EVALUATION OF SURFACE ROUGHNESS AND POWER CONSUMPTION IN
MACHINING FCD 450 USING COATED AND UNCOATED IRREGULAR
MILLING TOOLS

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ABSTRACT

Machining is the most important manufacturing process in these modern industries especially for producing automotive component. Quality, productivity and cost saving in manufacturing industries is one of the main manufacturer focus in making mechanical product in Sapura Industry. In this project, the effects of different cutting conditions (spindle speed, feed rate, and depth of cut, machining length and machining time) on surface roughness and power consumption on FCD450 cast iron by using CNC milling machine are studied. The experimental output indicated average decrement 27.92% for surface roughness by using coated compare uncoated tool. Average decrement 9.32% for power consumption by using coated compare uncoated tool. The suggested cutting parameter for lowest surface roughness and lowest power consumption by using coated and uncoated tools are; cutting speed (3026 rev/min), feed rate (120 mm/min), depth of cut (0.75 mm), radial depth of cut (20 mm), machining time (73.5 second) and machining length (300 mm). From the results, the optimum cutting speed (2587.95 rev/min), feed rate (280.28 mm/min), lowest depth of cut (0.75 mm), radial depth of cut (10.88 mm), machining time (72.5 second) and machining length (269.4 mm) is suggested for further analysis and experiment of coated solid carbide cutting tools to get optimum performance. From the results experiments, it can be concluded that using coated solid carbide give optimum results in the term of surface roughness, power consumption, tool wear and tool life as compared to uncoated tools in milling. High quality surface and high productivity is obtained using coated tool compare uncoated tools because using coated is more economical in terms of energy and power requirements which meet the high demand of the industry nowadays.
**ABSTRAK**

Pemesinan adalah proses pembuatan yang paling penting dalam industri moden terutama untuk menghasilkan komponen automotif. Kualiti, produktiviti dan penjimatan kos dalam industri pembuatan adalah salah satu tumpuan utama dalam membuat produk mekanikal untuk Industri Sapura. Dalam projek ini, kesan daripada keadana pemotongan yang berbeza (kelajuan gelendong, kadar suapan dan kedalaman pemotongan, panjang pemesinan dan masa pemesinan) pada kekasaran permukaan dan penggunaan kuasa pada FCD450 besi tuang dengan menggunakan mesin pengilangan CNC telah dikaji. Pengurangan sebanyak 27,92 % terhadap kekasaran permukaan adalah dengan menggunakan alatan bersalut berbanding alatan yang tidak bersalut. Manakala pengurangan penggunaan kuasa sebanyak 9.32% terhadap alatan bersalut. Parameter pemotongan yang dicadangkan untuk mendapatkan kekasaran permukaan dan penggunaan kuasa terrendah dengan menggunakan alatan bersalut dan alatan tidak bersalut adalah; kelajuan pemotongan (3026 put / min), kadar suapan (120 mm / min), kedalaman pemotongan (0.75 mm), dalam pemotongan (20 mm), masa pemesinan (73.5 saat ) dan panjang pemesinan (300 mm). Daripada keputusan eksperimen untuk alatan bersalut, optimum kelajuan pemotongan yang dicadangkan untuk analisis lanjut dan eksperimen bersalut alat pemotong karbida pepejal untuk mendapatkan prestasi yang optimum adalah (2587,95 put / min) , kadar suapan (280.28 mm / min), pemotongan kedalaman paling rendah (0.75 mm), dalam pemotongan (10,88 mm), masa pemesinan (72.5 saat ) dan pemesinan panjang (269.4 mm). Daripada keputusan eksperimen, dapat disimpulkan bahawa menggunakan alatan bersalut memberikan hasil yang optimum terhadap kekasaran permukaan, penggunaan kuasa, alat haus dan hayat alat lebih lama berbanding alatan yang tidak bersalut. Permukaan yang bagus dan produktiviti yang tinggi dapat diperolehi dengan menggunakan alatan bersalut berbanding meggunakan alatan tidak bersalut disamping ia lebih jimat dari segi tenaga dan kuasa bagi memenuhi keperluan dan permintaan yang tinggi daripada industri masa kini.
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<td>CL</td>
<td>Chip Load</td>
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<td>DOC</td>
<td>Depth of Cut</td>
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<td>FR</td>
<td>Feed Rate</td>
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<td>GPS</td>
<td>Geometry Product Specifications</td>
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<td>ISO</td>
<td>International Organization for Standardization</td>
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<td>ML</td>
<td>Machining Length</td>
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<td>RDOC</td>
<td>Radial Depth of Cut</td>
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<td>SFM</td>
<td>Surface feet per minute</td>
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<td>SS</td>
<td>Spindle Speed</td>
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LIST OF SYMBOLS

(Fz)    Thrust force
Ra      Surface Roughness
VB      Flank Wear land
VB_k    Allowed Flank Wear land
Rz      Average Maximum Height
Rt      Maximum Height of Surface
Rv      Maximum Valley Depth
Rp      Maximum Peak Height
R Motif Motif Parameter
C       Carbon
Si      Silicon
Mn      Manganese
P       Phosphorus
S       Sulphur
Mg      Magnesium
Fe      Iron
CHAPTER 1

INTRODUCTION AND GENERAL INFORMATION

1.1 PROJECT BACKGROUND

Machining can be defined as a process that involved removing the material from the work piece and cut it into desired size and shape in form of machining chip. It’s also can be considered as the most essential process in manufacturing processes. Main industry goal’s is to manufacture high quality product, as well as low cost in short time. One of the most important elements in machining is the tools and cost of each tool can be varied and expensive according to their function and endurance.

First step for machining in planning process is starting from selection of cutting tool to know the cutting condition as well as to obtain specific data of tool life, cutting force, surface roughness, chattering and vibration, which is traditionally carried out base on planner experiences and general knowledge which is need to measured and recorded to compare with standard part (regular cutting tool). Besides that, handbook and tool catalogues are used to know standard data of the tool and machine before run the task.

A new cutting tool performance behaviour test can be applied to help businesses gain a competitive edge and it’s also describe all the tool characteristics’. The study of power consumed by the tool helps to find out the life of the tool for maximum productivity, helps to select the capacity of the motor required for the machine and it also helps for designing machine components. Wide of knowledge and have a better understanding about engineering material is essential for manufacturer during development.
To know characteristic of new cutting tool, various experiments should be conducted to obtain cutting tool specifies data to achieve the main general objectives which are to evaluate the power consumption and surface roughness effect of cutting tool due to variation of spindle speed, feed rate, depth of cut and radial depth of cut. To analyze surface roughness and power consumption of coated and uncoated irregular milling tool for optimum parameters in the machining length and machining time to measure the performance and to determine the optimum cutting parameters based on average surface roughness and power consumption result on the milling machine. Performance of machining process depends on the surface smoothness, and power consumption so that it’s become the major topics in process planning and machining optimization in industry to increase the productivity of the product and lowering tooling cost.

1.2 PROBLEM STATEMENT

Quality and efficiency of the product in manufacturing industries is one of the main manufacturer focus and to increase the productivity of the product in Sapura Industry, one larger factor is selection of cutting tools and cutting condition for machining. To know characteristic of new cutting tool, various experiments should be conducted to get optimum cutting tool performance to achieve the main objectives tools to fulfil Sapura’s requirement. This research project focused surface roughness and the power consumption test by FCD 450 cast iron using irregular milling tool coated and uncoated solid carbide. This material was been selected because they can be considered as materials that widely used in Sapura industry for block engine application.

1.3 OBJECTIVE OF THE RESEARCH

1. To evaluate the power consumption and surface roughness effect of cutting tool due to variation of spindle speed, feed rate, depth of cut and radial depth of cut.
2. To analyze surface roughness and power consumption of coated and uncoated irregular milling tool for optimum parameters in the machining length and machining time to measure the performance
3. To determine the optimum cutting parameters based on average surface roughness and power consumption result on the milling machine.
1.4 SCOPE OF STUDY

1) To conduct machining experiment of irregular end mill for coated and uncoated solid carbide end mill Ø20mm by using CNC KE55 Milling Machine.

2) To evaluate the surface roughness and power consumption effect of cutting tool due to variation of cutting conditions such as spindle speed, feed rate, axial and radial depth of cut, machining time and machining length.

3) To analyse and compare surface roughness and power consumption of coated irregular milling tool due to optimum parameter for cutting conditions.

1.5 FLOW CHART

The sequences of works have been planned for this project in order to achieve the project objectives. This flow chart is useful to ensure that all work regarding this project will be carried out as planned and smoothly. The process flow chart is shown in figure 1.1 below. Figure 1.1 shows the process starts by defining the project background and the objectives of the project. Research are done for journal and reading material regarding project, this step is very important to ensure that project run smoothly and to keep the project within its scope. Journal and reading material are review according to the project title and scope.

Procedure and methodology of the project are planned and recorded. In machining and experiment process the material of the project are determined, experiment method and fabrication of the tool are done and the calculation regarding economic value of the tool, if the result and analysis are acceptable and within the project objectives, the data from the machining and experiment are discussed and then concluded. Figure 1.1 show the project flow chart. Whereas Gantt chart can be referred in appendices A.
Figure 1.1: Project flow chart

Start Project

1. Defined project background and objectives of the project
2. Research for journal and reading material regarding project
3. Read material and the journal for the literature review
4. Experiment setup and procedure are planned

- No
  - Machining and experiment data is recorded

  - Yes
  - Data are analysed and discussed
  - Project are concluded
  - Presentation of Project
  - Submission of project report
  - End
CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

General objective for the new cutting experiment done by previous researcher is to know their performance behaviour such as tool wear, tool life, vibration, surface roughness, power consumption on the machine and etc. according their standard test. (Kusuma.N, 2014). But one of the objective for this experiment is to understand the behaviour of tool for coated and uncoated solid carbide, workpiece surface roughness and power consumption by using CNC Milling Machine. The good surface roughness is depend on the characteristic of tool used because the tool life is one of the most importance aspect must be considered because tool condition monitoring is vital to prevent workpiece and the tool from damage as well as to increase the effective machine time of machine tool. Tool wear is a phenomena where the material used to construct the cutting tool gradually peeling off during machining process due to the combination of mechanical-thermal-chemical process (Cook, 1973).

Literature review was conducted to achieve the objective of this experiment by set up the coated and uncoated 8 flute solid carbide as the cutting tool, FCD450 cast iron block as the workpiece material in order to acquire the result on surface roughness and power consumption on the work piece by using CNC milling machine. Productivity at the machine and machine efficiency can be improved by using coated and uncoated 8 flute solid carbide cutting tool with their optimum parameter. To realise it, some of the suitable test must be implement follow standard test about surface roughness and power consumption testing and all related data is recorded for future analysis.
2.2 MACHINING

Definition of the machining can be described as the process where the cutting tool remove unwanted material from the work piece by follow machining standard parameter to produce the desire shape. There have three major type of material removal process which are mechanical, chemical and thermal. Metal cutting is one of the most significant manufacturing processes in the area of material removal (Chen J.C, 1997). (Black J.T, 1979) defined metal cutting as the removal of metal chips from a workpiece in order to obtain a finished product with desired attributes of size, shape, and surface roughness.

The common used in cutting tool experiment for material removal process is only mechanical. Machinability can be expressed as the easiness or difficulty in a machining operation involving cutting conditions such as cutting speed, feed rate and depth of cut. The machinability of a material can be defined by measuring the tool life, surface roughness and cutting force.

2.2.1 Turning

Turning is one of the widely used machining processes. The productivity of the turning process is mainly limited by machine tool chatter caused by the interaction between cutting tool and workpiece structure and dynamics of the cutting process. Study of force is very importance in turning operation because cutting force relate strongly with cutting performance such as surface accuracy, tool wear, tool breakage, cutting temperature, self- excited, forces vibration and etc., (Silliman, 1992). Coated and uncoated carbide tools are widely used in the metal- working industry and provide the best alternative for most turning operations (Deepak, 2013).

Figure 2.1 shows type turning operation such as turning, boring, facing, grooving and thread cutting allow for a wide variety of features be machine, including slot, taper, thread, flat surface, and complex contour.
2.2.2 Milling

Milling is one of the multi-point cutting for material removal processes which using sharp cutting tool to remove the material against the workpieces. Milling is a fundamental process and the most encounter metal removal operation in manufacturing industry. The quality of a milled surface is a key role for improving fatigue strength, corrosion resistance, and creep life (Mohammed T, 2007). The process of generating a milled surface is affected by several factors, some of them, namely the cutting conditions and tool geometry, are of primary importance in determining the quality of a milled surface (Evalio et. al., 1983). (Jalili Saffar et. al., 2009) stated that the main parameters
in machining affecting tool deflection and surface finish are axial depth of cut, radial depth of cut and feed rate. (Nagi et. al., 2008) described that surface roughness is more sensitive to the feed rate and the depth of cut. Figure 2.2 shows type of milling operations.

![Type of milling operations](http://www.custompartnet.com/wu/milling)

**Figure 2.2:** Type of milling operations


### 2.2.3 Drilling

Drilling process is one of the most importance machining process that have been usually used in industry for manufacturing districts (Bagci, 2006). Drilling is the process of rotating cutting tool to remove material from the stationary solid material workpiece to create a hole or enlarge holes, high precision holes and threated holes by used drill bit. For broaching and sawing, it’s not required rotation of the tool for multi-point cutting process. Counterboring, countersinking and tapping are the example of drilling process. About 75% of the drilling operation is used in manufacturing area for metal cutting process (kovacs, et. al., 2011). Figure 2.3 shows 4 type of drilling operation.
2.2.4 Abrasive machining

Abrasive machining is the operation using any tool that have small abrasive particle to remove a small chip of material on the workpiece same as milling or turning process. Main purpose for this process is to get the high quality of surface finish and increase the quality of the product (zero defect). The most common abrasive using is grinding as shown in Figure 2.4.
2.3 CNC MILLING MACHINE

Milling machine is one of the most multifunction machine tools. In 1820, Eli Whitney is the first person that invent and built the milling machine. One of the first studies to examine energy usage of computer numerical controlled (CNC) machines was done by (Filippi et. al., 1981). This study found that the largest loss of efficiency in machining was due to machine under-utilization. Figure 2.5 show example of cutting operation that can be done by milling machine. End, milling is widely used in industry and one of the importance machining operation because it has capability to obtain various profile and curve surface (Kalpakjian and Schmid, 2006).

Computer Numerical Control (CNC) machines are widely used in manufacturing industry. The industries that commonly used this machine are including automobile and aerospace industry (Mike et. al., 1999). Benefit using CNC milling machine is this machine give 100% correct with what they produce when being programmed correctly. Besides that, CNC machine more expensive compare to conventional machine and high skill worker are required to operate CNC machine.
Figure 2.5: CNC Milling Machine


2.4 END MILLING PROCESS

End milling is the operation that the tool moved across the stationary workpieces to get rid of the material from the surface of the work material by rotating tool on an axis perpendicular (Kalpakjian and Schmid, 2006). It’s also very importance process because of its capability to produce various profile and curve surface. End milling is the widely used operation for metal removal in a variety of manufacturing industries including the automobile and aerospace sector where quality is an important factor in the production of slots, pockets and moulds/dies (Mike et. al, 1999; John and Joseph, 2001). Therefore, the desired finish surface is usually specified and the appropriate processes are selected to reach the required quality. Several factors influence the final surface roughness in end milling operation.