PARAMETRIC OPTIMIZATION OF DRY WIRE CUT ELECTRIC DISCHARGE MACHINING AND INTELLIGENT MODELING OF THE PROCESS

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Abstract

Wire electrical discharge machining (WEDM) is a widely accepted non-traditional material removal process used to manufacture components with intricate shapes and profiles. It is considered as a unique adaptation of the EDM process, which uses an electrode to initialize the sparking process. In our project, an attempt is made to optimize the vital machining parameters for performance measures like MRR and Surface roughness in WEDM for Monel 400 alloy. The selected material with unique characteristics will be machined. The important data set related to process parameters is extracted from Response Surface Methodology.

Keywords – *Material Removal Rate, Surface Roughness, Response Surface Methodology*

I. INTRODUCTION

Machining removes certain parts of the work pieces to change them to final parts. Machining nowadays has been classified in two types: (1) Traditional Machining; (2) Non-traditional Machining. Traditional Machining, also known conventional machining requires the presence of a tool that is harder than the work piece to be machined. This tool should be penetrated in the work piece to a certain depth. Moreover, a relative motion between the tool and work piece is responsible for forming or generating the required shape. The absence of any of these elements in any machining process such as the absence of tool-work piece contact or relative motion makes the process a nontraditional or non-conventional one.

II. RELATED WORK

Kunieda and Furudate (2014) defined the development of a new dry wire electrical discharge machining method. They were conducted an experiment without using dielectric liquid, instead of dielectric liquid they used only gas atmosphere. For improving the accuracy of finish cutting, the vibration of the wire electrode is required to be minimizing with the negligibly small process reaction force. High accuracy and finish cutting may be recognized in dry-wire electrical discharge machining. But, some disadvantages of dry wire electrical discharge machining like lower material removal rate comparison to conventional wire electrical discharge machining and lines are more likely to be generated over the finish surface.

Okada et al., (2016) introduced a fine wire electrical discharge machining using thin wire electrode. In wire electrical discharge machining process, uniform distribution of spark location is essential to achieved for stable machining performance. But, it is difficult to precisely evaluate the distribution of spark location by the conventional branched electric current method when workpiece is considered as thin. Hence, they proposed a new method to analyze the distribution of spark location using a high-speed video camera. From this camera, locations of sparks are identified and analyzed through the recorded images. The machining parameters such as servo voltage, pulse interval time and wire running speed are significantly effects on the distribution of spark location.

Yan and Lai (2015) presented the development and application of a new fine-finish power supply in wire-EDM. The transistor-controlled power supply composed of a full-bridge circuit, two snubber circuits and a pulse control circuit was designed to provide the functions of anti-electrolysis, high frequency and very-low-energy pulse control. Test results indicated that the pulse duration of discharge current can be shortened through the adjustment of capacitance in parallel with the sparking gap. High value of capacitance contributes to longer discharge duration. A high current-limiting resistance results in the decrease of discharge current. Peak current increases with the increase of pulse on-time and thus contributes to an increase in thickness of recast layer. Experimental results not only verify the usefulness of the developed fine-finish power supply in eliminating titanium's bluing and rusting effect and reducing micro-cracking in tungsten carbide caused by electrolysis and oxidation, but also demonstrate that the developed system can achieve a fine surface finish as low as 0.22 μm Ra.

Fuzhu et al., (2016) discussed about the coupled thermo-mechanical analysis, both the three-dimensional temperature and also the stress 13 distributions in the micro wire are determined. As a result, the tension of the micro wire electrode during the WEDM process can be optimized in accordance with the discharge energy, which is sampled and fed back to the tension control system in real time. Then the development of an optimal tension control system characterized by the form of master–slaver structure makes it possible to keep the wire tension optimal in the process of WEDM. The results of the machining experiments show that the optimal wire tension control is effective on the improvement of the machining accuracy with the prevention of wire breakage for the micro WEDM.

II. OBJECTIVES

1.To analyse the effect of process of Dry EDM on the material removal rate and surface roughness for Monel K400 material.

2. To optimize response parameters by Response Surface Methodology (RSM) for the given input parameters.

3.To determine the optimum combination of machining factors and their levels.

4.To compare the experimental Material Removal Rate values and surface roughness values with Ton and Toff.

5.To find the accuracy for MRR and Surface Roughness during Dry Wire EDM of Monel 400.

III. WORKING PRINCIPLE

Dry Electric Discharge Machining (Dry EDM) is an improvement of the oil EDM process in which the fluid dielectric is replace by a gaseous dielectric. High velocity gas flowing through the tool electrode into the inter electrode gap substitutes the fluid dielectric. The flow of high velocity gas into the gap facilitates removal of debris and prevents too much heating of the tool and work piece at the discharge spots. Providing rotation or planetary motion to the tool has been found to be necessary for maintaining the stability of the dry EDM process. Tubular tools are used and as the tool rotate, high velocity gas is supplied through it into the discharge gap. Gas in the gap plays the role of the dielectric medium necessary for electric discharge. Also, continuous flow of fresh gas into the gap forces waste particle away from the gap. Tool rotation during machining not only facilitates flushing but also improves the process stability by reducing arcing between the electrodes.

IV.STEPS USED IN RSM

Steps In RSM Using Design Expert 8.0.

1.To get started, click on the file menu and select either new design or open design.
Click the Response Surface folder tab to show the designs available for RSM.

2.The default selection is the box behnken design , which is used for our project , Click the down arrow in the Numeric Factors entry box and select 4 and output responses as 3.

3. Enter the maximum and minimum values for each process parameters with all symbols and units for respective parameters.

4. Next step is to enter the response parameters as surface roughness, MRR and Kerf width.

5. According to this method array had been created and output parameters which are noted down to enter into the respective columns.

V.INPUT PARAMETERS

Factor A: Pulse On Time (µs)

Factor B: Pulse Off Time (µs)

Factor C: Wire Feed Rate (m/min)

Factor D: Current (A)

VI. TABLE : Input Variables With Level Values

S.No	MACHINING PROCESS PARAMETERS	LEVEL 1	LEVEL 2	LEVEL 3
1	Pulse on	35	25	20
2	Pulse off	10	8	6
3	Wire feed rate	0	1	2
4	Current	3	4	5

VII. DESIGN CALCULATION

T_{on}	T_{off}	Wire feed	Current
35	10	0	3
35	10	1	4
35	10	2	5
35	8	0	3
35	8	1	4
35	8	2	5
35	6	0	3
35	6	1	4
35	6	2	5
30	10	0	3
30	10	1	4

30	10	2	5
30	8	0	3
30	8	1	4
30	8	2	5
30	6	0	3
30	6	1	4
30	6	2	5
25	10	0	3
25	10	1	4
25	10	2	5
25	8	0	3
25	8	1	4
25	8	2	5
25	6	0	3
25	6	1	4
25	6	2	5
35	8	0	3
30	8	1	4

VIII. RESULT

S.No.	T_{on}	T_{off}	Wire feed	Current	R_a	MRR
Units	µs	µs	m/min	A	µm	kg/s
1	35	10	0	3	5.26	0.000503422
2	35	10	1	4	4.81	0.000500248
3	35	10	2	5	5.58	0.000507151
4	35	8	0	3	5.02	0.000501928
5	35	8	1	4	4.67	0.000508809
6	35	8	2	5	5.28	0.000500307

7	35	6	0	3	5.26	0.000497699
8	35	6	1	4	5.78	0.000489934
9	35	6	2	5	5.12	0.000489508
10	30	10	0	3	4.97	0.00053572
11	30	10	1	4	4.52	0.000556862
12	30	10	2	5	5.12	0.000517147
13	30	8	0	3	4.02	0.000560486
14	30	8	1	4	4.84	0.000538248
15	30	8	2	5	5.22	0.000560971
16	30	6	0	3	5.03	0.000579801
17	30	6	1	4	4.5	0.00056389
18	30	6	2	5	4.83	0.00053051
19	25	10	0	3	3.32	0.000591166
20	25	10	1	4	3.2	0.00061272
21	25	10	2	5	3.68	0.000596463
22	25	8	0	3	4.03	0.000629142
23	25	8	1	4	4.32	0.000590663
24	25	8	2	5	3.67	0.000586454
25	25	6	0	3	3.8	0.000607916
26	25	6	1	4	3.56	0.00062549
27	25	6	2	5	4.12	0.000607122
28	35	8	0	3	5.21	0.000493239
29	30	8	1	4	4.3	0.000596521

IX. CONCLUSION

In this work an attempt was made to optimize the vital machining parameters for performance measures like MRR and Surface roughness in WEDM for Monel 400 alloy. The selected material with unique characteristics was machined and number of experiments. The important data set related to process parameters is extracted from statistical analysis tools and Mathematical models were developed for analysis. The following lines exemplify the inclusive works taken up in road towards optimization.

- RSM's Experimental design method was used to obtain optimum parameter combination and to determine the optimal values of MRR and Surface Roughness.

- The optimum combination of process parameters for attaining maximized MRR are Pulse On time=25 microseconds, Pulse off time =9.33 microseconds ,Wire feed=0mm/min ,Current=4 Ampere and the corresponding MRR is 6.03252 $\times e^{-4}$ kg/s, Kerf width is 0.255 mm and Surface Roughness is 3.55876 μm.
- RSM methodology was used on prediction accuracy for MRR and Surface Roughness during Dry WEDM of Monel 400.
- The interpolation of the prediction from the developed models, experimental Material Removal Rate values were compared with the predicted values of the RSM model and they were closely agreed.

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