OPTIMIZATION OF PROCESS PARAMETERS USING WEDM PROCESS

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ABSTRACT

Wire-cut Electric Discharge Machining is used to cut conductive metals of any severity or that are difficult or unacceptable to trim with traditional methods. In order to reduce the experimental processing, software computing techniques "Taguchi" and "ANOVA" have been used to investigate the effects of the WEDM process parameters and subsequently to predict set of optimal parameters for optimum quality characteristics in high chromium tool steels. This research outlines the Taguchi's parameter design approach, which has been applied during the machining process. This procedure eliminates the need for repeated experiments and saves time. The machining parameters investigated are Peak current, Pulse on time (T-ON), and Pulse off time (TOFF) and Wire feed rate on Material Removal Rate (MRR) of HODREX 400 and HODREX 500 materials for cutting on WEDM.

Keywords: Wire-cut EDM, Taguchi, ANOVA, Process Parameters;

1. INTRODUCTION

With the development of mechanical industry, the demands for alloy materials having high hardness, toughness and impact resistance is increasing. Wire-cut Electric Discharge Machining is used to cut conductive metals of any hardness or that are difficult or impossible to cut with traditional methods. The problem of arriving at the optimum levels of the operating parameters has attracted the attention of the researchers and practicing engineers for a very long time. The objective of the present article depicts various WEDM process parameters on the machining quality and to obtain the optimal sets of process parameters.

The Taguchi technique has been applied to look into the effects of the WEDM process parameters. An orthogonal array (L9) has been employed to carry on the experiments. The new data and S/N analysis are used to determine the influence of selected parameters on MRR.

2. LITERATURE REVIEW

J. T. Huang, et.al, [1]determines the optimal selection of machining parameters for the Wire Electrical Discharge Machining (Wire-EDM) process by applying grey relational analyses to Grey theory can provide a solution for a system in which the model is unsure or the information is incomplete.

S. S. Mahapatra and Amar Patnaik, [2] has developed the relationship between control elements and responses like MRR, SF and kerf are established by means of nonlinear regression analysis, resulting in a valid mathematical model.

N. Tosun, et.al, [11] found that increasing the pulse duration, open circuit voltage and wire speed increases the crater size, whereas increasing the dielectric flushing pressure decreases the crater size. The degree of importance of machining parameters on the wire crater size is set by using analysis of variance (ANOVA).

3. EXPERIMENTAL PROCEDURE AND MATERIALS

WEDM is a special form of the traditional EDM process in which the electrode is a continuously moving conducting wire. The material is eroded from the workpiece by a series of discrete sparks between the work piece and the wire electrode (tool) separated by a thin film of dielectric fluid (de-ionized water) which is continuously forced fed to the machining zone to flush away the eroded particles. The motion of the wire is controlled numerically to achieve the desired three - dimensional shape and accuracy of the work part. Although the average cutting speed, relative machining costs, accuracy and surface finish have been improved many times since the commercial inception of the machine, much more improvement is still required to satisfy the increasing demand of precision and accuracy by different manufactures. It is a well-known fact that a high material removal rate and a very good surface finish can never be achieved simultaneously in WEDM process.

The experiments have been taken on the SPRINTCUT WEDM. A diffused brass wire of 0.25 mm diameter is used as the cutting instrument. The tool steel is a high carbon, high chromium alloy and HARDOX are used as the specimen.

The specimens are of rectangular frame having a thickness of 14 millimeter. The de-ionized water is used as dielectric and its temporary worker. Is kept at 20ºC. The three input process parameters, namely peak current (IP), pulse-on time (TON), pulse-off time (TOFF), wire feed (WF). The programming has been done with the reference to the WCS. The reference point has been defined by the ground edges of the work piece. The program is made for cutting operation of the work piece and a profile of 20 mm x 20 mm square has been thin.

a. HARDOX-400

C	0.136
Si	0.241
Mn	1.352
P	0.009
S	0.005
Cr	0.418
Mo	0.061
Ni	0.054
B	0.002

Table 3.1. Hardox-400 Composition

b. HARDOX-500

C	0.129
Si	0.226
Mn	0.702
P	0.005
S	0.005
Cr	0.631
Mo	0.024
Ni	0.047
B	0.0004

4. Software Computing Technique:

Taguchi: The Taguchi technique has been used to investigate the effects of the WEDM process parameters and subsequently to predict set of optimal parameters for optimum quality characteristics in high chromium tool steels. This research outlines the Taguchi's parameter design approach, which has been applied to optimize machining parameters during the machining process. This process gets rid of the need for repeated experiments and saves time.

Taguchi specified three situations

- Larger the better (for example, agriculture yield)
- Smaller the better (for example, carbon dioxide emissions)
- On Target, Minimum-variation (for example a mating part in an assembly)

Selection of Variables: The variables selected are torn, T-off, IP and WF.

Selection of Levels: The levels selected are 3 for each of the variable.

Selection of Orthogonal Array: As three variables are studied in the present study and each having three floors, and the level of freedom connected with one variable is 2 (Number of levels-1). So the degree of freedom associated with the three variables is 6. Hence, an orthogonal array having at least 6 DOF is to be taken. In the present study, the L9 OA is selected.

S.No.	S/N Ratio
1	18.7270
2	18.2881
3	14.3212
4	12.3031
5	10.2327
6	13.4446
7	17.5753
8	20.2833
9	8.5699

Table 4.1. Parameters at different level

5. Result and Discussion

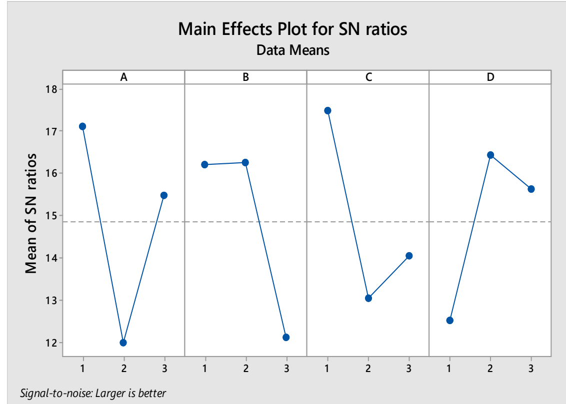
5.1 S/N Ratio Analysis

The S/N values are calculated with the help of software Minitab 17. The MRR value measured from the experiments and their corresponding S/N ratio values is listed in the given table 5.1.
S/N ratio is used as an objective function for optimizing parameters. Control factors are easily adjustable, and it is set by the manufacturer. These elements are most significant in defining the quality features.

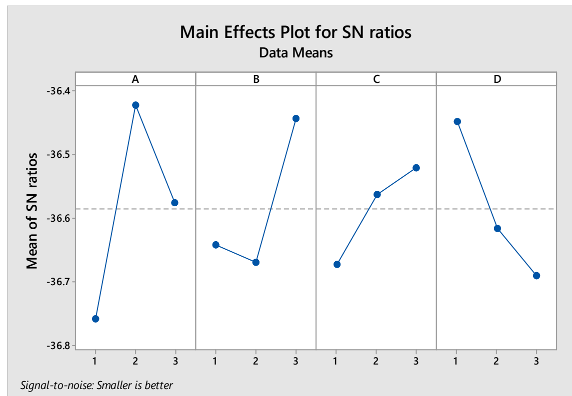
S.No.	T-ON	T-OFF	IP	MRR
	127	52	12	4.65
2	130	48	12	4.39
3	124	55	11	2.68
4	120	60	11	2.10
5	117	57	12	1.64
6	120	54	12	2.40
7	125	50	12	4.00
8	130	48	12	5.77
9	115	60	12	1.35

Table 5.1. S/N Ratios

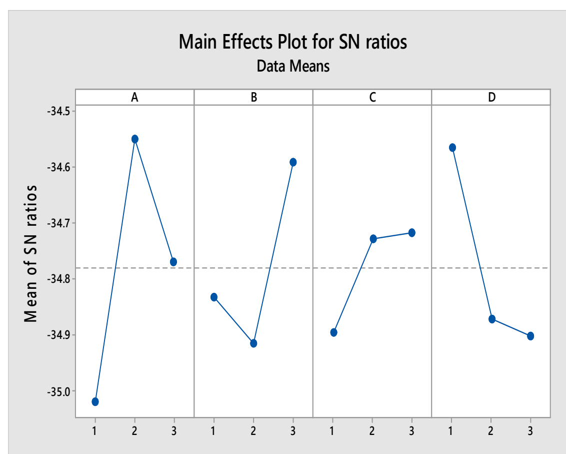
In the graph 5.1., signal-to-noise ratio approach to measure the quality characteristic deviates from the desired value.



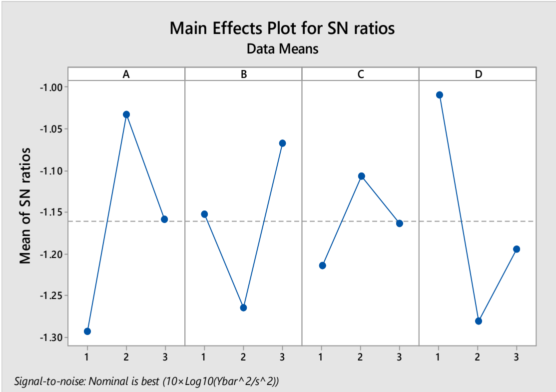
Graph 5.1.Main effects plot for S/N ratio (Larger is better)



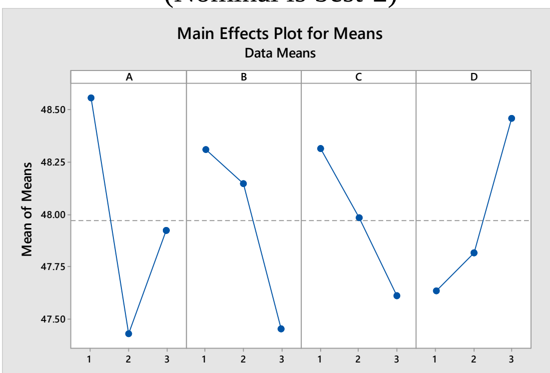
Graph 5.2.Main effects plot for S/N ratio (Smaller is better)



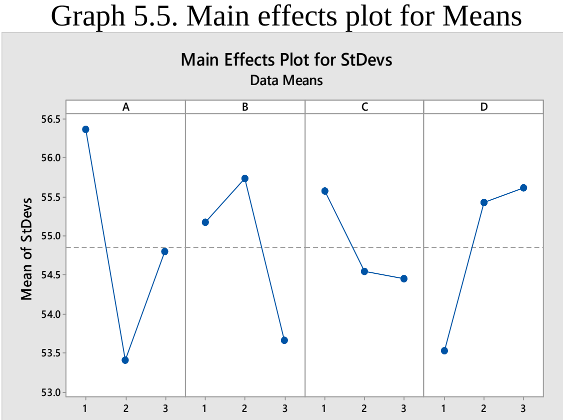
Graph 5.3.Main effects plot for S/N ratio (Nominal is best-1)



Graph 5.4.Main effects plot for S/N ratio (Nominal is best-2)

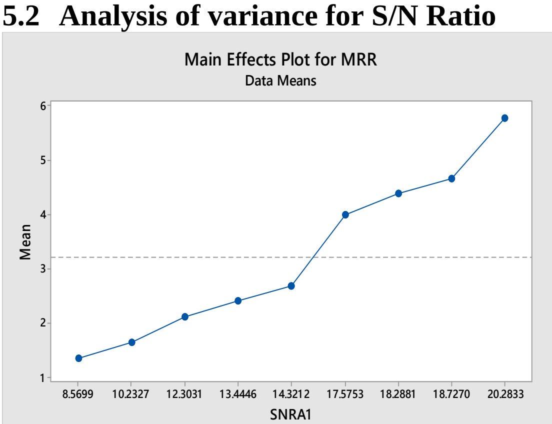


Graph 5.5. Main effects plot for Means

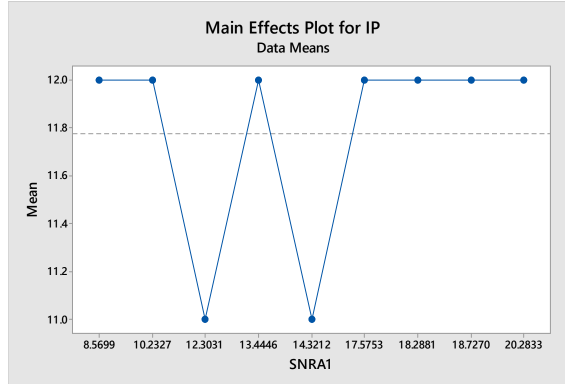


Graph 5.6.Main effects plot for Standard Deviation

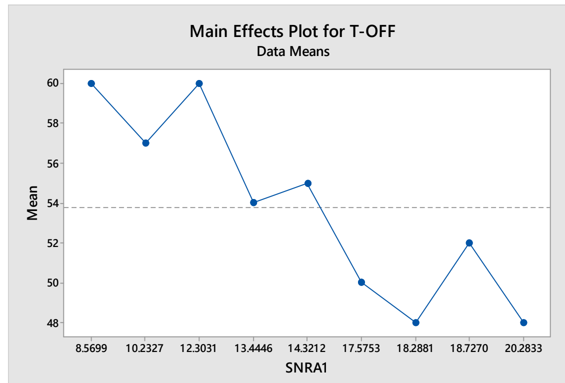
5.2 Analysis of variance for S/N Ratio



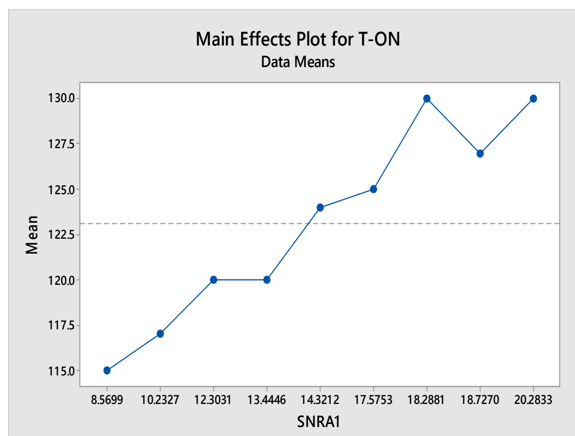
Graph 5.7Main effect plot for MRR



Graph 5.8Main effect plot for IP



Graph 5.9. Main effect plot for T-OFF



Graph 5.10 Main effect plot for T-ON

5.3. Effect on material removal rate

Regardless of the category of the performance characteristics, greater S/N value corresponds to a better performance. Therefore the optimum level of process parameters is the level with the greatest value of S/N ratio. The MRR increases with the increase in pulse on time and decreases with the increase in the pulse of time and spark gap set voltage. This is because the discharge energy increases with the pulse on time and peak current leading to a faster cutting rate. As the pulse of time decreases, the number of discharges within the given period becomes more which leads to a higher cutting rate.

With increases in spark gap set voltage the voltage discharge gap gets widened resulting into a lower cutting rate and then sudden starts increasing. It is also evident that cutting rate is minimum at first level of pulse of time and maximum at the first level of pulse of time.

5.4 Optimization

After analyzing S/N graphs and mean plots for optimal conditions for the selected response variable (Material Removal Rate), it is found that the MRR increases with the increase in pulse on time, and decreases with increase in pulse off time and spark gap set voltage. This is because the discharge energy increases with the pulse on time and peak current leading to a faster cutting rate. As the pulse off time decreases, the number of discharges within a given period becomes more which leads to a higher cutting rate.

6. Conclusion

The test for the optimal parameter setting with its selected level was concluded to evaluate the quality characteristics for WEDM of HARDOX-400 and HARDOX-500. Experiment 1 show the highest signal to noise ratio values, indicating the optimal process parameter set of T_{on}, T_{off}, IP; WF has the best values among the nine experiments which can be compared with result of ANOVA for validation of results. The response value obtained from the confirmation experiment is MRR=0. 00333 GM/Sec

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