

SUPPRESSION OF CHATTER IN HIGH-SPEED
MILLING MACHINE USING SPINDLE SPEED
VARIATION METHOD WITH MICROPHONE
FEEDBACK PID CONTROLLER

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and, in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science.

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I hereby declare that the work in this thesis 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 University Malaysia Pahang or any other institutions.

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ABSTRAK

Proses pengilingan berkelajuan tinggi merupakan teknologi umum dan serba boleh jika dibandingkan dengan kaedah konvensional bagi tujuan industri pemotongan logam. Walau bagaimanapun, pemesinan kerap kali terganggu disebabkan oleh getatuk semasa proses pengilingan. Getatuk menghasilkan kesan bergelombang pada permukaan berpunca dari getaran yang terhasil sepanjang proses, menyebabkan kawasan permukaan kasar, meningkatkan kadar haus mata alat dan mengurangkan jangka hayat gelendong mesin. Maka, untuk mengurangkan getatuk dan menghasilkan permukaan yang lebih baik, kajian ini memberi tumpuan pada kaedah variasi kelajuan gelendong semasa pemesinan berkelajuan tinggi. Kajian ini menyiasat kesan gabungan pelbagai kedalaman pemotongan dan kelajuan potong dengan menggunakan mikroskop metalurgi dan penguji kekasaran permukaan mudah alih selepas pengilingan akhir pada aluminium 6061 dan P20 keluli. Kajian ini dijalankan dengan membangunkan kawalan PID untuk menyampaikan maklum balas secara terus atau atas talian kepada mesin berdasarkan data yang disalurkan oleh sensor mikrofon. Data yang diterima kemudiannya akan dianalisis dalam bentuk masa dan frekuensi. Selain itu, hasil permukaan selepas proses pemesinan turut diperolehi. Ia menunjukkan penambahbaikan pada permukaan selepas kaedah variasi kelajuan gelendong mesin diguna pakai dalam proses pengilingan berkelajuan tinggi. Keputusan yang diperolehi dari kaedah bukan konvensional ini menunjukkan kadar suapan sangat mempengaruhi hasil permukaan. Ini sebaliknya dengan parameter kedalaman pemotongan dimana nilai bacaan kekasaran permukaan terus meningkat bila kadar suapan ditingkatkan dan kedalaman potongan dikurangkan. Selain itu, kadar haus mata alat hampir tidak berubah menunjukkan bahawa kadar pembuangan logam sangat menyumbang kepada kadar haus. Dalam eksperimen selanjutnya, keadaan permukaan dan topografi menunjukkan penambahbaikan sehingga 86.7% semasa proses eksperimen aktif berbanding eksperimen awal. Ini selepas kaedah variasi kelajuan pemotongan dan pengilingan berkelajuan tinggi dilaksanakan. Ini membuktikan bahawa getatuk semasa pemesinan boleh dicegah menggunakan kaedah variasi kelajuan gelendong dengan kawalan PID dan maklum balas mikrofon. Kajian ini menyumbang kepada industri pengilingan berkelajuan tinggi dengan meningkatkan produktiviti selain boleh menjimatkan masa dan kos. Selain itu, kaedah ini dapat mencapai kecekapan, ketepatan, kualiti bahan kerja akhir yang tinggi dan menghapuskan proses separa penamat.

ABSTRACT

High-speed milling process is the most common and versatile technology compared with conventional milling process for machining productivity of metal cutting industry. However, the productivity of machining is often limited by chatter at high speed in milling process. Chatter is a wavy mark on a product surface finish that occurs when self-excited vibration developed during the process, which results in low surface finish, high degree of tool wear and less spindle lifetime. Main purpose of this study is to suppress chatter by spindle speed variation method at high-speed machinery and a better surface finish. Before chatter study proceeds, non-conventional machining applied with the high-speed machining method. This experiment investigates the effects of varying combination of depth of cut and feed rate to tool wear rate length using metallurgical microscope and surface roughness using portable surface roughness tester after end milling of aluminium and P20 steel. Then, in further experiment, PID controller was developed to give on-line feedback to the machine based on data fed by the microphone sensor. The data received from microphone sensor is analyzed in time and frequency domain. Furthermore, after machining, result also was compared with the surface roughness and surface topography of all cutting conditions. Results gathered from high-speed machining method applied on non-conventional milling shows feed rate significantly influences the surface roughness value while depth of cut does not as the surface roughness value keep increasing with the increase of feed rate and decreasing depth of cut. Whereas, tool wear rate almost remain unchanged indicates that material removal rate strongly contributes the wear rate. In further experiment, material's surface roughness and surface topography improved until 86.7% in active experiments better than initial experiments after spindle speed variation has been implemented together with high-speed milling technique. This proves that chatter occurrence during machining can be suppressed using spindle speed variation method with microphone feedback PID controller. The researches contribute to high-speed milling usage industries with extra benefits of high productivity and can conserve time and money. Moreover, this method could enable providing high efficiency, accuracy, quality of final workpieces and eliminates semi-finishing process.

TABLE OF CONTENT

DECLARATION OF THESIS

TITLE PAGE

ACKNOWLEDGEMENT ii

ABSTRAK iii

ABSTRACT iv

TABLE OF CONTENTS v

LIST OF TABLES ix

LIST OF FIGURES x

LIST OF SYMBOLS xiii

LIST OF ABBREVIATIONS xiv

CHAPTER 1 INTRODUCTION

1.1 Research Background 1

1.2 Research Problem Statement 4

1.3 Research Objective 4

1.4 Research Scope 5

1.5 Thesis Organization 6

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction 7

2.2 Development of High-speed Machining 8

2.2.1 High-speed Milling Technique 11

2.2.2 High-speed Milling Technique Application in Normal Machining 13

2.3	Chatter in Machining Process	13
	2.3.1 Chatter in High-speed Milling Process	15
	2.3.2 Development of Chatter Suppression Method	18
2.4	Chatter Suppression by Spindle Speed Variation	20
2.5	PID Controller	23
2.6	Fast Fourier Transform (FFT)	26
2.7	Summary	29

CHAPTER 3 METHODOLOGY

3.1	Introduction	30
3.2	Machining Experiment for HSM application to normal machining	32
	3.2.1 Design of Experiment	32
	3.2.2 Different cutting speed	34
	3.2.3 Surface roughness and tool wear measurement	36
3.3	Design of Experiment	37
	3.3.1 Spindle Motor Control Unit	40
	3.3.2 microphone Sensor and DAQ Instrument	42
	3.3.3 Workpiece Preparation and cutting tool	43
	3.3.4 Machining Parameters	44
	3.3.5 Software for data Recording and Analyzing	45
3.4	Design of Experiment for Active PID Controller	46
	3.4.1 Feedrate	51
3.5	Summary	52

CHAPTER 4 RESULTS AND DISCUSSION

4.1	Introduction	53
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4.2	HSM Technique Experiment	54
	4.2.1 Low Cutting Speed Result	54
	4.2.2 High Cutting Speed Result	56
	4.2.3 Discussion	57
4.3	PID Chatter Detection	60
	4.3.1 Time Domain Frequency Result	60
	4.3.2 Surface Roughness Result	65
4.4	SSV Verification in Suppression Chatter	68
	4.4.1 Feed rate variation Result	69
	4.4.2 Depth of Cut Variation Result	70
	4.4.3 Surface Topography Result	71
4.5	Surface Roughness Comparison	77
4.6	Summary for Chapter 4	80
CHAPTER 5 CONCLUSION		
5.1	Introduction	82
5.2	Thesis Contribution	84
5.3	Recommendations	85
REFERENCES		87

LIST OF TABLES

Table 2.1	Comparison between conventional & high-speed machining.	12
Table 3.1	Description of aluminium 6061 and P20.	33
Table 3.2	The specification of the control box	41
Table 3.3	Characteristics of microphone	43
Table 3.4	Characteristics of Aluminium	44
Table 3.5	Parameters of Machining Experiment	45
Table 3.6	Descriptions of functional icons used through experiment	45
Table 3.7	Pre-Experiment parameters with constant spindle speed	48
Table 3.8	Number of experiments with constant feedrate.	51
Table 3.9	Number of experiments with constant depth of cut	51
Table 4.1	Amplitude ratio of sound pressure	60
Table 4.2	Classification of Surface Roughness and FFT amplitude value	68

LIST OF FIGURES

Figure 2.1	Temperature as a function of cutting speed	9
Figure 2.2	Face vertical milling	10
Figure 2.3	Comparison of production indexes.	12
Figure 2.4	Chatter vibration marks.	13
Figure 2.5	Exploits the stability of lobes	17
Figure 2.6	Block diagram of generative chatter loop	18
Figure 2.7	Stability lobes based on orthogonal chatter theory	19
Figure 2.8	Process damping mechanism in dynamic cutter after Tlusty	19
Figure 3.1	Flowchart of the Project	31
Figure 3.2	(a) Aluminium Alloy 6061 (b) P20 Steel	32
Figure 3.3	Design of machining material using Catia 5V60 software	33
Figure 3.4	Experiment setup of tool and material	35
Figure 3.5	Experimental setup (a) before machining (b) during machining	35
Figure 3.6	(a) During pocket cutting process	35
Figure 3.7	(a) Mitutoyo portable surface roughness tester model SJ210 series (b) Metallurgical microscope machine	36
Figure 3.8	(a) Surface roughness measurement (b) Contact point at machining area Machining Experiment for HSM application to high-speeds machining	36
Figure 3.9	Experiment setting arrangement	38
Figure 3.10	Variable Frequency Drive Unit (VFD) of the machine	40
Figure 3.11	Spindle motor	40
Figure 3.12	Control box	41
Figure 3.13	378C01 microphone sensor by PCB Piezotronics	43
Figure 3.14	NI-USB-4431 DAQ	43
Figure 3.15	Single flute end mill	44
Figure 3.16	DasyLab workspace	45
Figure 3.17	Actual setup of the designed experiment	47
Figure 3.18	Active control system setting	48
Figure 3.19	Arduino Board with RS-485 module	49
Figure 3.20	Microphone amplifier and DC offset circuit	49
Figure 3.21	Wiring connection between module and VFD	50
Figure 4.1	Aluminium material after machining process at 2mm depth of cut	54

Figure 4.2	Average surface roughness vs. varying combination of feed rate of First Experiment for Aluminium and P20 Steel.	55
Figure 4.3	Average surface roughness vs varying combination of depth of cut of first experiment for Aluminium and P20 Steel	55
Figure 4.4	Aluminium after machining process at 1mm, 80mm/min and 3500 rpm	56
Figure 4.5	Average surface roughness vs varying combination of feed rate of second experiment for Aluminium and P20 Steel	57
Figure 4.6	Average surface roughness vs varying combination of depth of cut of second experiment for Aluminium and P20 Steel	57
Figure 4.7	The metallurgical microscope image taken that displays tool wear length for second experiment Aluminium with $v=Fr=doc=$, (a)(b)(c)	58
Figure 4.8	The metallurgical microscope image taken that displays tool wear length for second experiment Aluminium with $v=Fr=doc=$, (a)(b)(c)	58
Figure 4.9	The metallurgical microscope image taken that displays tool wear length for second experiment (a)-(c) aluminium at velocity 3500 rpm (a)158.2 μm , (b)163.1 μm (c)163.8 μm wears length vs. varying combination of feed rate	59
Figure 4.10	The metallurgical microscope image taken that displays tool wear length for second experiment (a)-(c) P20 steel at velocity 3500 rpm (a)181.2 μm , (b)180.6 μm (c)173.0 μm	59
Figure 4.11	result for non-stable and stable condition for (a), and (b), respectively.	60
Figure 4.12	Sound pressure pattern of (a) no vibration, (b) average, (c) poor, (d) very poor, and (e) severe chatter condition.	61
Figure 4.13	FFT result for non-stable and stable condition for (a), and (b), respectively	63
Figure 4.14	Amplitude of spectral density of microphone signals at 400 Hz. The cutting parameter variation is (a) depth of cut (mm), (b) feed rate (mm/min), and (c) spindle speed (rpm).	64
Figure 4.15	Surface roughness of the specimens. The cutting parameter variation is (a) depth of cut (mm), (b) feedrate (mm/min) and (c) spindle speed (rpm).	66
Figure 4.16	Time and frequency domain of 2900 mm/min feed rate (a) before and (b) after spindle speed control.	69
Figure 4.17	Time and frequency domain of 0.2 mm depth of cut (a) before and (b) after spindle speed control.	70
Figure 4.18	Surface topography result of material during constant depth of cut (a) S_a before SSV, (b) S_a after SSV, (c) S_v before SSV, (d) S_v after SSV, (e) S_z before SSV, (f) S_z after SSV	72

Figure 4.19	Results of material during constant of depth of cut (a) Sa before and after SSV, (b) Sc before and after SSV, (c) Sz before and after SSV implementation.	73
Figure 4.20	Surface topography result of material during constant depth of cut (g) Sa before SSV (h) Sa after SSV (i) Sv before SSV (j) Sv after SSV (k) Sz before SSV (l) Sz after SSV.	75
Figure 4.21	Result of material during constant depth of cut (a) Sa before and after SSV, (b) Sv before and after SSV and (c) Sz before and after SSV implementation	76
Figure 4.22	Surface roughness value of the specimen in active control for (a) depth of cut and (b) feed rate variable.	78
Figure 4.23	Surface finish of 0.2 mm depth of cut (a) before and (b) after spindle speed control.	79
Figure 4.24	Surface finish of 2900 mm/min feed rate (a) before and (b) after spindle speed control.	79

LIST OF SYMBOLS

d.o.c	Depth of cut (mm)
f	Feed rate (mm/min)
N	Velocity (m/s)

LIST OF ABBREVIATIONS

CNC	Computer Numerical Control
DAQ	Data Acquisition Board
DTFT	Discrete Time Fourier Transform
FKP	Faculty of Manufacturing Engineering
FFT	Fast Fourier Transform
HSM	High Speed Machining
MRR	Material Removal Rate
PID	Proportional Integral Derivative
SSV	Spindle Speed Variation
USB	Universal Serial Bus
VFD	Variable Frequency Drive

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