# FUZZY ACTIVE VIBRATION CONTROL FOR LATHE MACHINE

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Thesis submitted in fulfilment of the requirements
for the award of the degree of
Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

DECEMBER 2010

**UNIVERSITI MALAYSIA PAHANG**
**FACULTY OF MECHANICAL ENGINEERING**

We certify that the project entitled "Fuzzy Active Vibration Control for Lathe Machine" is written by Muhamad Faisal Ezuarie Bin Draman. I have examined the final copy of this project and in my opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. I herewith recommend that it be accepted in partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering.

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I hereby declare that we have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

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## STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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## ACKNOWLEDGEMENTS

All praise to supreme almighty Allah s.w.t. The only creator, cherisher, sustainer and efficient assembler of the world and galaxies whose blessings and kindness, give blessing and health, enabled me to accomplish this project successfully. Allah will bless you.

I am grateful and would like to express my sincere appreciation to my kind project supervisor, Mr. Muhammad Hatifi Bin Hj. Mansor for his germinal ideas, valuable guidance, advice and continuous encouragement, constructive criticism and suggestion throughout this project. Without his continued support and interest, this thesis would not have been the same as presented here.

I acknowledge my sincere indebtedness and gratitude to my family, especially my mum, Noriah Binti Majid and my dad, Draman Bin Mamat for their love, dream and sacrifice throughout my life. I cannot find the appropriate words that could properly describe my appreciation for their support and pray throughout for mine. May Allah will bless them in this world and here after.

My sincere thanks go to all my friends and all people who involve direct and indirect in provide assistance and co-operations at various occasions. Their view tips are useful indeed in helping me finish my thesis.
Thanks you.

## ABSTRACT

This project report deals with development of the control system for the conventional lathe machine. Vibration during turning process caused chatter in surface product and affects the outcome of products. The control system used to suppress vibration a chatter using machining process. Dynamic and mathematically model had derived from the two degree of freedom (2-DOF) for the cutting tool. Control system used in project a passive system and active system. The passive system used to show the instability of system. For active system that had been introduces two type of controller such as typically technique proportional-integral-derivative (PID) and Fuzzy Logic Control (FLC). To complete the active system, linear actuator had been used. The simulation had been run using MATLAB/SIMULINK® software. Comparative study had been done between passive and active control system. From comparative study, Fuzzy PID showed an effectiveness result that suppresses vibration during machining process. Fuzzy PID produced small error nether than typically PID and passive system. For the conclusion, Fuzzy PID control is superior robust, stable and accurate controller compare the PID control.

# ABSTRAK

Laporan ini membincangkan tentang projek membangukan sistem kawalan bagi mesin larik konvensional. Getaran semasa proses melarik disebabkan oleh *chatter* yang berlaku pada permukaan produk yang mempengaruhi hasil produk. Sistem kawalan digunakan untuk mengawal getaran disebabkan oleh *chatter* semasa proses pemesinan. Model dinamik dan model matematik diterbitkan daripada dua darjah kebebasan (2-DOF) bagi mata pemotong mesin larik. Sistem kawalan yang digunakan dalam projek ini adalah sistem pasif dan sistem aktif. Sistem pasif digunakan bagi menunjukkan ketidakstabilan sistem. Bagi sistem aktif pula, dua jenis *controller* digunakan. Antaranya seperti proporsional-integral-derivatif (PID) dan Fuzzy Logic Control (FLC). Linier aktuator digunakan bagi melengkapkan sistem aktif. Simulasi telah dijalankan dengan menggunakan perisian MATLAB / SIMULINK®. Perbandingan kajian telah dilakukan antara sistem kawalan pasif dan aktif. Menerusi perbandingan kajian, Fuzzy PID menunjukkan hasil keberkesanan yang terbaik dalam mengawal getaran semasa proses pemesinan. Fuzzy PID menghasilkan *error* yang kecil jika dibandingkan dengan sistem kawalan PID dan kawalan pasif. Kesimpulannya, sistem kawalan Fuzzy PID adalah kawalan terbaik, stabil dan tepat jika dibandingkan denagn kawalan PID.

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# LIST OF SYMBOLS

| | |
|---|---|
| $F$ | Force |
| $F_f$ | Frictional force |
| $c$ | Viscous damping coefficient |
| $v$ | Velocity |
| $a$ | Acceleration |
| $m$ | Mass |
| $\omega_0$ | Undamped angular frequency |
| $\xi$ | Damping ratio |
| $U(t)$ | Reference input |
| $Y(t)$ | Output response |
| $m(t)$ | Control signal |
| $K_p$ | Proportional gain |
| $K_i$ | Integral gain |
| $K_d$ | Derivative gain |
| $T_i$ | Integral time constant |
| $T_d$ | Derivative time constant |
| $\alpha$ | Constant value |
| $N$ | Newton |
| $\ddot{x}$ | Angular acceleration |
| $\dot{x}$ | Angular velocity |
| $x$ | Angular displacement |
| $F_x$ | Force *x*-axis |
| $F_y$ | Force *y*-axis |

| | |
|---|---|
| $F_c$ | Cutting force |
| $F_t$ | Thrust force |
| $F_a$ | Actuator force |
| $m$ | Mass of cutting tool |
| $k$ | Stiffness of spring |

## LIST OF ABBREVIATIONS

| | |
|---|---|
| 2-DOF | Two Degree Of Freedom |
| D | Derivative |
| FL | Fuzzy Logic |
| FLC | Fuzzy Logic Control |
| FTS | Fast Tool Servo |
| FYP | Final Year Project |
| I | Integral |
| L | Large |
| M | Medium |
| P | Proportional |
| PD | Proportional -Derivative |
| PI | Proportional-Integral |
| PID | Proportional-Integral-Derivative |
| S | Small |

# CHAPTER 1

# INTRODUCTION

## 1.1 INTRODUCTION

An industrial sector especially in manufacturing most used conventional lathe machines. The lathe machine in production line requires high precision for every single part of product. It important to make sure the part has standardized for every components. A product had standardized and specific tolerance can assemble easily. The machining process is started time to maintain quality of product. Various type of machine used in the manufacturing industrial. But for this thesis just only focus on the lathe machine. The conventional lathe machine is used to investigate about the disturbed vibration. From that point, the advance precision lathe machine is high prices compare the conventional lathe machine. So, this project comes out with idea to implement the control system in the conventional lathe machine.

The basic concept of lathe machine operated which spins the workpiece and the cutting tool standing at the static point. Lathe machine can operated the machining process such as cutting, drilling or deformation shape with several of cutting tool type. The lathe operation suitable to applies for workpiece that have symmetry shape about an axis of rotation (Laudebaugh, 1988). When the workpiece not clamp vary well, it produced vibration for the whole machine. So, the solution for this problem by design control system to sense the vibration and suppresses it. For the better machines, the body structure is solidly constructed with broad bearing surface for stability and manufactured with great precision. It helps ensure the components manufactured on the machines can meet the required tolerances and repeatability.

Lathe turning operated by remove the material from a rotating workpiece via the movements of various cutting tools. Sometimes in the lathe process, frequently occur the problem related to relative dynamic motion between cutting tool and workpiece. It cause chatter that give the results bad surface finishing in the workpiece. From this study, the performance of lathe machine and the accuracy machine can increase by overcome the problem relative to dynamic motion between cutting tool and workpiece. Two type of active control system investigated to achieve target of study. The active systems used are proportional-integral-derivative (PID) and PID hybrid by Fuzzy Logic Control (FLC) The control system is function to reduce of the dynamic motion between cutting tool and workpiece by control the vibration of the cutting tool. The controller also can reduces noise level that related with the tool life.

This Final Year Project (FYP) title is “Fuzzy Active Vibration Controller for Lathe Machine”. It’s been done in order to suppress the vibration that generate in the lathe machine. This study will investigate by simulation scheme control diagram. Simulation will run in the MATLAB/SIMULINK® software. This topic will elaborate more detail in the chapter 2 and chapter 3.

## 1.2 PROBLEM STATEMENTS

Most of mechanical component such as machines or structures will failure cause by vibration. This situation also happens in the lathe machine, the most machines used in industry. Many problems have been found such as chatter. Chatter is a dynamic instability of the cutting process (Hseih, 1996). Chatter cause from the interaction of the dynamics metal cutting process and the structural dynamics of the machine tool. If chatter uncontrolled, it easily spoil the surface accuracy, damage the cutting tool blade and also produce irritating unacceptable noise.

Therefore, the typical techniques such PID used to investigate for reduce chatter in turning operations. A few methods used to suppress vibration. The first technique used is a passive control system. Passive control is method used the tuned vibration absorber for the suppression of chatter. The other technique is active control system technique. For active control, the actuator or sensor has added in the system to detect

and suppress it. Active control methods have become increasingly popular compare to passive control. Active vibration control has be chose to suppress the vibration in lathe machine. The detail of the active control system explains in the chapter 2. For all this problem and ideas to solve the vibration will discuss in the next chapter.

## 1.3 OBJECTIVE OF THE STUDY

The main objective of study to suppress of lathe machine vibration using Fuzzy PID control beside that the result obtain the technique will be compare in the typically technique.

## 1.4 SCOPE OF THE STUDY

This study is limited to the problem that related with the vibration in lathe machine. Problem solve by add the control system to machine. That control system will be investigated in this study. There are scopes of study will be focus on:

i. 2-DOF displacement of the lathe machine cutting tool.
ii. Dynamic model and mathematical model of lathe machine cutting tool.
iii. Parameter of turning process from previous study.
iv. Run simulation using MATLAB/SIMULINK® software.
v. Implement the typically technique PID as controller.
vi. Implement Fuzzy PID controller.
vii. Evaluate system performance between PID control system and Fuzzy PID control system base on the result obtain.
viii. Comparative study between PID control and Fuzzy PID control.

## 1.5 SIGNIFICANT OF STUDY

There are few significances of this study when objectives have been achieved. The significance of study is investigated suitable scheme control system for lathe machine. The scheme control system function to suppress vibration in the lathe machine. Control system designed implement in the lathe cutting tool. The parameter used base on lathe turning process. This study focus on simulation method with simulate control system have been design by using MATLAB/SIMULINK® software and investigate every type of controller suitable for this system. The experiment study can be continuous for more real live situation the vibration in lathe machine. This study tried improve the lathe machine performance base on many type of expectation for the accuracy of the product and the other. The idea to create the active vibration control system to overcome the chatter lathe operation by implement controller. This control system technology can be commercialized for industrial sector.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 INTRODUCTION

This chapter is more to recognize the basic understanding of knowledge about the study. The topics like lathe machine, vibration, active vibration control and also controller should be familiar for facilitate of investigation.

Know the knowledge of lathe machine operation and the parameter that related and suitable to apply in this study. Recognize the mathematical model of cutting tool by the dynamic model. The method to use for study is simulation. So, the controller that will use listed, learn and can be adept to apply for the next chapter. Proportional-integral-derivative (PID) control and Fuzzy Logic control (FLC) are the controller use for this study. The method to design, tune, set parameter and software use will explain detail in this chapter.

Besides that, the important thing should know vibration control. From that point, the previous study will be reference to know the technique used. The technique PID and Fuzzy Logic control (FLC) will briefly elaborated and analyzed. The comparative study will make between this two controllers, the conventional PID technique and PID controller with Fuzzy Logic (FL).

This study consists with two active controllers that implementing in lathe machine cutting tool. For PID controller, the method review is Ziegler–Nichols method or the other suitable method. Besides that, Fuzzy Logic Control (FLC) review about the type of fuzzy control concept such as fuzzification, rules evaluation, aggregation and

defuzzification. For further study, this PID technique and PID with Fuzzy logic control added will used in simulation.

## 2.2 LATHE MACHINE

A lathe is a machine removes material by rotating the workpiece against a cutter. Although a lathe machine can be used for many purposes, it is particularly adapted to turning operations for cylindrical workpieces which symmetry bar about an axis of rotation (Laudebaugh, 1988). Other that turning, a lathe can also be used to perform drilling, boring and reaming operation. In addition, it used for cutting treads and turning taper with appropriate attachments. It also can be adapted to simple milling or grinding operation (Begeman, 1957). Figure 2.1 shown as the conventional lathe machine that used in the industrial.

**Figure 2.1:** Conventional lathe machine

Source: Glenn McKechnie (2006)

A lathe is probably the oldest of all the machine tools as well as the most important on in modern metal cutting practice. There are many different types of lathes with vary in size, design, method of operate, arrangement of gears and purpose (Begeman, 1957). In general, they can be classified as speed lathes, engine lathes, turret lathes and etc.

Accurate of positioning and holding workpiece on lathe are critical requirements for successful turning and other machining operations. Parameter used in this study base on the turning process operation. Turning processes involve the spinning of workpiece and static cutting tools. A lathe is machine using single-point tools. A single-point tool is the static of cutter with the rotating workpiece.

Lathe have used wide in the industry. For the beginning of history, lathe common use in wood turning and also shape of pottery. Lathes machine usually used in woodturning, metalworking, metal spinning and glass working. Ornamental lathes can be produce three-dimensional solids of incredible complexity. The material is held in place by either one or two centres, at least one of which can be formed on a lathe include baseball bats, candlestick holders, table legs, bowls, musical instruments (especially woodwind instruments), crankshaft and camshaft (Jemielniak, 1990) (Brower, 1957).

Metalworking lathe are standard terms for any a large class of lathes designed for machining hard materials. These rigid machine tools remove material from a rotating workpiece via the (typical linear) movements of various cutting tools such as tool bits and drill bits (Shaw, 1984).

Lathe machine should be improving for the every moment to produce the good product with high accuracy and quality. The problem identified should be follow by the new solution or technique to resolve it for the future. It can design vary model depending on the application. The new technique real helpful to ensure the components manufactured can meet the required tolerances and repeatability endurance.