

# Optimizing the Cutting Time and Surface Finish for EDM-Wire Cut Process of AISI 1045 Steel

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**Abstract**— This paper aims to optimize the machined surface as well as to study the effect of current strength and wire speed on wire cut machining on AISI 1045 steel against the timing of roughness of straight gear surface. The surface results analyzed are the surface roughness values obtained by conducting surface roughness testing. Variations of current used are 3 amperes, 5 amperes, and 7 amperes, while the wire speed used is 8 mm / min, 10 mm / min, and 12 mm / min. In the process of wire cut machining is used a brass cutting material with 0.25 mm wire diameter. The results showed that the greater the current and wire speed used then the surface roughness value will be lower, otherwise the smaller current and wire speed used then the surface roughness value will be higher. The results of data analysis using ANOVA analysis, correlation, and regression method obtained optimal condition to get low surface roughness value and fast cut time that is at 7 amperes current with wire speed 8 mm / min.

**Keywords**—Wire cut; surface finish; cutting time; AISI 1045 steel.

## I. Introduction

A wire cut machine is a CNC machine that works automotive through a computer control system. The wire-cut machine has the ability to produce high precision products with varying levels of surface finish was desired [1-2]. Surface finish, especially in some high-precision products, are parameters that need to be considered. Products produced with a certain level of surface roughness will determine the functionality of the product. The accuracy of the surface finish value of a product will determine whether the product works properly [3-4].

Wire cut machine is a nonconventional machine that is often used in various research objects [5-6]. Research concerning setting the wire cut cutting parameters on straight gears has been done before. Tosun et al [7] conducted a study on the effect of cutting parameters on surface roughness on wire cut with steel workpiece SAE 4140. This study concluded that pulse duration, open circuit voltage, and wire speed greatly affect the surface roughness cutting. Increasing the pressure of the dielectric fluid can be obtained by a finer cutting surface.

Fitriawan [8] conducted research on MRR (material removal rate) and surface roughness result of the cutting process of wire cut machine using the S45C stainless material. The surface finish with process parameter setting in this research was modeled by the power function equation which then transformed into equation linear. It was concluded that the roughness of cutting result and MRR in cut wire process is influenced by variable power setting, off time and taper cutting angle.

Mahapatra and Patnaik [9] have also conducted research on the optimization of process parameters on the wire cut by using Taguchi method. The results of this study suggest that the current, frequency, and velocity of dielectric fluid flow and their interactions have a significant effect on cutting in increasing MRR,

minimizing roughness of cutting results, and narrowing the cutting width.

This research also produces setting parameters of cutting wire cut process. This paper aims to optimize the cutting parameters for a minimum of surface finish and cutting time. The optimization of wire cut parameters was also performed by [10].

## II. Research Methodology

### A. Materials and Cutting Tools

Specification of the workpiece used in this experiment is AISI 1045 steel. While the type of wire used for the electrode wire cut is brass with a thickness of 0.25 mm. The responses of surface finish can be measured using the surface tester of Mitutoyo SJ320. In this experiment, the wire cut machine of ONA AF25 was used to cut workpiece became gear.

### B. Cutting Parameters

In this experiment, the cutting parameters were used to cutting the workpiece as shown in Table 1.

Table 1. The cutting parameter for wire cut

Parameters	Units
Current (Amp.)	3, 5, and 7
Wire Speed (mm/m)	8, 10, and 12
Wire diameter (mm)	0.25
Type of wire	Brass

## III. Results and Discussion

The wire cut process has been performed on the AISI 1045 workpiece to form the gears. Furthermore, the next process is testing the surface finish, where the experimental results can be shown in Figs. 2 and 3.

In order to obtain a smooth machined surface and short of cutting time. Thus, it can be performed by the optimization of the cutting parameters by using software Design of Expert (DOE) Version 6.0. This software was also used in their experiments [4,11,12]. The result of ANOVA analysis was described in Table 2.

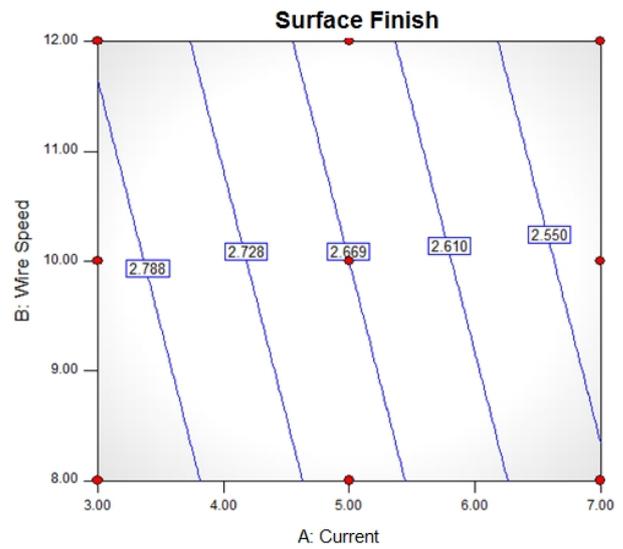


Figure 1. Surface finish model in plot 2D

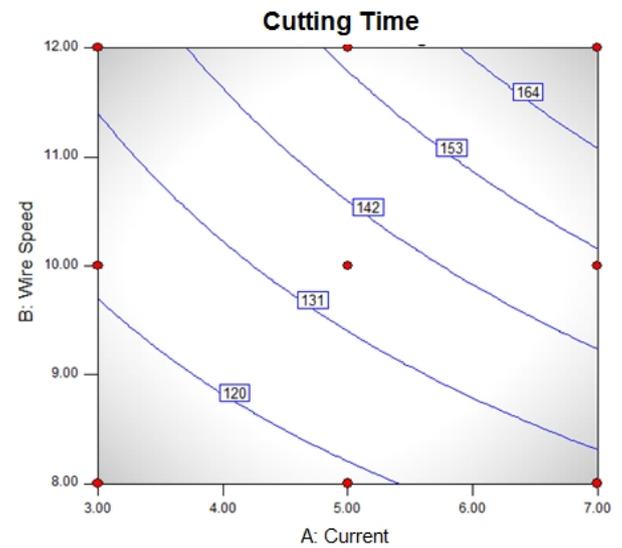


Figure 2. Cutting time model in Plot 2D

Table 2. ANOVA analysis for surface finish and cutting time

Source	Sum of squares	DOF	Mean square	F-value	Prob.<F
<b>Surface finish</b>					
Model	0.13	2	0.067	13.04	0.0065
A	0.13	1	0.13	24.84	0.0025
B	6.34E-03	1	6.34E-03	1.24	0.3080
<b>Cutting time</b>					
Model	3465.17	2	1155.06	71.45	0.0002
A	1290.67	1	1290.67	79.84	0.0003
B	2053.50	1	2053.50	127.02	<0.0001
AB	121.00		121.00	7.48	0.0410

The optimization model is used to know the combination of factor levels for each response simultaneously, where optimization can be performed numerically or graphically. This goal will be combined with the overall desire function to get the optimal solution including maximizing the function. Thus, the smooth surface finish value and fast cutting time value can be determined. The time parameter was also used by Makmur et al [13]. This parameter was measured the ejector system to eliminate the exhaust gas.

The final empirical model of surface finish and cutting time in the actual factor was as follows:

$$(Ra)^{-1} = 3.1953 - 0.0728 * Current - 0.0163 * Wire Speed \tag{1}$$

$$(Tc)^{-1} = 75.9167 - 6.4167 * Current + 2.3750 * Wire Speed + 1.375 * C * Wire Speed \tag{2}$$

The optimal solution was suggested by the calculation results of DOE as shown in Figure 3. By simply changing the target, the solutions can be obtained for comparison purposes before the final selection of the factor setting.

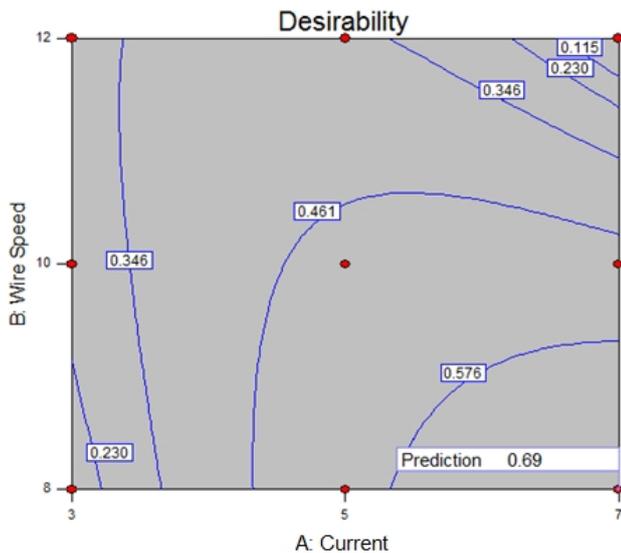


Figure 3. Optimization model in desirability plot

Graphical optimization involves creating a plot overlay generated by superimposing contours for different surface responses. The portion of the shaded plotted overlay is the boundary for all desired responses, as shown in Figure 4 which determines the value of the dependent variable allowed. In this

particular case, it is desirable to determine the appropriate region for the process arrangement so that the surface roughness should not exceed 2,650 μm, and the cut-off result is 140 min (2 h 20 min).

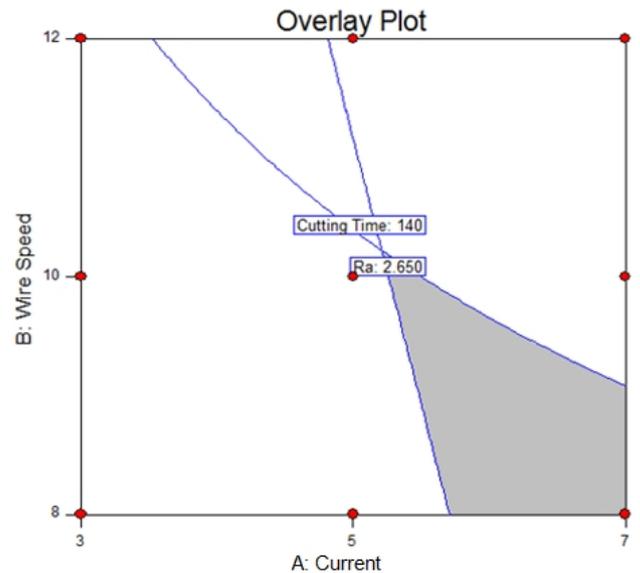


Figure 4. Optimization model in overlay plot

The cutting process on the wire-cut machine uses two variables: the current and the wire speed travel well. The result of surface roughness and cutting time is significantly influenced by strong variables of current and wire cut. This is in accordance with the facts proposed by Tosun et al [6] that wire speed is very influential on the roughness of the cutting surface. This phenomenon is also reported by a study conducted by Mahapatra and Patnaik [8] who examined the optimization of the parameters of wire cut EDM machining process by using the Taguchi method with the result that the magnitude of the current and the interaction gave a significant effect on cutting conditions in minimizing surface finish, and able to narrow the width of cutting.

In this experiment, it can be obtained for other responses such as power consumption [14-15], and energy consumption [16-17].

#### IV. Conclusion

The conclusions that can be drawn from the experimental results are as follows:

1. The current variable gives a significant influence on the roughness of the straight gear surface. The

greater the current was used, the surface finish of the straight gear is lower. The smaller the current is used, the higher the roughness of the straight gear surface.

2. Variable wire speed gives a significant effect on the roughness of the straight gear surface. The greater the value of wire speed that is used then the roughness of the straight gear surface is lower, otherwise the smaller the value of the speed used, the higher the surface roughness value.

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