UNIVERSITI TEKNIKAL MALAYSIA MELAKA

OPTIMIZATION OF TURNING PROCESS OF THIN WALL CYLINDER

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Management) with Honours.

By

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FACULTY OF MANUFACTURING ENGINEERING

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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ABSTRACT

For efficient use of machine tools at optimum cutting condition, it is necessary to find a suitable optimization model which can find optimum feasible solution rapidly and explain the constraint well. As the actual turning process parameter optimization is highly constrained and non linear, a design of experiment of full factorial is used to find the optimum cutting condition and to get clear idea of constraints at the optimum condition. This report has focused on an experiment on finding the optimum machining parameters for precision cutting of thin wall cylinder. It included the turning process and the measurement machine such as coordinate measurement machine (CMM), optical comparator as a tester to check the diameter of the hole making. In this study, a ferrous metal (mild steel) product is running in parallel or irregular shape so a design of experiment (DOE) can conduct an experiment to obtain the most optimum parameters such as feed rate, cutting speed and clamping force. Designs of 16 experiments with different parameters are used in this study. The material will be run into the CNC lathe machine with different parameters that have been fixing by the design of experiment table to fulfill the main objective of this study. The measurement machine such as coordinate measurement machine are used for examine the accuracy of the hole diameter and ovality. The result will be generated by using Minitab v15 software by entering all the measurements data and some graph will be plotted in order to find the main effect which is significant. From these three parameters, the factors that give the main effect in cutting quality will be determined. This result will be used to find the suitable values or level combination to produce the good quality in turning operation.

ABSTRAK

Kecekapan pengendalian peralatan mesin untuk mendapatkan kadar pemotongan yang optimum amat diperlukan untuk penyelesaian dalam pencarian kadar optimum dengan cepat dan dapat dijelaskan sebaik mungkin. Sepertimana nilai optimum parameter yang sebenar adalah terhad dan tidak linear, sebuah eksperimen yang menggunakan factor-faktor yang terlibat diaplikasikan untuk mencari kadar pemotongan yang optimum dan dapat menjelaskan idea tentang kendalian yang paling optimum. Laporan ini tertumpu pada satu ujian untuk mendapatkan keadaan yang optimum bagi parameter mesin tentang pemotongan produk yang mempunyai permukaan dinding yang nipis. Proses pemotongan yang akan digunakan adalah proses melarik dan mesin pengukuran yang akan digunakan ialah mesin pengukuran koordinat, mesin optikal komparator yang akan digunakan untuk menguji ketepatan lubang yang akan dibuat. Dalam kajian ini, logam ferus akan digunakan yang diletak selari dan dalam bentuk bulat yang tidak tentu dan sehubungan dengan itu satu ujikaji dalam konsep bentuk eksperimen dijalankan bagi mengendali satu ujikaji dalam memperoleh parameter yang paling optima dan faktor-faktor yang terlibat dalam ujikaji ini ialah kadar suapan, kelajuan pmotongan dan kekuatan cengkaman. 16 eksperiman akan dijalankan untuk ujikaji ini. Benda kerja akan dijalankan ke dalam mesin larik CNC dengan parameter yang berlainan seperti yang telah ditetapkan dalam bentuk eksperimen bagi mencapai objektif yang telah ditetapkan dalam kajian ini. Keputusan eksperimen akan diolah menggunakan program Minitab 15 dengan memasukkan semua data dan graf akan diplotkan untuk mencari punca utama yang mempengaruhi nilai potongan. Tiga faktor yang digunakan akan dikaji dan keputusan akan digunakan untuk mencari kombinasi yang sesuai untuk menghasilkan kualiti pemotongan yang bagus dalam operasi melarik.

DEDICATION

To my beloved father, Malek Bin Mohammad Shah and mother, Fauziah Binti Hashim for all support that you have given to me.

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CHAPTER 1
INTRODUCTION

In this section, this chapter will provides and explain the background, scope, problem statement and the importance of the study. Besides, this section will briefly touch the concept of material stability, machine parameters, and tool for precision cutting of irregular shape of certain ferrous metal.

In machining operations, one of the types of machining process is turning. Turning is the process whereby a single point cutting tool path is parallel to the surface. It can be done manually, in a conventional lathe, which frequently requires continuous supervision by the operator, or by using a CNC lathe. Turning includes those operations that produce a cylindrical conical part or any different geometrical shapes. It involves the use of rotating work piece which creates a cutting motion. There are a number of turning operations which are common to the machining of metals, woods, and plastics. Among the most important are straight turning, taper turning, facing, etc. Turning process can also be classified based on their part size, type of machine, processing capacity, machining accuracy, principle of operation design features, number of spindles and workpiece position.

Normally, the axis between the cutting tool and the rotation of spindle are either perpendicular or parallel. So, it was the factor that influences the quality of the surface of the material. Meaning to say that the vibration can happen in certain case which will cause product is not produced in good quality. Do take note that vibration cannot be completely eliminated because even a workpiece with simple geometry could also produce minimum vibration. An optimal strategy to control and isolate the vibration from machining operation is applied in this case study. In terms of cutting process, material removal rate play important note in generating vibration. The material removal rate depends on two factors which are feed rate and depth of cut.

By maintaining and control the position between the cutting tool and workpiece is a way to get very good surface quality and positioning accuracy in the machine tool parameter and measurement.

Control the factors that influence in the performance of this case study is a contributor to make some project achieved. By control and examine the characteristic during the operation from disturbance like the position of material(radial and feed), clamping force of machine tool, the cutting speed, also the parameters of machine like the cutting speed, feed rate during the cutting operation, depth of cut and others small factors that influence the performance of project. By highlight and alert all of this characteristic will make the proposed of this case study succeeded in reducing the cutting tool vibration and its performance.

Force on the tool involve in the important aspect in machining to provide a good result of some project of case study. It means the right selection and correct measurement example like the clamping force, the tenacity of material and others can make project succeeded. For any manufacturer or who want to involve in machine tool producing, the knowledge and value added for the estimation of force specially in design of machine tool, the performance of machine, the tool holder and fixtures and the strength of material is important to learned about the force. The cutting force is a priority in optimizing the tool with right angle and accurate measurement.

Materials that are used are ferrous metal and cast iron. Iron based alloys account for a large portion of a metals production. The range of compositions and microstructures of iron based alloys is far wider than any other system. Pure iron is soft and ductile. Development of scratch free and deformation free grain structures is difficult. Sheet steels present the same problem, which can be complicated by protective coatings of zinc, aluminum, or Zn-Al mixtures. In general, harder alloys are much easier to prepare. Cast iron may contain graphite, which must be retained in preparation. Inclusions are frequently evaluated and quantified. Volume fractions can vary from nearly 2% in a free machining grade to levels barely detectable in a premium, double vacuum melt alloy. A wide range of inclusion, carbide and nitride phases has been identified in steels. Addition of 12% or more chromium dramatically reduces the corrosion rate of steels, producing a wide range of stainless steel alloys. Tool steels cover a wide range of composition and can attain very high hardness's.

Preparation of ferrous metal and alloys is quite straightforward using contemporary methods. Edge retention and inclusion retention are excellent, especially if automated equipment is used.(D.Scott Mackenzie, George E.Totten 2006).

Nowadays, the features during the turning operation are an important part to be mention clearly because it was a factor that can succeeded some case study or project. A good understanding of the behavior of machine, the relationship between the workpiece metal and cutting tool material is a way to do in making a very good condition during the operation. For the case study which is had cutting process, the requirement about the cutting condition and process parameter is most highly important. To determine the cutting parameter, the understanding of ferrous metal behavior must be known first before we decide in material selection. The depth of cut, cutting speed, feed rate and effect of rake angle is a feature that we have to know in effective machining process. The selection of cutting tool materials for particular application is among the most important factors in machining operations. Characteristic of cutting tool is thermal shock resistance, wear resistance, chemical stability and inertness and lastly is toughness. The familiar cutting tool that have been used in industry nowadays is high speed steel (HSS), coated carbide, ceramics, diamond and many others. (Serope Kalpakjian, 2006)The characteristic, the application, and limitations of these tool materials in machining operation, including the required characteristic we outlined and including cost.

High speed machining has been currently used in this high technology era. Since 1990's, the estimation of high speed machining has been extensive. By applying the high speed machining to the ferrous metal using turning process to determine the effect of tool material, coating, and cutting operating parameter on cutting force, tool life, and workpiece surface. The majority of turning operations involve the use of simple single point cutting tools. The geometry of a typical right hand cutting tool for turning is familiar using. Such tools are described by a standardized nomenclature. Each group of tool and workpiece material has an optimum set of tool angles, which have been developed largely through experience.

1.1 Problem Statement

Nowadays in this high technology era, anything can be providing with any ways especially in engineering field. The demand from customer must be followed by the manufacture to make customer satisfaction. Sometimes the requirements are unpredictable and from there, the new ways have to create to make the project can achieve the target. In machining process, the main factors that have to me alert are the parameter of tool, the material selection and others. When machining a thin wall cylinder the ovality problem always arise. The jaw design and development, and cutting parameters will determine the result like the minimum ovality can get. The optimum of all this parameters needs to be determined in order to get the maximum good finishing product in term of hole diameter accuracy.

1.2 Objective

The main purpose og this project are:

i. To determine the thin wall cylinder accuracy with difference cutting parameters using CNC turning machines.

ii. To investigate the factors affecting accuracy of thin wall cylinder.

iii. To generate mathematical model for cutting of thin wall cylinder.

1.3 Importance of the study

The importance of the study is determine the optimum cutting parameter during the turning operation using carbide cutting tool and the factors affecting in determining the accuracy of thin wall cylinder and can generate the mathematical model by using DOE method. Also, can setting the parameter that include feed rate and speed where the result will prolong a service life of engineering components particularly for manufacturing industries.

1.4 Scope of the study

In order to understand the design of parameter, the definition, the purpose of the project and the application of machining parameter in manufacturing field, this section will briefly explain detailed. The study is to investigate about optimum cutting parameter for producing quality thin wall product. To meet this purpose the method used is basically to know the performance of different parameter by statistical tool such as bar chart, main effort plot and DOE using Minitab 15 software.

The research of this project is conducted in house at Manufacturing Laboratory of University Teknikal Malaysia Melaka (UTeM) and ADTEC Alor Gajah. The project proceeds by using CNC turning process machine and the product that want investigate is the size of thin wall hollow cylinder. Material used for this project is mild steel.

The cutting tool that has been used for this experiment is carbide and the coolant that been used is semi synthetic coolant like FUCHS. The coolant and the cutting tool was the same until all of this experiment is complete.

CHAPTER 2

LITERATURE REVIEW

This chapter will explained about all the elements used for this report. First explanation will come to the machines, processes, cutting tools and operation sequences for lathe machine in order to know the element used to calculate the machine parameter and the value of stability for thin wall. Then we will come to the explanation on how the calculation of parameter and stability can caused the optimum value of ovality problem in thin wall cylinder cutting.

2.0 CNC (Computer Numeric Controller)

A computer numerical control (CNC) machine is an NC machine with the added feature of an onboard computer. The onboard computer is often referred to as the machine control unit or MCU. Control units for NC machine are usually hardwired, which mean that all machine functions are controlled by the physical electronics elements that are built into the controller. The onboard computer, on the other hand, is "soft" wired, which means the machine functions are encode into the computer at the time of manufacture, and they will not be erased when the CNC machine is turned off. Computer memory that holds such information is known as ROM or read only memory. The MCU usually has an alphanumeric keyboard for direct or manual data input (MDI) of part programs. Such programs are stored in RAM or the random access memory portion of the computer. They can be played back, edited and processed by control. All programs residing in RAM, however, are lost when CNC machine is turned off. These programs can be saved on auxiliary storages devices such as punched tape, magnetic tape, or magnetic disk. Newer MCU units have graphics screen that can display not only the CNC program but the cutter paths generated and any errors in the program. (J.V.Valentino, J. Goldenberg, 2008). CNC technology has evolved to include "conversational programming" which is software that allows the CNC operator to create CNC programming at the machine. Most common method of programming is still computer aided software. APT is one software system that used for creating CNC programs. There is much other such software system that can perform the CNC processes. The postprocessors are the part of software that converts computer language to CNC code to match a specific CNC machine. (Robert Quesada, 2005). Computer numeric control (CNC) system use a dedicated program to perform NC functions in accordance with control commands stored in computer memory. The computer provides basic computing capacity and data buffering as a part of the control unit. Parts program are entered either manually to the tape reader or interactively using CAM (computer aided manufacturing) software. CNC machine tools incorporate many advantages, such as programmed optimization of cutting speeds and feeds, work positioning, tool selection, chip disposal, and accuracy and repeatability. This last advantage is an important feature to evaluate CNC equipment. Accuracy is the ability to position the machine table at desired location. Repeatability is the ability of the control system to return to a given location that was previously programmed into the controller. (P.F.Ostwald, J.Munoz, 1997).

2.1 CNC Lathe Machining

This section explained several opinions based on literature that has been collected. Rajendar Singh say, Lathe is one of the most versatile and widely used machine tools all over the world. It is commonly known as the mother of all other machine tool. The main function of a lathe is to remove metal from a job to give it the required shape and size. The job is securely and rigidly held in the chuck or in between centers on the lathe machine and then turn it against a single point cutting tool which will remove metal from the job in the form of chips. (R.Singh, 2006). Around 1950s, servomechanisms were applied to lathe machine as the lathe machine can be controlled together with other machine tools via numerical control (NC). It is often that the lathe machine was coupled with the computers in order to yield the computerized numerical control (CNC). From year 1970 onwards, new design of machining tools had been introduced into machining industry that brought along an effect of greatly reducing the times for tool positioning and movements between cuts. These new CNC design had been designed base directly to the development of numerically controlled (NC) machine tools from 1950s. In CNC machining tools, all the motions are mechanically separated and each different motion are driven by their own motor and coordinated electronically that allow more complicated feed motion can be done. As year 1970 come, the CNC lathe machine has more precise numerical control of feed motion, along with reduction of set-up time than can approximately halving the machine tools non-productive cycle times. In around 1980s, the reduction of non-productive cycle time for lathe machine had becoming more intense as the spread throughout all manufacturing industries of new types of machine tools that have become called turning centers. These new tools that had been first develop in year 1960 for mass production industries that individually can make operations that before this need to be done with several machine tools. The reduction in non-productive cycle times is possible because of the rucing loadings and set-ups. Individual time's savings increase with part complexity and the number of setups that can be eliminated. Centres are also much more expensive than more simple traditional machine tools and need to be heavily used to be cost effective (T.Child, 2000). Joseph have same concept about CNC lathe but different opinion and it was, CNC lathe is a machine tool designed to remove material from stock that is clamped and rotated around the spindle axis. Most metal cutting is done with a sharp single point cutting tool. Drilling, reaming, tapping, turning, and boring are operations performed on a CNC lathe. (J.Goldenberg, 2008). While Steven Schmid says in the most advanced lathes, movement and control of the machine tool and its component are achieved by computer numerical controller (CNC). To take advantage of new cutting tool material, computer controlled lathes are designed to operate faster and higher power available as compared to other lathes. They are equipped with automatic tool changers (ATC). Their operations are reliably repetitive, maintain the desired dimensional accuracy, and require less skilled labor once the machine is setup. They are suitable for low to medium volume production (S.Schmid, 2006). Jairo and Phillip say the oldest and most common machine tool is the lathe, which removes material by rotating the workpiece against a single point cutter. Parts are held between centers, attached to a faceplate, supported in a jaw chuck, or gripped in a draw in chuck or collet. Although the machine is suited to turning cylindrical work, it also used for other operations. Plane surfaces can be machined by supporting the work in faceplate or chuck. Work held in this manner can be faced, centered, drilled, bored, or reamed where the tool is approached from the end of "face" of the stock. In