

Effects of Process Parameters on Machining Time in Wire Electrical Discharge Machining of 9CrSi Steel

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Abstract

This paper introduces a study on the influence of process parameters on the machining time in Wire Electrical Discharge Machining of 9CrSi tool steel. In this study, a total of experiments were performed based on full factorial design and the work-piece material was 9CrSi steel. The input parameters including cutting voltage, pulse on time, pulse off time, servervoltage, wire feed and cutting speed were selected for investigation of the effects of the input parameters on the machining time. The influence of the input parameters on the surface roughness were investigated by analysing variance. Furthermore, based on the results of the experiments, a regression equation for determining the machining time was proposed.

Keywords: WEDM, machining time, full factorial design, tool steel machining.

I. INTRODUCTION

Wire electrical discharge machining (WEDM) is a non-traditional machining process which has been used for machining irregular shape parts as well as electrically conducting materials. Consequently, there have been a lot of researches in order to investigate the effects of process parameters as well as to optimize the EDM process for finding the optimum input parameters. Until now, many researches on this area have been done for machining different work materials such as hybrid metal material [1], stainless steel (SS304) [2], A356.2 aluminum alloy [3], titanium alloy [4], brass [5], Hastelloy –C-276 [6] and tool steel EN 31 [7, 8]. In order to select the optimum WEDM parameters, researchers have used different methods including Taguchi method

[1, 2], Box-Benken method [4], Genetic algorithm method [6], Full factorial design [9] and so on.

This paper presents a study on the influence of process parameters on the machining time in Wire Electrical Discharge Machining of 9CrSi tool steel. In this study, the effects of input parameters including pulse on time, pulse off time, server voltage, wire feed, cutting voltage, and cutting speed on the machining time were investigated. Also, a model for calculation of the machining time when machining tool steel 9CrSi was proposed.

II. EXPERIMENTAL WORK

In investigation of the influence of the input process parameters, a two levels full factorial experimental design was applied because this gives all possible combinations of process parameters. The set-up of the experiments is described as follows:

-Machine: Fanuc Robocut α -1 iA (Figure 1);

-Work-piece material: 9CrSi steel;

-Wire used: Brass wire of diameter 0.25 mm;

-Dielectric fluid: Deionized water;

-Input parameters: cutting voltage (VM); pulse on time (T_{on}); pulse off time (T_{off}); serve voltage (SV); wire feed (WF); cutting speed (SPD). The levels of the input parameters were shown in Table 1;

-Number of experiments: 32.

When conducting experiments, the machining time was measured. The various levels of input parameters and the results of the output response (the machining time) are shown in Table 2.



Fig. 1: Wire-Cut Electrical Discharge Machine

Figure 2 shows the graph of the main effect of each factor for evaluating the influence of factors on the response and the relative strength of the effect. As in the Figure, the value of machining time increases

Parameter	Level 1	Level 2
Cutting voltage	3	9
Pulse on time	7	13
Pulse off time	9	15
Server voltage	25	35
Wire feed	8	12
Cutting speed	4.5	5.5

Table 1: Input parameters and their levels.

significantly with the increase of the cutting voltage, the pulse on time, the pulse off time, the serve voltage and the wire feed. It is also effected by the cutting speed.

Fig. 3 presents the Pareto chart of the standardized effects from the largest effect to the smallest effect. According to in this chart, the bars that represent eleven factors including the cutting voltage (factor A), the pulse on time (factor B), the pulse off time (factor C), the serve voltage (factor D), the wire feed (factor E) and the interactions AB, AC, AD, AE, BE and CE cross the reference line. Therefore, these

StdOrder	RunOrder	CenterPt	Blocks	VM	Ton	Toff	SV	WF	SPD	Machining time (min.)
24	1	1	1	9	13	15	25	12	4.5	6.35
20	2	1	1	9	13	9	25	12	5.5	7.50
3	3	1	1	3	13	9	25	8	5.5	15.10
10	4	1	1	9	7	9	35	8	4.5	16.64
4	5	1	1	9	13	9	25	8	4.5	9.59
21	6	1	1	3	7	15	25	12	4.5	18.80
...										
17	31	1	1	3	7	9	25	12	5.5	23.08
26	32	1	1	9	7	9	35	12	5.5	7.98

Table 2: Experimental plans and output response.

StdOrder	RunOrder	CenterPt	Blocks	VM	Ton	Toff	SV	WF	SPD
24	1	1	1	9	13	15	25	12	4.5
20	2	1	1	9	13	9	25	12	5.5
3	3	1	1	3	13	9	25	8	5.5
10	4	1	1	9	7	9	35	8	4.5
4	5	1	1	9	13	9	25	8	4.5
21	6	1	1	3	7	15	25	12	4.5
...									
17	31	1	1	3	7	9	25	12	5.5
26	32	1	1	9	7	9	35	12	5.5

Table 3: Experimental plans and output response.

factors are statistically significant at the 0.05 level with the response model.

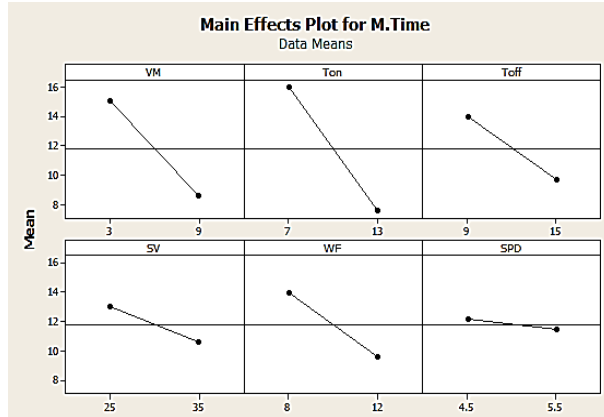


Fig. 2: Main Effects Plot for Machining Time

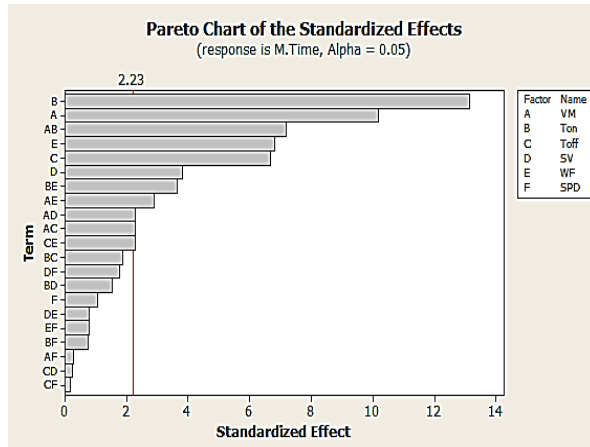


Fig. 3: Pareto Chart of the Standardized Effects

III. RESULTS AND DISCUSSIONS

The Normal Plot of the standardized effects is described in Figure 4. It is seen from the Figure that, the cutting voltage, the pulse on time, the pulse off time, the serve voltage and the wire feed are the significant effect factors. Also, all the effects which lie along the line (including F and interactions AF, BC, BD, BF, CD and CF) are negligible.

Figure 5 describes the estimated effects and coefficients for the machining time after ignoring insignificant effects. It was found that factors which have a significant effect on a response have P-values lower than 0.05 are the cutting voltage, the pulse on time, the pulse off time, the serve voltage, the wire feed and their interactions (Figure 5). Therefore, the following equation can be used for describing the

relation between the machining time (M. Time) and the significant effect factors:

$$M. Time = 11.777 - 3.253V_M - 4.2t_{on} - 2.132t_{off} - 1.221SV - 2.18WF + 2.295V_M t_{on} + 0.727V_M t_{off} + 0.732V_M SV + 0.919V_M WF + 1.158T_{on} WF + 0.724t_{off} WF \quad (1)$$

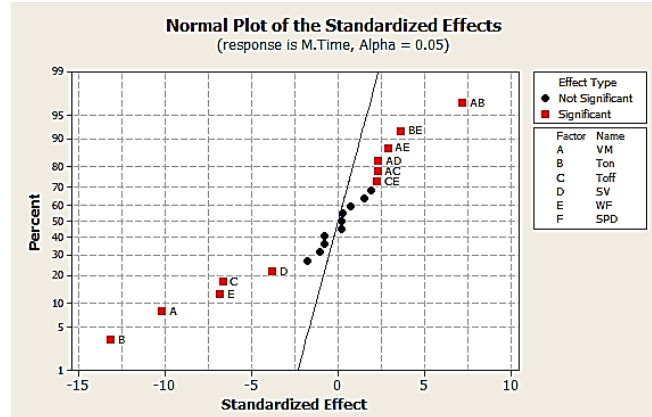


Fig. 4: Normal Plot for Machining Time

Estimated Effects and Coefficients for M.Time (coded units)

Term	Effect	Coef	SE Coef	T	P
Constant		11.777	0.3352	35.13	0.000
VM	-6.507	-3.253	0.3352	-9.71	0.000
Ton	-8.401	-4.200	0.3352	-12.53	0.000
Toff	-4.264	-2.132	0.3352	-6.36	0.000
SV	-2.441	-1.221	0.3352	-3.64	0.002
WF	-4.359	-2.180	0.3352	-6.50	0.000
VM*Ton	4.590	2.295	0.3352	6.85	0.000
VM*Toff	1.455	0.727	0.3352	2.17	0.042
VM*SV	1.464	0.732	0.3352	2.18	0.041
VM*WF	1.838	0.919	0.3352	2.74	0.013
Ton*WF	2.316	1.158	0.3352	3.46	0.003
Toff*WF	1.448	0.724	0.3352	2.16	0.043
S	1.89621				
PRESS	184.096				
R-Sq	95.53%				
R-Sq(pred)	88.56%				
R-Sq(adj)	93.08%				

Fig. 5: Estimated Effects And Coefficients for Machining Time

IV. CONCLUSION

A study on the influence of process parameters on the machining time in Wire Electrical Discharge Machining of 9CrSi tool steel. Also, the influence of the input parameters including the cutting voltage, the pulse on time, the pulse off time, the server voltage, the wire feed, and the cutting speed on the machining time were evaluated by experiments. This experiments were

performed in two levels full factorial design. From the results of the study, a regression equation for determining the machining time was proposed.

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