MACHINING SURFACE ROUGHNESS MONITORING USING ACOUSTIC EMISSION METHOD

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

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

DECEMBER 2010

SUPERVISOR'S DECLARATION

I hereby declare that I 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

I am grateful and would like to express my sincere gratitude to my supervisor Mr.Che Ku Eddy Nizwan Che Ku Hussin for germinal ideas, invaluable guidance, continuous encouragement and constant support in making this research possible. He has always impressed me with his outstanding professional conduct, his strong conviction for science, and his belief that a Degree program is only a start of a life-long learning experience. I am truly grateful for his progressive vision about my training in science, his tolerance of my naive mistakes, and his commitment to my future career. I also would like to express very special thanks for their suggestions and co-operation throughout the study. I also sincerely thanks for the time spent proofreading and correcting my many mistakes.

My sincere thanks go to all my lab mates and members of the staff of the Mechanical Engineering Department, UMP, who helped me in many ways and made my stay at UMP pleasant and unforgettable. Many special thanks go to member engine research group for their excellent co-operation, inspirations and supports during this study.

I acknowledge my sincere indebtedness and gratitude to my parents for their love, dream and sacrifice throughout my life. I cannot find the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to attain my goals. Special thanks should be given to my committee members. I would like to acknowledge their comments and suggestions, which was crucial for the successful completion of this study.

ABSTRACT

This thesis is to investigate the machining surface roughness monitoring using acoustic emission method. The objective of this project is to collect the data acquisition of the experiment by operating milling process, to study the correlation of AE parameter with work piece surface quality by comparing the AE signals with average roughness, R_a of the work piece's surface measured by using Perthometer, and to develop algorithm for online machining condition monitoring. In order to done this experiment, there are several steps to be taken. Firstly is the experimental setup. Milling machine will be used through this project. Work piece will be placed on the table and the cutting tool will rotate continuously. AE sensor will be placed on the work piece, and adhesively bonded onto the surface of the work piece with grease applied between the specimen and the sensors. Before experiment is started, the AE system need to be tested first to check whether AE system can receive AE signals properly. This can be done by using pencil break test. When lead of pencil break, it will generate as equal signal as AE signal emitted during experiment. Then, the experiment is run using carbide coated cutting tool and Aluminium alloy for work piece. Machine parameter use will be varies to get different pattern of AE signal, as different value of surface roughness also will be collected. From all data collected (energy, counts, power spectrum density, R_a), algorithm for surface roughness monitoring can be made and be used in industry. Based on experiment data, the pattern of AE parameter with Fast Fourier Transform, FFT can be concluded. For smooth surface, *Ra* value in range of 0.643 µm – 0.879 µm will have the frequency below 1 Hz and amplitude is high only at that value. For the rough surface, *Ra* value in range of 2.833 µm – 3.004 µm will have the frequency from 1 Hz to 2 Hz and amplitude is high continuously at that value. In term of count, smooth surface will generate counts in range of 20 000 to 30 000 and rough surface will counts 30 000 and above.

ABSTRAK

Tesis ini ditulis untuk pemantauan kekasaran permukaan bahan dalam permesinan menggunakan kaedah pancaran akustik. Objektif projek ini adalah untuk mengumpul data dengan menjalankan operasi pengisaran, mengkaji kaitan antara parameter AE dengan kekasaran bahan, R_a menggunakan *Perthometer*, dan membina algoritma untuk pemantauan mesin secara terus. Untuk menjalankan kajian ini, beberapa langkah perlulah dilakukan terlebih dahulu. Pertama adalah penyediaan mesin. Mesin pengisaran akan digunakan sepanjang proses ini. Bahan kerja akan diletakkan di atas meja kerja dan pekakas pemotong akan berputar secara berterusan. AE sensor akan diletakkan di tepi bahan kerja dan dilekatkan dengan gris antara permukaan sensor dan tepi bahan kerja. Sebelum kajian dimulakan, sistem pancaran akustik perlulah dicuba terlebih dahulu untuk mengesan jika sistem boleh menerima isyarat dengan baik. Ini boleh dilakukan dengan ujian patah mata pensil. Apabila mata pensil patah, ia akan mengeluarkan sejumlah isyarat sama seperti isyarat pembebasan akustik semasa kajian dilakukan. Kemudian, kajian dijalankan dengan menggunakan mata pemotong karbida bersalut dan bahan kerja aluminium. Parameter pemesinan adalah berlainan bagi setiap set kajian untuk mendapatkan corak pembebasan akustik yang berlainan dan nilai permukaan bahan yang berlainan. Berdasarkan data dari kajian, corak parameter AE dan Penjelmaan Fourier Pantas, FFT dapat disimpulkan. Untuk permukaan yang halus, nilai R_a antara 0.643 µm – 0.879 µm akan menghasilkan frekuensi bawah 1 Hz dan amplitud tinggi hanya pada nilai itu sahaja. Bagi permukaan kasar, nilai R_a antara 2.833 µm – 3.004 µm akan mempunyai frekuensi diantara 1 Hz dan 2 Hz dan amplitudnya adalah tinggi secara berterusan. Dalam terma hitungan pula, permukaan halus akan menghasilkan bacaan antara 20 000 hingga 30 000 dan permukaan kasar pula adalah lebih daripada 30 000.

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R_a	Roughness average
v_c	Cutting speed
%	Percent
dB	Decibel
D_c	Depth of cut
f	Feed

LIST OF ABBREVIATIONS

AE	Acoustic Emission
FFT	Fast Fourier Transform
CNC	Computer Numeric Control
RPM	Spindle speed
N	Number of tooth
CPT	Chip per tooth
PSD	Power spectral density

and save more time and cost for the industries. For the offline method, data cannot be taken unless the machine is stop first. The cutting tool have to be looked under the microscope to analyze the microstructure of it before any assumption can be made about the tool. By differentiate both of this method, we can know that online method is more applicable for industries due to its benefits which is save time and cost. For this experiment, Acoustic Emission signal analysis is used. The choice of this type of monitoring is because the machining monitoring can be done while the machine is still running. Besides, data get from the experiment is more accurate due to the location of sensor. In this experiment, the sensor will take direct reading from the cutting tool and therefore data is not influenced by other source. The main field of application for AE sensors is tool breakage detection. At the instant of breakage, there is a sudden jump in the signal. In order to detect this signal peak, a dynamic threshold crossed by a tool breakage is calculated on-line from the signal. The resulting threshold easily follows gradual changes in the signal, due for example to changing depths-of-cut, but is violated by steep-flanked signal peaks. Violation of the threshold therefore indicates a tool breakage.(Kbnig et al, 1994)

1.2 PROBLEM STATEMENT

Generally, machining condition monitoring is a process to monitor the machine parameter. In machining, the most important parameter that has to keep in attention is the condition of cutting tool. Although in many machining operations the cutting tool is the least expensive component of the cutting system compared to the machine and workpiece, most of the monitoring effort is concentrated on ensuring that it is in good working condition. This is because changing the cutting tool results in down time which is very costly. Therefore, an essential part of an untended machining system is the ability to change tools when they are worn or broken. The cutting tool needs to be changed before catastrophic failure damages the workpiece and possibly the machine. In years before, industries uses the conventional method of monitoring which is offline monitoring. The offline monitoring process can only be run when the machine is not operating. This type of monitoring can be carried out through skilled machinists' knowledge and experience. This type of process has cost industries lot in term of quantities of production, time and money. The shortage of skilled machinists, as well as cost saving concerns, has led to the popularity of unmanned machining systems in this area. So, by using Acoustic Emission method, the cost rely by the industries can be saved.

Acoustic Emission method is an online monitoring process is, widely used in the industries now. By the term of online monitoring, monitoring machining condition can be done while the machine is still operating. The use of conditional monitoring allows maintenance to be scheduled, or other actions to be taken to avoid the consequences of failure, before the failure occurs, stop unscheduled outages, optimize machine performance, and reduce repair time and maintenance costs. By using AE method, the accuracy of the data taken is reliable because the energy emitted by the source can be exactly taken by the sensor without external disturbances. With this type of monitoring, hopes that the machining condition can be easily monitored and can help the industries to save cost wheres area involved.

1.3 OBJECTIVE OF THE RESEARCH

The purpose of this project is to;

1. Collect the data acquisition of the experiment.

   In order to collect the data, milling process is used. The sensor will be located at the workpiece and then transfer the data collected to data acquisition machine. All data in term of energy, count, and rms will be saved by the machine.
2. To study the correlation of AE parameter with work piece surface quality.

   The AE parameters, which have been saved by data acquisition machine is used to correlate with workpiece's surface quality. Surface roughness will be measured using Perthometer and then compared with the AE signal saved.
3. To develop algorithm for online machining condition monitoring.

   From all data collected, which AE parameters and surface roughness, algorithm for machining condition monitoring is developed. By this, conclusion can be made as for the monitoring machining condition.

1.4 HYPOTHESIS

The work piece's surface finish is related to the cutting tool condition. When the cutting tool is working in bad condition, the surface finish is rough as vice versa. As stated by ANSI, 1985, the value of roughness average, R_a for milling process is between ranges of 25 µm to 0.20 µm if the machine's application is less and in ranges 6.3 µm to 1.6 µm in average application. Based on this value, the surface roughness can be determined and the condition of the work piece can be justified.

1.5 SCOPE OF WORK

The approach in the machining condition monitoring will be as follows:

i. Using an AE sensor in a frequency range of 150-300kHz while running a milling machine
ii. Using AE parameter which is count, and frequency spectrum to correlate with workpiece surface roughness.
iii. Apply the Matlab software to develop algorithm.
iv. Using carbide coated for cutting tool.
v. Using Alluminium alloy (AA6061-T6), as workpiece.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

All machining processes remove material to form shapes. As metals are still the most widely used materials in manufacturing, machining processes are usually used for metals. However, machining can also be used to shape plastics and other materials which are becoming more widespread. Basically all the different forms of machining involve removing material from a component using a rotating cutter. The differences between the various types arise from the relative motion between cutting tool and workpiece and the type of cutting tool used.

Typically machining will be done using a machine tool. This tool holds the workpiece and the rotating cutting tool and allows relative movement between the two. Usually machine tools are dedicated to one type of machining operation, although some more flexible tools allow more than one type of machining to be performed. The machine tool can either be under manual or automatic (Computer Numeric Control - CNC) control. Automatic control is more expensive because of the need to invest in the necessary control mechanisms however it becomes more desirable as the number of components produced increases and labour costs can be reduced.

The speed at which a machine tool can process individual components is a function of the cutting speed of the tool and the downtime involved in changing the workpiece and maintaining the tool (this will usually involve changing the cutting edges of the tool). Some very flexible tools allow automatic changing of components and cutting tools, however they greatly add to initial purchase price of the machine tool.

The cutting speed of the tool is usually dictated by the type of material being machined, in general the harder the material, the slower the machining time. Machining speed can be increased by increasing the rotational speed of the cutter; however this will be at the expense of the tool life. Hence for machining processes there is an optimum cutting speed that balances tooling costs with cutting speed.

In order to dissipate the heat generated between the work piece and the cutting tool, cutting fluids are sprayed onto the tool. The cutting fluid also acts to remove cut material away from the cutting region and lubricates the tool - work piece interface but may require that the component is cleaned afterwards.

2.2 TYPES OF MACHINING

In terms of annual dollar spent, machining is the most important of the manufacturing process. Machining can be defined as the process of removing material from a workpiece in the form of chips. The term metal cutting is used when the material is metallic. Most machining has very low set-up cost compared to forming, molding, and casting processes. However, machining is much more expensive for high volumes. Machining is necessary where tight tolerances on dimensions and finishes are required.

The types of machining can be divided into two classifications. They are traditional/conventional machining and non conventional machining. Processes which are done on conventional machine like lathe, shaper, and grinding is called conventional machining and for non-conventional machining are done by the applications of those methods which are well developed such as electrochemical machining(ECM), water jet machining(WJM), abrasive jet machining(AJM), electric discharge machining(EDM), AND ultrasonic machining(USM).

In this paper, only conventional machining will be reviewed since milling process is used for the experiment. As stated before, conventional machining is consisted of several processes including turning, grinding, drilling, and milling.

2.2.1 Turning Proces

Turning is another of the basic machining processes. Turning produces solids of revolution which can be tightly toleranced because of the specialized nature of the opertaion. Turning is performed on a machine called a lathe in which the tool is stationary and the part is rotated. The figure below illustrates an engine lathe. Lathes are designed solely for turning operations, so that precise control of the cutting results in tight tolerances. The workpiece is mounted on the chuck which rotates relative to the stationary tool.

The typical dimensional tolerances for turning process is, ± mm :

- Fine : 0.025 – 0.13 mm
- Rough : 0.13 mm

The Figure 2.1 is the illustration of lathe machine, machine used in turning process.

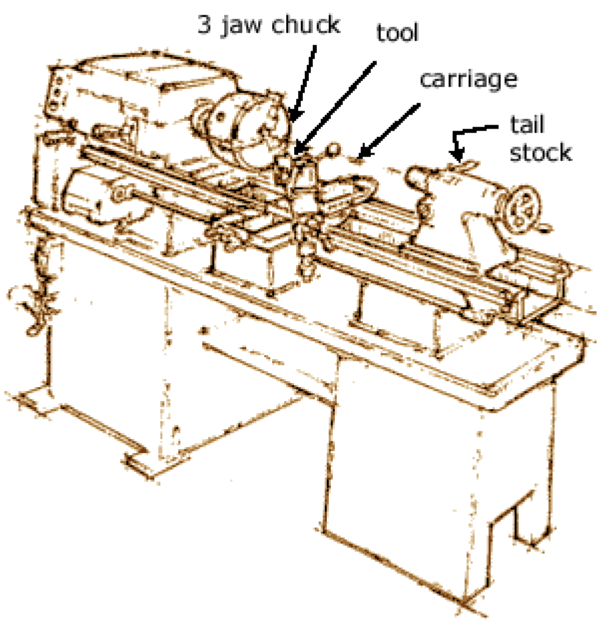

Figure 2.1: Lathe machine

Source: efunda.com (2005)

Turning process refers to cutting as shown in Figure 2.2:

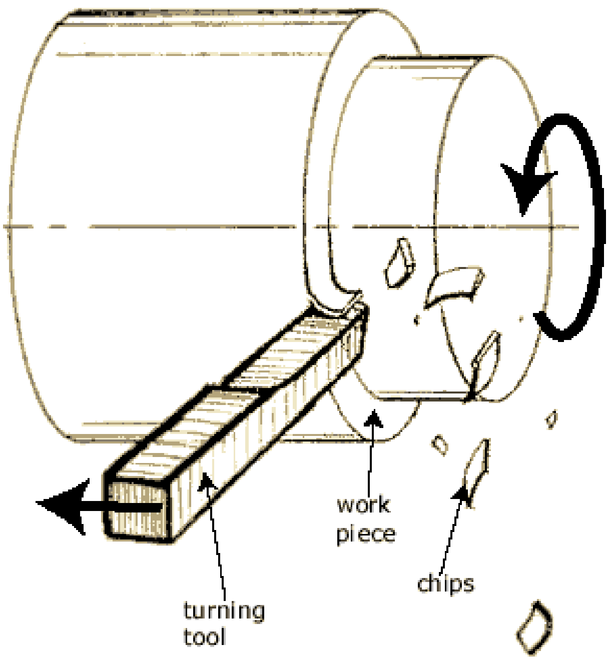

Figure 2.2: Cutting process

Source: efunda.com (2005)

The term "facing" is used to described removal of material from the flat of a cylindrical part as shown below. Facing is often used to improve the finish of surfaces that have been parted. Facing can be shown as in Figure 2.3 .

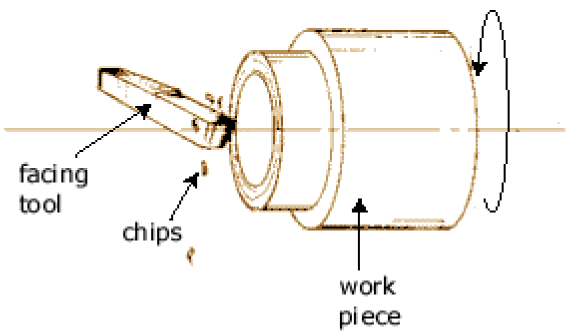

Figure 2.3: Facing

Source: efunda.com (2005)

2.2.2 Milling Process

Milling is as fundamental as drilling among powered metal cutting processes. Milling is versatile for a basic machining process, but because the milling set up has so many degrees of freedom, milling is usually less accurate than turning or grinding unless special rigid fixturing is implemented.

For manual machining milling is essential to fabricate any object that is not axially symmetric. There is a wide range of different milling machines, ranging from manual light-duty Bridgeports^{TM} to huge CNC machines for milling parts hundreds off feet long. Figure 2.4 is illustrated the process at the cutting area.

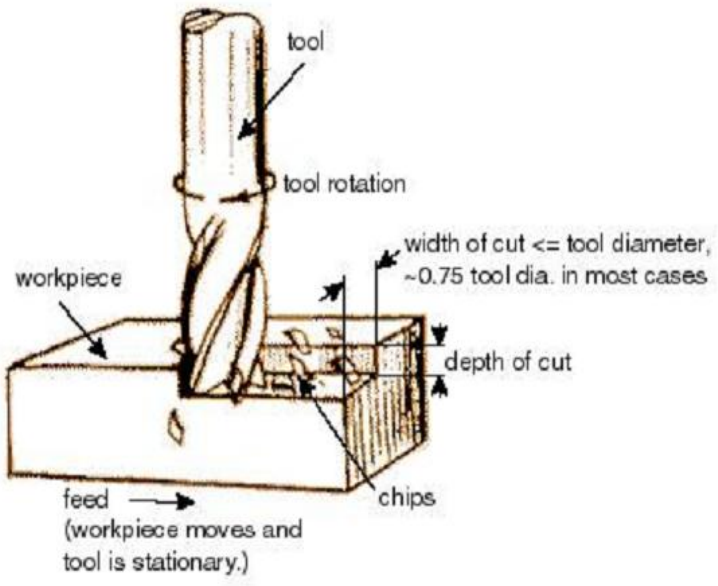

Figure 2.4: Milling process

Source: efunda.com (2005)

Figure 2.5 is illustrated a typical column-and-knee type manual mill. Such manual mills are common in job shops that specialize in parts that are low volume and quickly fabricated. Such job shops are often termed "model shops" because of the prototyping nature of the work.

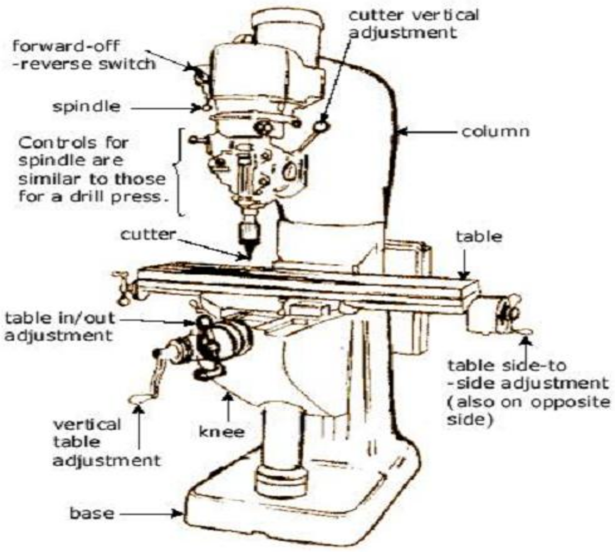

Figure 2.5: Typical Column-And-Knee Type Manual Mill

Source: efunda.com (2005)

Figure 2.6 is the illustration of the milling machine in separataion. The table can be moved to right and left, the saddle can be moved forward and backward and the knee is used to change the height of the milling head.

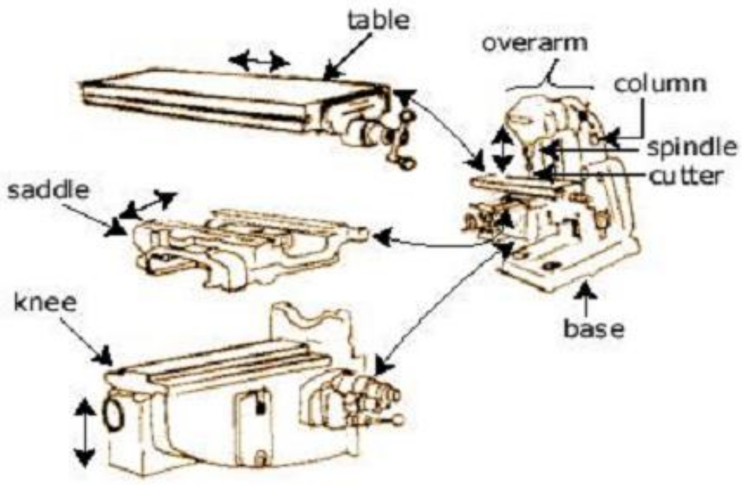

Figure 2.6: Separated part of milling machine

Source: efunda.com (2005)

2.2.3 Drilling Process

This is a very common machining process used to produce holes in components. To create a hole, a drill bit is rotated at high speeds. The screw thread shape of the drill bit causes materials to be cut away as the drill bit is pushed into the workpiece.

There are several types of drill available. Hand held drills are useful for drilling holes in any location, but requires accurate use. Pillar drills used in workshops are fixed orientation drills. The work piece is clamped so that it can't move which makes it easier to drill more accurate holes. The problem with pillar drills is that the work piece has to be small enough to fit on to the table. Note that different materials have their own drill bits

As shown in Figure 2.7, drilling process is a process to make a hole at the workpiece. Drilling involves the creation of holes that are right circular cylinders. This is accomplished most typically by using twist drill. The figure also illustrate the cross section of hole being cut by a common twist drill.The chips must exit through the flutes to the outside of the tool. In order to making the drilling process going smoothly, coolant must be applied and delivered through the drill bit shaft.

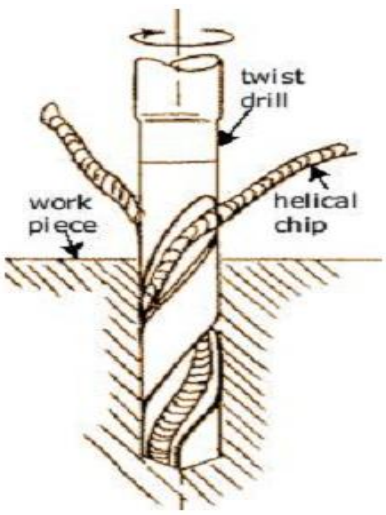

Figure 2.7: Drilling process

Source: efunda.com(2005)