimating and more consistency in costing.

2.2 Computer Numerical Control (CNC)

CNC refers to a computer that is joined to the NC machine to make the machine versatile. Information can be stored in a memory bank. The programme is read from a storage medium such as the punched tape and retrieved to the memory of the CNC computer. Some CNC machines have a magnetic medium (tape or disk) for storing programs. This gives more flexibility for editing or saving CNC programs. Figure 2.1 illustrates the general configuration of CNC.

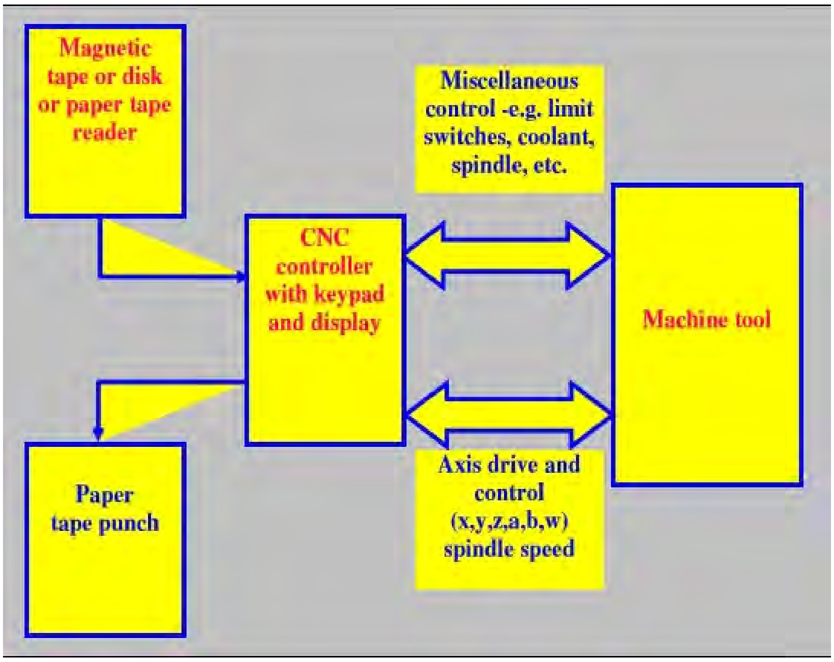

Figure 2.1 : The General Configuration of CNC.

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