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Research Article

Experimental investigation of effects of cutting parameter on MRR for EN-42 on WEDM using Taguchi Method

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Abstract

This research work presents influence of process parameters on surface roughness and material removal rate (MRR) while wire electrical discharge machining of EN-42. Experiments have been conducted with four process parameters viz., pulse on time, pulse off time, peak current and wire feed rate. Taguchi's orthogonal array (L_{16}) was employed for experimental investigation. ANOVA analysis was used to determine most significant factors affecting the machining performance.

Keywords: *Surface roughness, MRR, wire electrical discharge machining, EN-42, Taguchi technique, ANOVA.*

Introduction

In Traditional machining the cutting tools need should be sturdy than the work piece to be machined. The tool is required to enter into the work piece to some level for semi-finished the work piece. In traditional or conventional machining processes, machine tools, such as shaper, planer, lathes, drill presses etc. are used with a sharp cutting tool to remove materials to achieve desired shape. In engineering industries, there are govern for alloy materials keeping high toughness, strength, hardness, and impact resistance are increased. However, these materials are difficult to be machined by conventional machining methods. For this reason, the non-traditional machining methods like water jet machining, electrical discharging machine, abrasive jet machining, (EDM) etc. are applied to the materials. Wire Electrical Discharge Machining is the process by which material is wear off with the support of a series of sparks between the tool and work piece. The work piece and the wire are covered in the dielectric fluid which also takes as a coolant and wash out the debris. The progress of wire is handling numerically to acquire the required three dimensional shapes and the high rate of accuracy of the work piece. Wire EDM, is not a new type of machining. It was invented in the latish1970s', and has done revolution changed in the tools and dies industries. This is the important wide range cutting machine formulated for this sector in the past years. In that process, no physical connection between work piece and tool, so the materials of any hardness can be easily cut if they are electrically conductive. Since the wire not strike the workpiece, so that no pressure apply on the workpiece and clamping pressure required to maintain the workpiece is less. The electrical conductivity is an important factor in this type of machining few methods are used to increase the effectiveness of the machining of less electrical conductive materials. The Spark Theory on the wire EDM is identical to the vertical EDM process. Many sparks can be analyzed at one time. The temperature of each electrical sparks is expected near about 15,000° to 21,000° Fahrenheit. This process help in many applications like in aerospace, nuclear and automotive industries, to machine accuracy and improper shapes in the different electrically conductive materials. These characteristics make Wire EDM is a process which remained as a competitive and economic machining option fulfills the demands of machining requirements of the short product development cycles.

Literature

F.T. Weng *et al.* (2002) Studied about the Micro machining using tungsten carbide tool electrodes has been raised in copper plate on a conventional CNC-EDM machine. The following conclusions were concluding: Linear micro-slots such as 2D trajectory can be refined on conventional CNC-EDM machine. The projected batch production method for multi-electrodes can save time and reduced the cost of both the electrodes and the work pieces in fabrication.

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N. Tosun *et al*. (2003) studies of the impact of the cutting parameters on the size of erosion craters (diameter and depth) on wire electrode and theoretically and experimentally investigated in the wire electrical discharge machining (WEDM). In this study, effects of the pulse duration, wire speed, and dielectric flushing pressure on the dimensions of craters in the wire were experimentally observed in WEDM. It is found that increasing the pulse duration, wire speed and open circuit voltage, increases the crater diameter and depth, where an increasing the dielectric fluid pressure reduced these factors. Wire speed and dielectric flushing pressure are less economic factors for determining the crater diameter and crater depth.

Amorima *et al*. (2005) studied on an experimental investigation on EDM of the AISI P20 tool steel under the finish machining. The material removal rate(MRR), volumetric relative wear and work piece surface texture Ra are analyzed against the variation of some of the most important EDM electrical variables using copper tool electrodes. From the study, it is observed that increase of average surface roughness of the work piece is directly connected to the increase in discharge current and discharge duration

Jaharah A.G. *et al*. (2008) studied about the performance of the copper electrode when EDM used AISI H13 tool steel. The various parameters considered are the peak current, pulse off-time and pulse on-time. The effect of peak current settings (1, 2 and 4 A), pulse off time (1, 2 and 4 μs) and pulse on time (3, 6 and 12 μs) are investigated on the machining performance of the surface roughness (Ra), electrode wear rate (EWR) and material removal rate (MRR). Following conclusion made base on the result:

- The optimal condition for the surface roughness was observed at low peak current, low pulse-on and pulse-off time.
- High MRR is obtained when setting at high peak current, medium pulse-on time, and low pulse-off time. Therefore the peak current is observed the major factor affected the MRR and surface finish for the finishing and roughing operations.

2. Experimental Details

Materials and Methods

The experiments were carried out on Electronica Sprint cut 734 CNC Wire Cut Machine manufactured by Electronica Machine Tools LTD., India.

Table 1 Chemical composition of EN-42

Element	% age by Weight
C	0.79
Mn	0.76
Si	0.21
S	0.03
P	0.026
Cr	0
Ni	0

Table 2 Parameters and their levels

Real Factor	Coded Factor	Parameter Name	Unit	Levels			
				Level 1	Level 2	Level 3	Level 4
Ton	A	Pulse on time	μs	105	110	115	120
Toff	B	Pulse off time	μs	30	35	40	45
Ip	C	Peak current	A	70	90	110	130
Wf	D	Wire feed	m/min	6	7	8	9

Brass wire of diameter 0.25 mm was used as a tool electrode. The EN-42 steel plate of 104mm x 97mm x 18mm size is mounted on WEDM machine tool and specimens of 5mmx5mmx18mm size are cut Chemical composition of EN-42 is shown in Table 1.

The output characteristics were evaluated in terms of surface roughness and MRR. The surface roughness was measured by using Mitutoyo surface roughness tester.

Taguchi's L_{16} orthogonal array was used for experimental design. Four process parameters were considered for experimentation viz., pulse on time, pulse off time, peak current and wire feed rate. To decide the level of parameters, a large number of experiments were conducted by varying one factor at a time and keeping other parameters constant. Parameters along with their levels are shown in Table 2.

Table 3 Taguchi's L_{16} orthogonal array with performance characteristics and respective S/N ratios

Ton(µs)	Toff(µs)	Ip(A)	Wf(m/min)	MRR	SNRA1	MEAN1
105	30	70	6	1.23	1.798102	1.23
105	35	90	7	1.19	1.510939	1.19
105	40	110	8	1.22	1.727197	1.22
105	45	130	9	1.24	1.868434	1.24
110	30	90	8	1.375	2.766054	1.375
110	35	70	9	1.435	3.137038	1.435
110	40	130	6	1.45	3.22736	1.45
110	45	110	7	1.47	3.346347	1.47
115	30	110	9	1.53	3.693829	1.53
115	35	130	8	1.56	3.862492	1.56
115	40	70	7	1.35	2.606675	1.35
115	45	90	6	1.31	2.345426	1.31
120	30	130	7	1.72	4.710569	1.72
120	35	110	6	1.9	5.575072	1.9
120	40	90	9	1.5	3.521825	1.5
120	45	70	8	1.41	2.984382	1.41

Table 4 Analysis of variance for Material Removal Rate

Source	DF	Seq SS	Adj SS	Adj MS	F	P	% contribution
Ton (µs)	3	12.3235	12.3235	4.10782	41.90	0.006	66.91
Toff(µs)	3	2.0326	2.0326	0.67753	6.91	0.073	11.03
Ip(A)	3	3.4430	3.4430	1.14765	11.71	0.037	18.69
Wf (m/min)	3	0.3234	0.3234	0.10779	1.10	0.470	1.75
Residual Error	3	0.2941	0.2941	0.09804			1.59
Total	15	18.4165					

3. Result and Discussion

Effect of process parameters on MRR

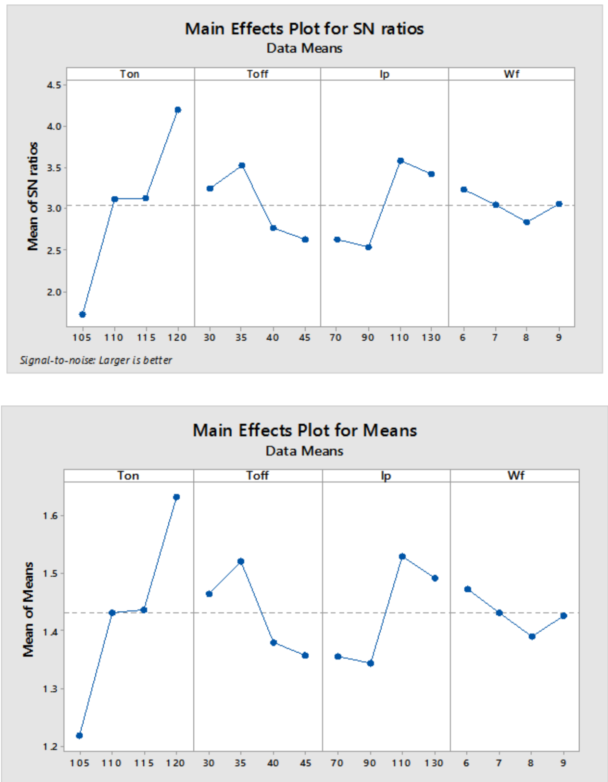

Fig.2 Effect of Process parameters on MRR

The effect of each parameter on the MRR is plotted on the graph in form of lines from the figure 2. Main effects plot for S/N ratios it can be clearly seen that the MRR increases as the pulse on time (Ton) is increased from 105µs to 110µs and after that it remains constant when the pulse on time is increased from 110 µs to 115 µs but after that it increases linearly when pulse on time increases from 115µs to 120µs. Main effects plot for S/N ratios between Pulse off time(Toff) and MRR show that the MRR value increases when Pulse off time increases from 30µs to 35 µs but after that MRR decreases when Pulse off time increases from 35µs to 45 µs. Main effects plot for S/N ratios between Peak current (Ip) and MRR show that the MRR value small decrease when peak current increases from 70(A)to 90(A),but after that MRR increases when peak current increases from 90 (A) to 110 (A).The value of MRR decrease when the peak current increase from 110A to 130A. The main effect plot for S/N ratios between MRR and Wire feed show that MRR value continue decrease when the value of wire feed increase from 6 m/min to 8 m/min and the MRR increase when wire feed value increase from 8m/min to 9m/min.

Conclusions

In this research work, influence and optimization of four machining parameters on two output characteristics namely surface roughness and MRR is presented using Taguchi's experimental design. To determine prime significant parameter affecting the output characteristics, ANOVA analysis was performed. Mathematical models are developed to establish the interrelationship between process parameters and output characteristics. Following conclusions are drawn from this research work:

1. It is concluded that for material removal rate maximum factor Ton(µs) has to be at high level 4, Toff(µs) has to be at high level 2, Ip(A) has to be kept at high level 3and Wf(m/min) has to be kept at high level 1 as shown in the table below.
2. According to ANOVA, the values of MRR for the percentage of contribution of the process parameters are calculated. From the value of percentage of contribution , each variables for MRR the rank of variables in descending order are Pulse on time (Ton) (1) > Peak Current (Ip) (2) > Pulse off time (Toff) (3)> Wire feed (Wf) (4)

Table 5 Optimal combination for material removal rate

Physical Requirement	Optimal combination			
	Ton (µs)	Toff (µs)	Ip (A)	Wf (m/min)
Maximum Surface roughness	120	35	110	6
	Level 4	Level 2	Level 3	Level 1

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