UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MACHINE TOOL RIGIDITY WHEN TURNING USING VARIES LENGTH AND DIAMETER OF WORKPIECE

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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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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TAJUK: Machine Tool Rigidity When Turning Using Varies Length And Diameter Of Workpiece

SESI PENGAJIAN: **2012/13 Semester 2**

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I hereby, declared this report entitled “Machine Tool Rigidity When Turning Using Varies Length of Diameter and Workpiece” 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 Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Management) with Honours. The member of the supervisory committee is as follow:

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(Project Supervisor)

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ABSTRAK

Penggunaan mesin telah meningkat di negara kita terutamanya dalam industri pembuatan, ketepatan alat mesin telah menjadi salah satu faktor penting yang mempengaruhi kualiti bahagian besi yang dihasilkan. Projek ini bertajuk "Ketepatan alat mesin apabila beralih menggunakan diameter dan panjang bahan besi yang berbeza." Tujuan projek ini adalah untuk menyiasat pengaruh ketepatan alat mesin kepada kualiti bahagian-bahagian yang berbeza dari segi panjang dan diameter. Peralihan operasi eksperimen telah dijalankan untuk mengkaji kesan ketepatan alat mesin pada dimensi bahagian besi. Persediaan eksperimen termasuk mesin turning HAAS CNC, VBMT 160404 carbide turning insert, pemegang alat, bahan besi (Keluli karbon rendah) dengan julat garis pusat dari 10 mm dan 15 mm dan julat panjang dari 25 mm, 30 mm dan 35 mm. Eksperimen telah dijalankan dengan menggunakan lima parameter yang berbeza iaitu kelajuan memotong, kedalaman memotong, kadar buangan, diameter bahan besi dan panjang bahan besi . Terdapat 81 sampel telah disediakan untuk pembangunan model dan ujian pengesahan. Eksperimen telah dijalankan dengan menggunakan lima parameter yang berbeza iaitu kelajuan pemotongan, kedalaman pemotongan, kadar suapan, diameter bahan kerja dan panjang bahan kerja. Untuk analisis keputusan, pelbagai alat regresi linear telah digunakan untuk pembangunan model manakala T-alat ujian yang digunakan untuk ujian pengesahan. Semua analisis ini dijalankan menggunakan Minitab 16 Software. P-nilai adalah lebih besar 0.05 iaitu 0.504, model persamaan untuk ketepatan tirus adalah sah dan model ini boleh digunakan untuk mesin lain pada masa hadapan. Selepas menjalankan kajian, terdapat hubungan yang kuat antara parameter pemesinan dan ketegaran mesin. Oleh itu, dengan meningkatkan ketegaran parameter pemesinan, kualiti produk yang dihasilkan dapat dipertingkatkan. Bagi kerja masa depan, proses mengesahkan model yang perlu dilakukan dalam pelbagai industri atau mesin untuk hasil yang lebih memuaskan.

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ABSTRACT

As machine utilization have been increasing in our country especially in manufacturing industries, machine tool rigidity have become one of the important factors that influenced the quality of parts produced. This project entitled “Machine tool rigidity when turning using varies length of diameter and workpiece”. The purpose of this project was to investigate the influences of machine tool rigidity on quality of parts with varies in length and diameter. Experiment setup involved the HAAS CNC turning machine, VBMT 160404 carbide turning insert, tool holder, work piece (Mild steel) with range of diameter 10 mm and 20 mm and range of length from 25 mm, 30 mm and 35 mm. There are 81 samples were prepared for model development and validation test. The experiment was carried out by using five different parameters which are cutting speed, depth of cut, feed rate, diameter of workpiece and length of workpiece. For the result analysis, multiple linear regression tools have been used for model development whereas T-test tool were used for validation test. All this analysis was carried out using Minitab 16 Software. The P-value was greater which is 0.504, the equation model for the taper accuracy was valid and this model may be applied to other machines in the future. After conducting research, there is strong relation between machining parameters and machine rigidity Hence, by improving the rigidity of machining parameters, the quality of product produced can be increased. For future works, the process of validating the model should be done in the different industrial or other machines for more satisfying result.

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DEDICATION

First of all, thanks to Allah for give me a life to do my final year project and with His power I can finish my project on time.

A lot of thanks to my family because give me full support and always help me if I have problems while living away. These thanks are especially for my dad, Mr. Abdul Ghani Bin Deraman , my mom, Madam Rosminah Binti Mohamad and my siblings.

Not to forget my member's for giving me support until my project is finish and last to special person, Tuan Haji Abdul Rahman Bin Mahmood thanks for your support and guidance during the completion of this project.

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"In the name of Allah, the most gracious, the most compassionate"

Alhmdulillah, thanks to Allah S.W.T., finally after facing a lot of challenges during my final year project, lastly I am getting to accomplish my motion where I can finish it successfully. There are a lot of numbers of peoples who have contributed in different ways in completing this project many support, indeed, this final year project could not have been completed without any of you.

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Last, but certainly not least, the continual encouragement and support of my parents and friends is deeply and sincerely appreciated. Thank you.

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LIST OF ABBREVIATION, SYMBOLS AND NOMENCLATURE

CNC	-	Computer Numerical Control
V	-	Cutting speed
F	-	Feed rate
DOC	-	Depth of cut

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CHAPTER 1

INTRODUCTION

This project entitled ‘Machine tool rigidity when turning using varies length of diameter and workpiece.’ The general view of manufacturing, background of the project, problem statement, objectives, scopes and project outlines has been discussed in this chapter.

Manufacturing industries have become the important industry throughout the whole world. Almost everything that we have used such as automobiles, households ,foods and even attires in daily life have produced from the processes of raw materials which have transformed into finished goods on a large scale with the use of machines, tools and labor to produce them. The manufacturing industries have been closely connected with engineering and industrial design. Some of the examples of major manufacturers in Europe include Volkswagen Group, Siemens, and meanwhile in Asia includes Toyota, Samsung, Nestle and Bridgestone.

Nowadays, the most commonly used machining operation in the manufacturing industry was lathe machine or CNC machine. A lot of cylindrical parts produce by turning operations such as shaft, axis, bearing and more. CNC systems, have been greatly automated using computer aided design (CAD) and computer-aided manufacturing (CAM) programs. Thus, machine has been the instrument that industries dealing with where precision production machining has been the main concentration. Other than that, cutting tool also has been used to remove material from the workpiece by means of shear deformation meanwhile machine tools also employed some sort of tool that did the cutting or shaping. All machine tools have got some means of constraining the workpiece and provided a guided movement of the parts of the machine.

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During a machining operation, machine tool rigidity has been a common problem which influences the dimensional accuracy of products produced. Basically, the machine tool rigidity is one of the most important factors which determine their quality of parts carried. The higher the rigidity of machine tool is, the lower sensitivity for cutting force is. Hence, we can investigate the influences of machine tool rigidity on dimensional accuracy of product which varies in length and diameter.

1.1 Background

Rigidity is a major factor in the dimensional accuracy of a machine tool. It is a function of the elastic modulus of materials used and also the geometry of structural components which include the spindle, bearings, drive train, and slideways. Without machine tool rigidity, some problems will likely happen such as vibration and chatter. Besides that, it is important to consider the machine tool design before doing machining processes. The aim of this project was to examine the influences of machine tool rigidity on dimensional accuracy of product which varies in length and diameter with the utilization of CNC turning machine. CNC turning machine was utilized for turning operation of parts. The variables used in the experiments of this project were cutting speed (V), depth of cut (DOC) and feed rate (F), length of workpiece and the diameter of workpiece.

1.2 Problem Statement

In manufacturing industries, when considering high quality products when fulfilling customer requirements, dimensional accuracy has been the important factor in understanding and meeting these needs. Primarily, a factor that should be taken into account when considering customer’s quality requirement is the rigidity of machine tool. Misunderstanding of this phenomenon has been one of the reasons why the industries could hardly achieve the dimensional accuracy of products the customers need. This research is carried out to validate this hypothesis and to find the degree of influence of

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machine tool rigidity on dimensional accuracy of product which varies in length and diameter.

1.3 Objectives

Based on the title and problem statements of this project, the objectives of this project include:

(a) To analyse the accuracy data of work piece in varies diameter and length.
(b) To establish a multiple regression model that was capable of predicting dimensional deviation in turning operation and putting up recommendation on it.
(c) To investigate the influences of machine tool rigidity on quality of parts with varies in length and diameter.

1.4 Scope

An experiment had been used to study the effect of machine tool rigidity on dimensional accuracy of parts. Experiment setup involved the HAAS CNC turning machine, VBMT 160404 carbide turning insert, tool holder, work piece (Mild steel) with range of diameter from 10 mm until 15 mm and range of length from 25 mm until 35 mm. The cutting speed was setup in this experiment where 81 samples were prepared for model development and for validation test with five levels of speed; 1700, 2120, 2550, 3120 and 3820 rpm. For the feed rate, 81 samples were prepared and cut in three levels of feed rate for model development and validation test; 0.5, 0.6, 0.7 mm/min. Besides that, there were three levels of depth of cut; 0.2, 0.3, 0.4 mm for the model development and validation test. In this experiment, all the samples had undergone skinning process or pre-cutting of 0.4, 0.6 and 0.8mm to remove the burr.

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1.5 Project Outlines

Based on the final year project (FYP), an organization has been constructed for the process flow chart of completion in order to fulfil course of degree in Universiti Teknikal Malaysia Melaka (UTeM). Below shows the format of organization:

Chapter 1: chapter 1 represents the introduction of the project that is conducted. The contents included are background, problem statement, objectives, scope and project outlines. It will explain clearly regarding the sub-topics influence in this research.

Chapter 2: chapter 2 represents the literature review on the background and basic information about machine tool rigidity, CNC lathe machine, the cutting tool parameters and etc.

Chapter 3: chapter 3 represents the methodology used to conduct the experimental. This chapter includes planning of the research, flow chart, machine setup process, experimental procedure, analysis and the sources of data.

Chapter 4: chapter 4 will be discussed on the result obtain and discussion of experiment and presentation of the data that have been collected during the processes. The progression, experimental data and analysis stated in this chapter.

Chapter 5: chapter 5 will represents the conclusion of the whole study and recommendation for future research.

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CHAPTER 2

LITERATURE REVIEW

This chapter reviewed in detail about the literature related to machine tool rigidity, machining process, the Mild Steel as the metal selection, CNC lathe machine, the process variables and etc. All the reviews in this chapter give a good knowledge and it has been a second reference when carrying out the project.

2.1 Machine tool rigidity

The accuracy of machined part dimensions rely upon the positional accuracy of the cutting tool relative to the part being machined. The accuracy of the machine tool that used to produce the part is often the restricted factor to obtaining the highest accuracy and part quality. The accuracy of the machine tool is primarily affected by the geometric errors caused by mechanical–geometric imperfections, misalignments and wear of the linkages and elements of the machine tool structure, by the non-uniform thermal expansion of the machine structure and static or dynamic load induced errors. A volumetric error is the relative error which is occurs between the cutting tool and the workpiece. By doing structural improvement of the machine tool through better design and manufacturing practices, these errors can be reduced.

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Based on research done by A.C. Okafor (1999), the physical limitations, production and design techniques solely cannot improve accuracy. Therefore, identification, characterization and compensation of these error sources are necessary to improve machine tool accuracy cost-effectively.

According to Votnow, he has defined stiffness or rigidity by the following equation;

$$j = \frac{P\gamma}{Y\rho} \qquad (1)$$

Where j = the stiffness of the machine tool element Kg/ Mk

$P\gamma$ = load applied along the Y direction, Kg (normal to machine surface)

$Y\rho$ = displacement or deflection of machine tool element along the Y direction under the action of the force, $P\gamma$

Later, A.P.Sokolovski has defined rigidity by the following equation to take into account the influence of cutting force components other than $P\gamma$ [2].

$$J = \frac{P\gamma}{Y\mathcal{S}} \quad \text{Kg/MK} \qquad (2)$$

Where $Y\mathcal{S}$ = Integral displacement of the cutting tool caused not by the

$P\gamma$ alone, but by the combined action of all components of

cutting force, MK

Thus, formula (1) and (2) define rigidity as a ratio of load to displacement (or deflection), through in the subject of strength of materials rigidity is expressed in altogether different manner. Rigidity, thus defined, represents the ability of the individual elements of a structure or machine component to resist deformation, and takes

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into account the mechanical properties of the materials used and the shape of the cross section.

Stiffness is a major factor in the dimensional accuracy of a machine tool. It is a function of;

a) The elastic modulus of the materials used

b) The geometry of the structural components. It is including the spindle, bearings, drive train, and slideways.

Machine stiffness can be upgraded by design improvements. (Kalpakjian,S. and Steven, S., 2010).

The rigidity is a “characteristics” that define the resistance to its performance when an external forces act on a linear guide, or a “level” of such resistance.Aung, K.W., (2009)

2.2 Machining processes and machine tools

Machining is a general term that described the group of processes which consists of the removal of material and adjustment of the surfaces of a workpiece after it has been produced by various methods. Several major types of material removal processes consist of;

a) Cutting processes: Involving a single point or various point cutting tools

b) Abrasive processes: such as grinding and related processes

c) Advanced machining processes: utilizing electrical, chemical, laser, thermal, and hydrodynamic methods to accomplish task.

Machine tools are the machines which the above processes are performed. The construction and characteristics have greatly affected the product quality, the surface

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finish, and the dimensional accuracy of the workpiece. In manufacturing operations, it is important to view machining operations as the systems were consisting of;

a) Workpiece

b) Cutting tool

c) Machine tool, and

d) Production personnel

Machining cannot be carried out competently or economically and also meet stringent part specifications without a comprehensive knowledge of the interactions among these four elements. (Kalpakjian, S. and Steven, S., 2010, pg. 553-555)

However, the knowledge of cutting forces and power involved in machining operations is important for the following reasons:

a) Machine tools can be properly designed to minimize the distortion of the machine components, maintain the required dimensional accuracy of the machined part, and help to select the suitable toolholders and work-holding devices.

b) The workpiece is capable of withstanding these cutting forces without excessive distortion.

Hence, the power requirements and the data of cutting forces must be known in order to enable the selection of a machine tool with adequate electric power.

As we know, stiffness analysis plays a vital role in the optimization of the machine tool. Based on research done by Yanmin Zhao (2011), stiffness is one of the most important performance indexes for metal cutting machine. Raising stiffness is beneficial to machine tools efficiency, machining accuracy and surface processing quality. On the other hand, the stiffness could affect the machining accuracy significantly. Therefore,

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the stiffness analysis has been widely used in design and optimization of machine tools. (Zhinjun Wu et al., (2011)

2.3 Mild Steel as the Workpiece

Several properties should be considered when selecting a piece of steel for a job which are strength, machinability, hardenability, weldability, fatigue resistance, and corrosion resistance.

As we know, mild steel is used in almost all forms of industrial applications and industrial manufacturing. It is a cheaper alternative to steel, but still better than iron. Mild steel or low carbon steel as the main component to through the process of machining containing several characteristics. Mild steel only contain a small carbon and other elements. It is softer and can be shaped more easily than higher carbon steels. Below shows some properties and uses of mild steel:

- Mild steel has a maximum limit of 0.2% carbon. The proportions of manganese (1.65%), copper (0.6%) and silicon (0.6%) are approximately fixed, while the proportions of cobalt, chromium, niobium, molybdenum, titanium, nickel, tungsten, vanadium and zirconium are not.
- A higher amount of carbon makes steels different from low carbon mild-type steels. A greater amount of carbon makes steel stronger, harder and very slightly stiffer than low carbon steel. However, the strength and hardness comes at the price of a decrease in the ductility of this alloy. Carbon atoms get trapped in the interstitial sites of the iron lattice and make it stronger.
- What is known as mildest grade of carbon steel or 'mild steel' is typically low carbon steel with a comparatively low amount of carbon (0.16% to 0.2%). It has ferromagnetic properties, which make it ideal for manufacture of many products.
- The calculated average industry grade mild steel density is 7.85 gm/cm3. Its Young's modulus, which is a measure of its stiffness, is around 210,000 MPa.

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