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

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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 gelatuk semasa proses pengilingan. Gelatuk 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 gelatuk 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 pengilangan 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 diperoleh. Ia menunjukkan penambah baikan pada permukaan selepas kaedah variasi kelajuan gelendon mesin diguna pakai dalam proses pengilingan berkelajuan tinggi. Keputusan yang diperoleh 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 penambah baik sehingga 86.7% semasa proses eksperimen aktif berbanding eksperimen awal. Ini selepas kaedah variasi kelajuan pemotongan dan pengilingan berkelajuan tinggi dilaksanakan. Ini membuktikan bahawa gelatuk semasa pemesinan boleh dicegah menggunakan kaedah variasi kelajuan gelendong dengan kawalan PID dan maklum balas mikrofon. Kajian ini menyumbang kepada industri penggilingan 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 signed 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 final part then degree measure of tool wear and less in amount the 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.

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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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