Modeling and Analysis of Electric Discharge Machining Process Parameters Using Response Surface Methodology

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Abstract - EDM is mainly used to machine difficult-to-machine materials and high strength temperature resistant alloys and machine difficult geometries. Proper selection of manufacturing conditions is one of the most important aspects in die sink electrical discharge machining process, as these conditions determine important e characteristics such as Surface Roughness, Material Removal Rate and Tool Wear Rate. To analyze the effects of machining parameters, current, pulse-on time, duty factor and voltage on the performance measures. The analysis of variance (ANOVA) will be carried out to indicate the proposed mathematical models can adequately describe the performance of the process within the range of the factors being studied. Analyzed results will show the significance of factors and their percentage of contribution of the selected factors to responses. The predicted results based on the developed models will be validated and compared with the experimental results. The experiments will be carried out on the super alloys using the tool electrode copper/brass on the die sink EDM. Taguchi technique is used for design of the experiments for conducting the experiments.

***Key Words*:** Electrical Discharge Machining (EDM) , Design of Experiments , Response Surface Methodology (RSM), Metal removal rate, tool wear rate.

1.INTRODUCTION

PRELIMINARY REMARKS

Electrical discharge machining is considered as one of the main non-conventional machining processes used for manufacturing geometrically complex or hard material parts that are extremely difficult to machine by conventional machining processes .New developments in the field of material science have lead to new engineering metallic material, composite materials, and ceramics, having good mechanical properties and thermal characteristics as well as sufficient electrical conductivity so that they can readily be machined by spark erosion. Electrical discharge machine (EDM) technology is increasingly being used in tool, die and mould making industries, for machining of heat treated tool steels and advanced material (super alloys, ceramics, and metal matrix composites) requiring high precision, complex shapes and surface finish

SIGNIFICATION OF THE PAPER WORK

Technologically advanced industries such as all industrial applications and consumptions have been demanding high strength temperature resistant (HSTR) materials high strength to weight ratio.

Stainless steel (304) has excellent resistance to a wide range of atmospheric environments and many corrosive media. It is subject to pitting and crevice corrosion in warm chloride environments and to stress corrosion cracking above about 60 °c. It is considered resistant to potable water with up to about 200 mg/l chlorides at ambient temperatures, reducing to about 150 mg/l at 60 °c.

Stainless steel is used for a variety of household and industrial applications such as screws, machinery parts, car headers, and food-handling equipment. 304 stainless steel is also used in the architectural field for exterior accents such as water and fire features.

Type 304 stainless steel is a T 300 Series Stainless Steel austenitic. It has a minimum of 18% chromium and 8% nickel, combined with a maximum of 0.08% carbon. It is defined as a Chromium-Nickel austenitic alloy

2. Body of Paper

Aim and scope of the works

The aim of the work is to investigate the optimal set of process parameters such as current, pulse ON time, pulse OFF time, voltage in electrical discharge machining (EDM) process to identify the variations in two performance characteristics such as material removal rate, tool wear rate values for machining.

Grade E 304 stainless steel used as work material using copper electrode tool. The experiments are conducted on L15 Box-Behnken design; modeling has been carried out using Response Surface method

Object of the work

The objective of this work is to develop the Mathematical modeling and analysis of Electrical Discharge Machining process parameters using Box-behnken design. This work done with Grade E 304 stainless steel as work piece material and copper as tool. The process parameters such as peak current, pulse on time, pulse off time and voltage were inputs with the considerations of performance characteristics such as material removal rate, tool wear rate value on the work material.

LITERATURE REVIEW

J. L. Lin et al. **[1]** Carried out a study on the Optimization of the electrical discharge machining process based on the Taguchi method with fuzzy logic. A multi-response performance index is used to solve the EDM process with multiple performance characteristics. The machining parameters pulse on time, pulse off time, voltage, current and duty factor are the optimized with considerations of the multiple performance characteristics MRR, TWR and SR.

T. Rajmohan et al. [2] Study on Optimization of machining parameters in EDM of 304 stainless steel. In this study, it is found that different combination of EDM process parameters are required to achieve higher MRR for 304 stainless steel. Signal to noise ratio (S/N) and analysis of variance (ANOVA) is used to analyze the effect of the parameters on MRR and also to identify the optimum cutting parameters.

EXPERIMENTATION

In this section I will discuss about the experimental work formulated prior to execution of work. It consists of an L-15 Box Behnkine Design, selection of work piece; experimental set-up, tool design and calculation of Material Removal Rate (MRR), and Tool wear Rate (TWR).

Experimental set up

Figure 1: Experimental set up

Selection of the work piece

Grade E 304 stainless steel is one of the most widely used materials in all industrial applications and consumption. Because of its aesthetic view in architecture, superior physical and mechanical properties, resistance against corrosion and chemicals, weld ability; it has become the most preferred material over others. Many conventional and non-conventional methods for machining stainless steel are available.

Tool design

The tool material used in Electro Discharge Machining can be of a variety of metals like copper, brass, aluminium alloys, silver alloys etc. The material used in this experiment is copper. The tool electrode is in the shape of a cylinder having a diameter of 10mm

Fig2: Grade E 304 Stainless Steel (Work Piece) And Copper (Tool)

Mechanism and Evaluation of MRR

$$\text{MRR} = \frac{Wi - Wf}{Time}$$

Where MRR= Material Removal Rate

W_i = initial weight before machining

W_f = final weight after machining

T = machining time = 5 min

Mechanism and Evaluation of Tool Wear Rate

$$\text{TWR} = \frac{TWi - TWf}{Time}$$

Where TWR= Tool Wear Rate

TW_i = initial weight before machining

TW_f = final weight after machining

T = machining time = 5 min

RESULTS AND DISCUSSION

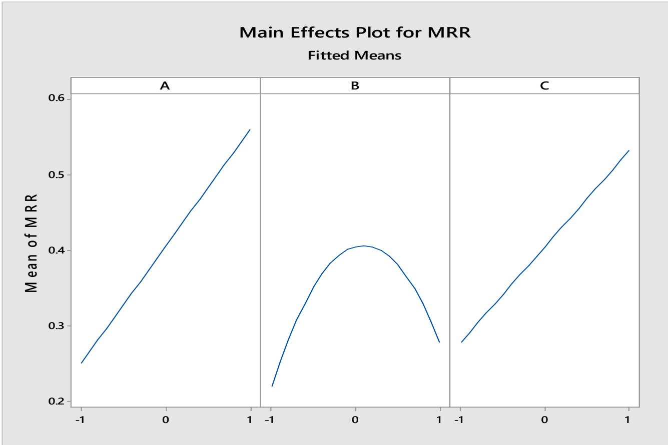

Fig3: Graph Representing the Variation of MRR with current, Ton, electrode rotation.

Analysis and Discussion of MRR

The MRR increases as the current increases throughout the entire range as shown in the fig 3. The MRR increases as the Ton increases and then decreases as shown in the fig3

The MRR increases as the electrode rotation increases throughout the entire range.

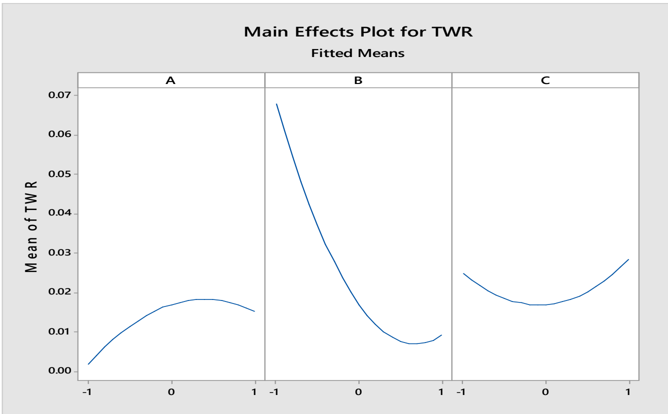

Fig4: Graph Representing the variation of TWR with current, Ton ,electrode rotation

Analysis and Discussion of TWR

The Tool Wear Rate increases with increase in current and then slightly decreases within the given range of values as shown in fig 4. The Tool Wear Rate increases and then decreases with Pulse on time (Ton) as shown in the fig 4 .The Tool Wear Rate increase with electrode rotation and then decreases.

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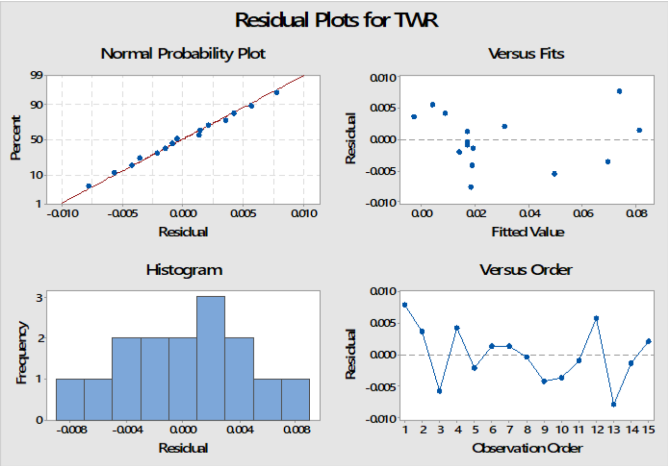
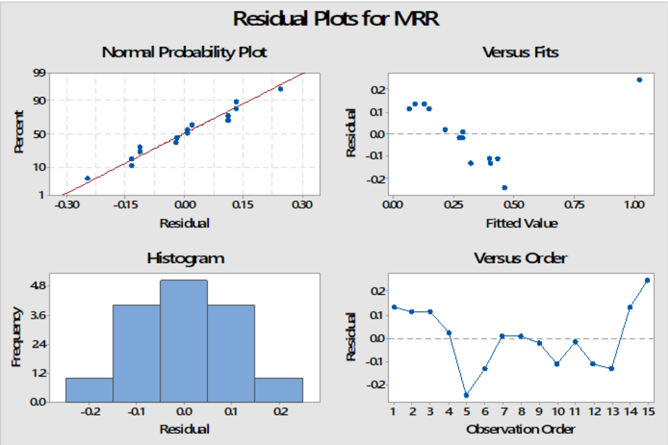
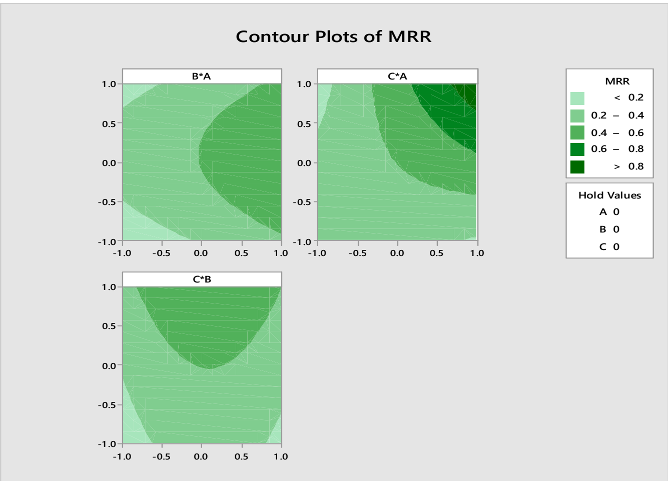
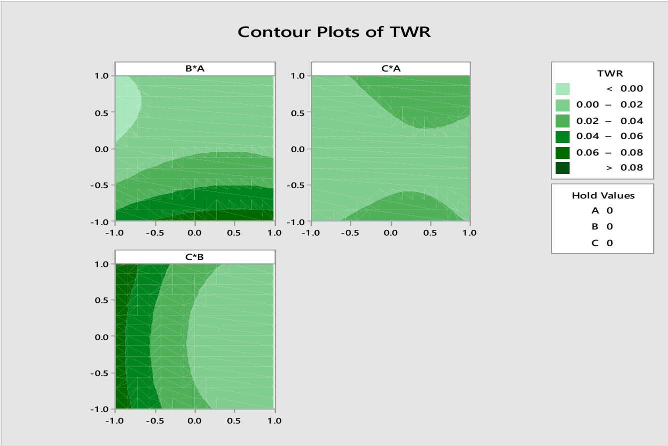
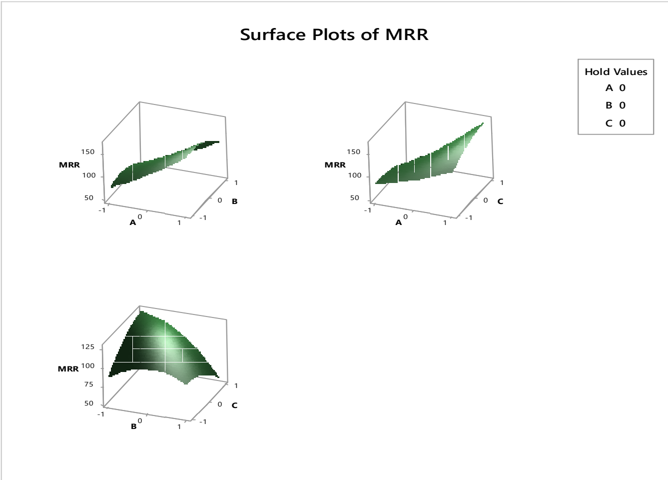
Mathematical modeling results

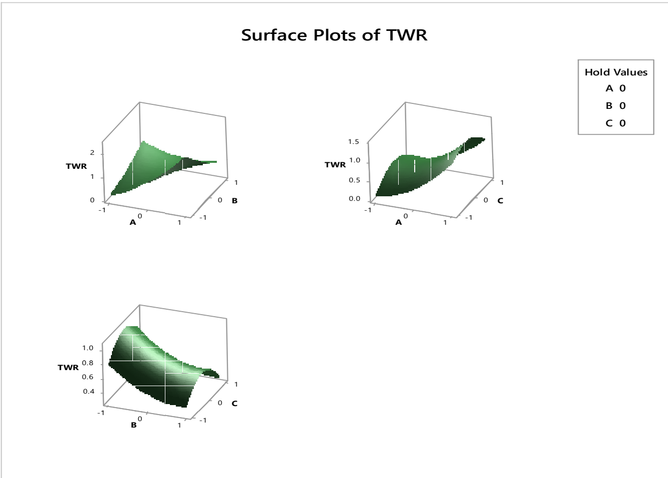












CONCLUSION

In this study the experiment was conducted by considering three variable parameters namely current, Voltage and duty cycle. The objective was to find the Material Removal Rate, and TWR and to study the effects of the variable parameters on these characteristics. The tool material was taken as copper and the work piece was chosen as Grade E 304 stainless steel. The parameters taken from the Box Behnken Design L15 was created and the experiments were performed accordingly. The following conclusions were drawn:

1. For MRR the most significant factor was found to be peak current followed by pulse on time and the least significant was duty cycle. The MRR increased nonlinearly with the increase in current. For Voltage the MRR first increased till voltage 36 and then decreased. With increase in duty cycle, MRR increased insignificantly.

2. For TWR the most significant factor was current followed by pulse on time and duty cycle respectively. TWR increased along with the increase in current. For increase in pulse on time, TWR increased linearly. Finally for Voltage, TWR slightly increased but only up to voltage 36 and then started decreasing.

SCOPE FOR FUTURE WORK:

Future research may focus on the Electrical discharge machining process parameters using box behnken design as more Material Removal rate ,less Tool Wear rate and good Surface Roughness in less time has been done on this recent technique.

REFERENCES

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