



## Optimum Cutting Parameters On Wood Carving Machining On 3D Machining Using Edu-Mill

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### KEYWORDS

Step-over  
Edu-Mill  
'Chengal' wood  
Surface finish  
RSM

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### ABSTRACT

The Computer Numerical Control (CNC) machine is the idea of an evolution in world of machining. Nowadays, the advance technology in CNC machine, the industrial production will be one step ahead compared than before. Based on this technology, a study of design and fabrication of Edu-mill CNC milling machine that compatible with the common type of machine in a small scale working area has been done. This new research was done to analyze the 3D performance of the Edu-mill CNC milling machine. The performance of profile (3D) cutting was tested to analyze the outcome of that function. The result of this study show by the surface finish of a sample from wood. The longer the time taken for machining process, the better the surface finish for the product.

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## 1.0 INTRODUCTION

Numerical control is based on the use of numerical data for controlling the position of the operative units of a machine tool during machining operation. Today, a more popular adaption of the basic process of NC is called Computer Numerical Control or CNC. Computer Numerical Control (CNC) Machining is the process through which controlled includes lathes, mills, routers and grinders all used for metal and plastic products.

Mini CNC machine is the machine that is similar to the usual CNC machine. Mini CNC machine is the small CNC machine that can operate like usual CNC machine but the area of the machining is limited. CNC machine is all about using the computer as a means to control machines that carves useful objects from solid block to material. There are many types of CNC machine. The common CNC machines are two-axis and three-axis CNC machine. The two-axis machine can move on vertical and horizontal only which are X and Y axis. Three-axis machine can do movement starting with three primary axis which are X, Y and Z axis.

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The CNC machine operation starts with the data collecting the data from the programming that extract from the computer-aided design (CAD) and computer-aided manufacturing (CAM). The programs produce the computer file and the will extract the command to operate the machine. The program will be transfer via post-processor and then be loaded into the CNC machine to start the machining.

The CNC machine is a system. To complete the system of CNC machine, there are four components which are mechanical design, drives module, system software and Automatically Programme Tool (APT) postprocessor. For the mechanical design system, this part is the part of hardware of machine which is the part body. For the drive system, the command signal was received from microprocessor. Microprocessor is consisting of motors, amplifier units and a power supply. For the software system, it is generating the program to the CNC machine to start the movement of tools and work piece. Besides that, CNC machine also includes of wiring in order to connect the power to the machine. To complete the whole CNC machine, all the elements must be in the good condition and must put at right place.

## 2.0 METHODOLOGY

The main objective of this project is to analyze the 3D performance of the Edu-mill CNC milling machine. In this section, it will tell about the experiment that had been done from the research up to the analysis to fulfill the objectives of the project. Before starting this project, reading is needed to be done whether from related journal or from the internet in order to understand the main point of the project. By making the literatures review, it helps in order to further understand the machining parameters need to be considered for this project. For this project, the experiment made are based on the table of the Edu-mill CNC milling machine that had been made. With this, the data and result that come out of the experiment is reliable and trusted.

'Chengal' tree is a popular hardwood tree. The natural distribution of this tree is restricted to Peninsular Malaysia, Singapore and Southern Thailand. 'Chengal' is found in mixed dipterocarp lowland forests, especially on undulating lands, in swampy areas and sometimes in dry areas of swamp forests. 'Chengal' is a durable hardwood timber and has a density of between 915 to 980 kilograms per cubic meter is normally used in heavy construction work, especially boats construction, pillars and bridges without the need to preserve because it is resistant from termites attacks. In Malaysia, a 'chengal' tree grows in lowland areas less than 1000 meters elevation, especially in areas with good water drainage. Normally 'chengal' tree grows well in the areas that receive rainfall more than 2000 millimetres per year and no drought.



**Figure 2.1:** 'Chengal' Wood.

To run the experiment, the table of machining parameters that needed to be investigated during the experiment should be completed. Table 3.1 shows of Response Surface Methodology (RSM) for the experiment. The table can be get from the analysis of variance (ANOVA) after parameter had been keyed in the software.

### 3.0 RESULTS AND DISCUSSION

Machining time is measured by taking the time of Edu-mill CNC milling machine cut the profile. The time measures are initial and final using Art-CAM and stopwatch. There are 13 results based on the table of Design of Experiment (DOE) were designed by response surface methodology (RSM). Each time will be taken data after the experiment.

**Table 3.1:** Design Layout and Experimental Results for Machining Time.

Run	Feed Rate (mm/sec)	Step-over (mm/size, % of D)	Time (min)
1	350	1.2	90
2	350	0.8	120
3	300	0.8	150
4	400	0.8	60
5	350	0.8	120
6	400	1.2	30
7	350	0.8	120
8	350	0.4	110
9	350	0.8	120
10	400	0.4	40
11	300	0.4	250
12	300	1.2	180
13	350	0.8	120

**Table 3.2:** ANOVA Results of the Machining Time.

ANOVA for Response Surface Linear Model						
Analysis of variance table [Partial sum of squares - Type III]						
Source	Sum of Squares	df	Mean Square	F Value	p-value Prob > F	
Model	35416.67	2	17708.33	36.21	< 0.0001	significant
A – Feed Rate	33750.00	1	33750.00	69.00	< 0.0001	
B – Step-over	1666.67	1	1666.67	3.41	0.0947	
Residual	4891.03	10	489.10			
- Lack of fit	4891.03	6	815.17		0.1354	
- Pure error	0.000	4	0.000			
Cor Total	40307.69	12				

Table 4.3 shows the table for final equation of linear models of time in terms of coded factors and actual factors is given below.

**Table 3.3:** Linear Models of the Machining Time.

Factor	Coefficient Estimate	df	Standard Error	95% CI Low	95% CI High	VIF
Intercept	116.15	1	6.13	102.49	129.82	
A – Feed Rate	-75.00	1	9.03	-95.12	-54.88	1.00
B – Step-over	-16.67	1	9.03	-36.78	3.45	1.00

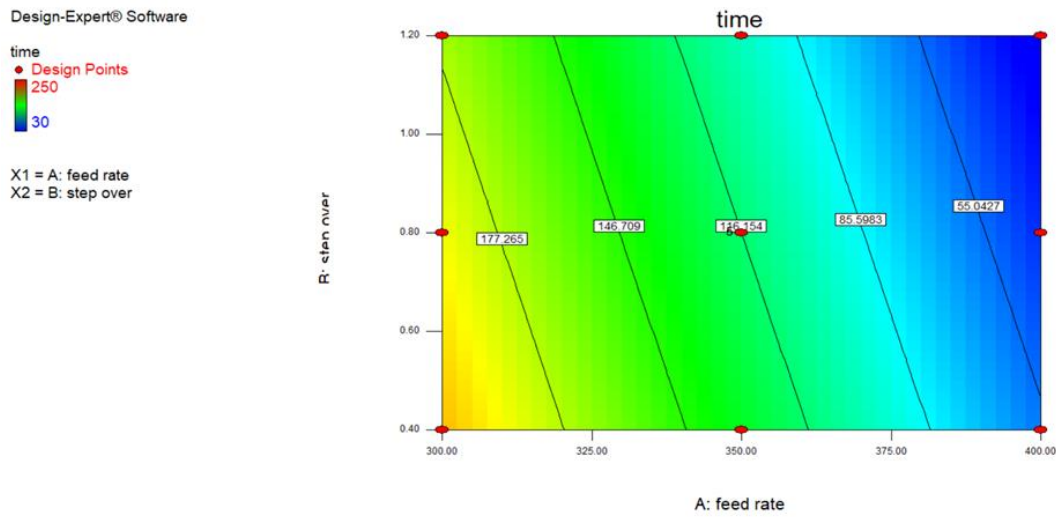
**Final Equation in Terms of Coded Factors:**

$$time = +116.15 - 75.00^{*A} - 16.67^{*B}$$

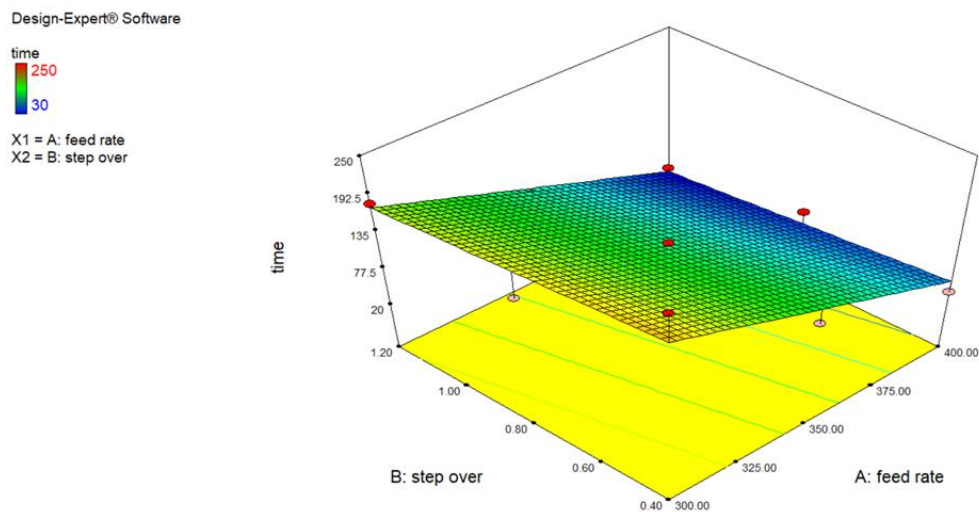
**Final Equation in Terms of Actual Factors:**

$$time = +674.48718 - 1.50000^{*feed\ rate} - 41.66667^{*step-over}$$

Figure 4.1 shows the contour graph and figure 4.2 shows 3D graph representation the machining time process between feed rate and step-over. The maximum value was 250 minute. It was found that the machining time was maximum value of feed rate, 400 mm/sec and step-over, 1.2 mm/size, % of D. For the minimum value, the reading was 30 minute. The machining time are minimum when the maximum value of feed rate, 400 mm/sec and step-over, 1.2 mm/size, % of D were used. The data shows the result of the experiment that the step-over has more effect on machining time than the feed rate.

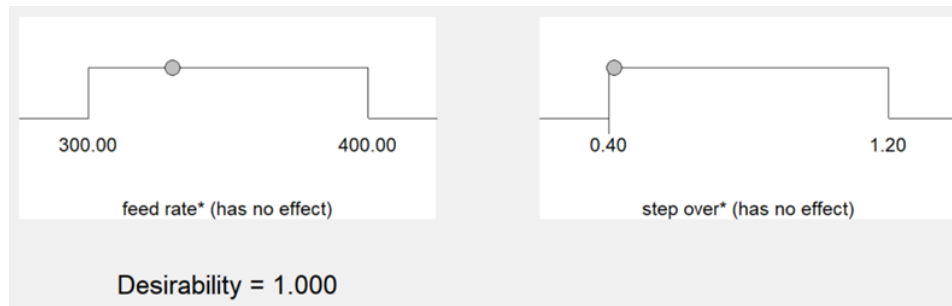


**Figure 3.1:** Contour Graphs for Time.



**Figure 3.2:** 3D Graph for Time.

One of the main goals of this experimental study is to find optimal machining parameters in order to control the surface quality and to obtain the lowest tool life value. All of the experiments have been conducted and analysed, the optimization of machining parameter have been suggested by the Design Expert software for get a minimum value of time. Figure 4.5 shows the machining parameters that have been optimized for getting the best minimum value of time. The suggestion was using the feed rate, 330 mm/sec and step-over, 0.42 mm/size, % of D.



**Figure 3.3:** Optimization of Machining Parameter for Machining Process.

### 3.2 COMPARISON SURFACE

The surface comparison of the 3D profile is tested by using Edu-mill CNC milling machine. The variable will be the step-over distance that will be controlled by the ArtCAM program. If the step-over is 1.2 mm/size, % of D, the surface will be rough and the cutting mark will be visible. Then, if the step over 0.4 mm/size, % of D, the surface will be smoother than the step-over 1.2 mm/size, % of D.



**Figure 3.4:** Step-over 1.2 mm/size, % of D.



**Figure 3.5:** Step-over 0.4 mm/size, % of D.

#### **4.0 CONCLUSION**

The result of the experiments has shown the importance of proper machining parameters selection in Edu-mill CNC milling machine. The parameters should be designed optimally in order to reach the prescribed quality surface of the work piece. In this contribution, the influence of selected machining parameters on machining time after cutting process of work piece has been analyzed and examined.

Before starting this project, reading needed to be done in order to understand the main point of the project. By making the literature review, it helps in order to further understand the parameter and building up the flow of project. For this project, the experiment made are based on the DOE that have been made regarding to the variable and parameter needed to be considered. By designing the experiment, major and minor error such as random error can be minimized and avoided. From the experiment results, the plotted graph conclude that the machining time is depends on the machining parameters (feed rate and step-over). As a result of the experiment, the lowest value of machining time is 30 minute. The lowest value was from the machining parameter of (feed rate: 300 mm/sec, step-over: 0.4 mm/size, % of D). Then, the highest value is 250 minute. The highest result was from the machining parameter of (feed rate: 400 mm/sec, step-over: 1.2 mm/size, % of D).

Based on the result of analysis, the value of machining time increased when the feed rate and step-over are decreased. For optimization, the Design Expert software have given suggestion of machining parameter for getting the best lowest value of feed rate and step-over for this experiment. The suggestion values were using the feed rate 330 mm/sec and step-over 0.42 mm/size, % of D.

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