JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

OPTIMIZATION OF PROCESS PARAMETERS IN WIRE CUT ELECTRICAL DISCHARGE MACHINING OF STAINLESS STEEL BY TAGUCHI METHOD

Vembathurajesh A[1], Mathalai Sundaram C[2], Nagarajan B[3], Nagaraja R[4], Harikishore S[5]

[1]Assistant Professor, Department of Mechanical Engineering,
Nadar Saraswathi College of Engineering and Technology Theni, Tamilnadu, India
[2]Professor, Department of Mechanical Engineering,
Nadar Saraswathi College of Engineering and Technology Theni, Tamilnadu, India
[3,4,5]Assistant Professor, Department of Mechanical Engineering,
Nadar Saraswathi College of Engineering and Technology Theni, Tamilnadu, India

Abstract : In this modern technology, the manufacturing sectors must concentrate on choosing the best machining conditions when wire electric discharge machining the toughest materials, which is extremely difficult to do using traditional machining techniques. The toughest material used in this study is machined stainless steel with dimensions of 50 x 50 x 18 mm. With distilled water acting as a dielectric fluid, 0.25 mm diameter zinc-coated brass wire is utilized as a wire tool. To optimize various input variables, a total of nine work pieces are machined with varying input parameters. With a constant wire tool feed rate, the input parameters Pulse On Time, Pulse of Time, Input Current, and Servo Voltage are changed. Following machining, Surface Roughness is measured on the machined surfaces, and the results are summarized. When compared to other pieces, the second work piece with input parameters of Pulse On Time = 115, Pulse Off Time = 55, Input Current = 230 Amps, and Servo Voltage = 10 V has a nice surface finish. Using the Taguchi Method, the input parameters for each of the nine work parts are optimized.

Keywords – Optimization, Wire Cut EDM, Stainless Steel, Taguchi Method

1. INTRODUCTION

An important technique is wire electrical discharge machining (WEDM), which requires high-precision and high-speed cutting to achieve increased accuracy and productivity. An essential machining method for creating intricate cutouts through challenging metals without the need for costly formed tools or grinding is wire electrical discharge machining, or WEDM. [1]. WEDM is a highly promising electro-thermal technique that achieves great precision for hard metal alloys. A spark will form and the temperature will rise to 10,000 degrees when the servo voltage is increased. Metal will be removed from the work piece as a result of this high temperature. Deionized water, such as dielectric fluid, separates the work piece (Anode) and wire tool electrode (Cathode), eroding material from both while continuously flushing away machining debris. CNC technology is used to regulate the wire's movement. With significant changes to the tooling and manufacturing sector, WEDM has dramatically increased accuracy, quality, productivity, and profit. The rapid pace of product development and mounting cost pressure have made matching criteria more stringent, and the WEDM process has shown to be a competitive and cost-effective machining solution over time. Stainless steels are widely utilized in many different industries due to their excellent mechanical qualities and resistance to corrosion. The most prevalent kind of stainless steel among them is austenitic stainless steel 304. Unfortunately, the low hardness, poor wear resistance, sensitivity to stress corrosion cracking in chloride solution, pitting corrosion, and other factors can weaken the strength of stainless steel, which restricts its use in industrial production [2-4]. Thus, the question of how to increase stainless steel's resistance to wear and corrosion in chloride ion solutions has arisen. In this instance, it quickly evolved to the point where ceramic layers were applied to the stainless steel surface. [5 - 7]. Because of its excellent mechanical qualities and exceptional resistance to corrosion in a variety of conditions, stainless steel materials are widely employed for numerous purposes [8].

2. MATERIALS AND METHODOLOGY

2.1. Response Surface Methodology

Response surface methodology (RSM) is a collection of mathematical and statistical techniques for empirical model building. The goal of carefully planning trials is to optimize an output variable, or response, that is affected by multiple independent variables, or input variables. An experiment is a sequence of tests, or runs, wherein the input variables are changed to determine the causes of variations in the response from the output. Reducing the expense of costly analysis techniques (such as the finite element method or CFD analysis) and the numerical noise they produce is the goal of applying RSM to design optimization. The most efficient way to analyze the data from factorial trials is to use the response surface method. It works well as a model and research tool for manufacturing issues. It conducts fewer investigations while delivering more information. The first experiment was conducted to identify the machining parameters that affect the MRR and Surface roughness, as well as to determine the range of the selected cutting parameters. This is an investigation strategy for exploring the limits of the input parameters and emerging experiential statistical model for the measured response. By definition, the limit of the process parameters must be defined in response surface method.

2.2. WEDM Cutting Process and Cutting Parameters

The biomedical, automotive, and aerospace industries all make extensive use of the WEDM cutting process for the high-precision machining of various conductive materials, including metals, metal alloys, graphite, and even some ceramic materials with varying degrees of hardness. The goal of the current study is to maximize the WEDM cutting conditions for oil-hardening, non-shrinking steel-based composites, which are typically challenging to machine using traditional cutting techniques.

2.3. SS-304 MACHINING PROCESS

Nine pieces of stainless steel with dimensions of 50 mm x 50 mm x 18 mm were used for milling. The machining was performed using the Wire Cut Electrical Discharge Machining depicted in the picture.

Fig.1. WEDM

The parameters of the process that were kept constant throughout the experimentation are:

- Workpiece: Stainless Steel 50 x 50 x 18
- Electrode (tool): 0.25 mm diameter of brass wire.

- Dielectric: Deionized water.
- Wire Feed Rate: 3 m/min

3. SURFACE ROUGHNESS

We used the 3D-SurfaScan (2015-3D, STIL-BRANCH, Paris, France) to measure the roughness of surface Ra; the area examined was 2 mm x 1 mm. To study the linear efficient of the process parameter sand the level of the ranges of cut parameters, we investigated each process parameter at three levels. The values of the initial parameters were chosen according to the manufacturers' recommendations for the tested material. The selected process parameters, as well as their identified levels for single-pass cutting operation during WEDM of Oil hardening Non Shrinking Steel based.

4. ANOVA METHOD

The proposed experimental design matrix planned as per "L9" orthogonal array (OA) for the current study is presented in An integrated method was used to optimize the process which the response surface methodology (RSM).

5. MATERIALS AND EXPERIMENTAL CONDITIONS

All the experimental tests were carried out on a WEDM machine and then the surface roughness values were measured employing Surface Roughness Tester.

Table 5.1 Chemical Composition of SS-304

Composition	Carbon(C)	Manganese	Silicon(Si)	Chromium (Cr)	Nickel(Ni)
%	0.07	2.00	1.00	17.50-19.50	8.0-10.5

Machining parameters used in the experiment and results of cutting speed and breaking are as follows.

Table 5.2 Machining Input Parameters

Levels	Pulse-On-Time Ton (_s)	Servo Voltage U (V)	Pulse-Of-Time Ton (_s)	IP	TIME IN MIN
1	110	10	50	230	69
2	**115**	**10**	**55**	**230**	**65**
3	120	10	60	230	55
4	110	20	50	230	69
5	115	20	55	230	65
6	120	20	60	230	55
7	110	30	50	230	69
8	115	30	55	230	65
9	120	30	60	230	55

6. INFLUENCE OF MACHINING PARAMETERS ON THE SURFACE ROUGHNESS

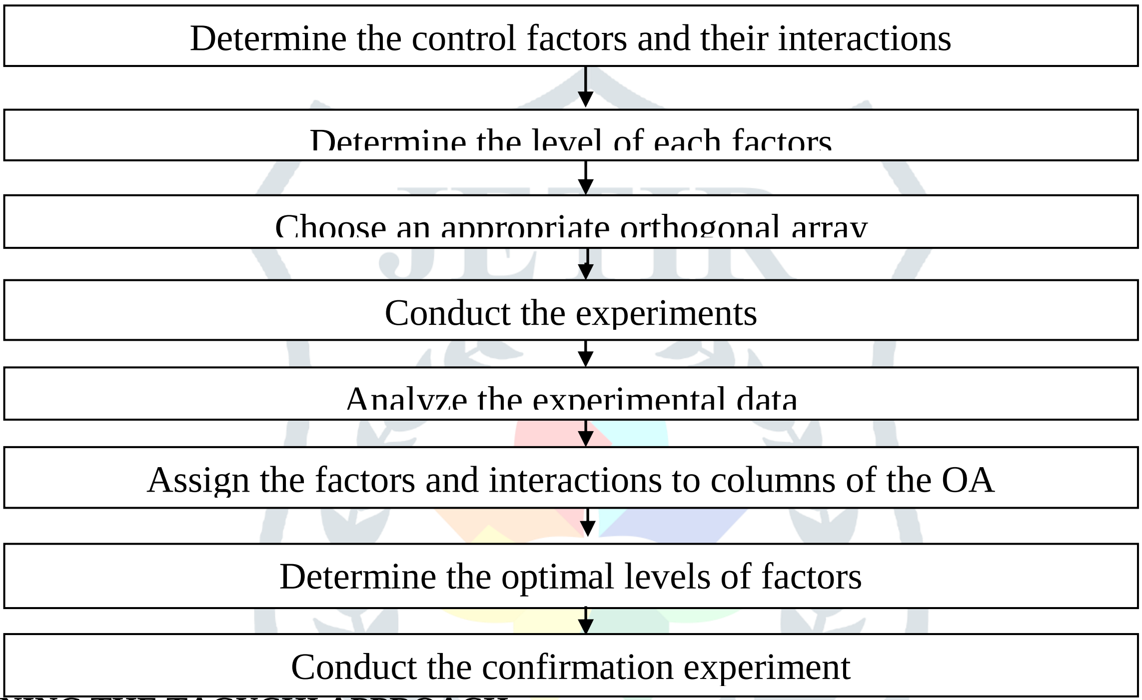
Arithmetic surface roughness (Ra) is the important constituent of the surface integrity (SI) of the cut pieces and the first qualification approach that should be considered. In WEDM machining, the machining factors that affect the surface integrity (SI) are generally the pulse-on-time, pulse-off time, current, current tension, injection of fluid pressure and so on. Surface positions in this work should depend on the transformations produced during the thermal loading of the machining. Particular attention should be paid to the choice of cutting conditions to ensure that the roughness of the cut surfaces meets the criteria given by the manufacturers. As well known, the WEDM cutting process is associated with high thermal stresses capable of inducing heterogeneous properties within the cutting surface of the workpieces. The alteration of these properties, generally at the surface or just under the surface of the manufactured parts, is referred to as surface roughness. The surface and the sub-surface are easily affected or damaged during the cutting operation. Cut surfaces thus have a strong influence on the performance of the components under the service conditions. The feedback and analysis of the damage of dynamic components show that severe ruptures due to fatigue, creep and micro-cracking due to corrosion initiate and propagate systematically on or near the surface of the component, their origin being highly dependent on the quality of the cut surface. Generally, the main problems due cutting process are identified as the burns, irregularities, edges or debris deposited on the surface, macro- and micro-cracks, cavities, micro defects such as inclusions, metallurgical alterations including distortion of the microstructure, phase transformations, temperature.

7. TAGUCHI TECHNIQUE

1.Taguchi defines Quality Level of a product as the Total Loss incurred by society due to failure of a product to perform as desired when it deviates from the delivered target performance levels.
2.This includes costs associated with poor performance, operating costs (which changes as a product ages) and any added expenses due to harmful side effects of the product in use.

8. TAGUCHI METHOD

1. Help companies to perform the Quality Fix!
2. Quality problems are due to Noises in the product or process system
3. Noise is any undesirable effect that increases variability
4. Conduct extensive Problem Analyses
5. Employ Inter-disciplinary Teams
6. Perform Designed Experimental Analyses
7. Evaluate Experiments using ANOVA and Signal-to noise techniques



9. DEFINING THE TAGUCHI APPROACH

1. Noise Factors Cause Functional Variation
2. They Fall Into Three "Classes"
    1. Outer Noise – Environmental Conditions
    2. Inner Noise – Lifetime Deterioration
    3. Between Product Noise – Piece To Piece Variation

10. RESULTS AND DISCUSSION

The main objective of the experiment is to optimize the wire cut EDM on OHNS parameters (cutting speed, feed rate, depth of cut) to achieve low value of the surface roughness. The experimental data for the surface roughness values for OHNS Steel are tabulated. The values of the surface roughness are calculated, using the ANOVA Method.

RESPONSE 1 SR

ANOVA for Response Surface 2FI Model (Aliased) Analysis of variance table [Partial sum of squares - Type 6.1]

Source	Sum of squares	df	Mean square	F-Value	P-Value probe > F
Model	0.40	5	0.079	0.23	0.9246 not significant
A-Pulse on Time	0.037	1	0.037	0.11	0.7634

B-Pulse off time	0.000	0			
C-Servo Voltage	0.041	1	0.041	0.12	0.7515
D-Time	0.013	1	0.013	0.038	0.8587
AB	0.000	0			
AC	0.090	1	0.090	0.26	0.6428
AD	0.000	0			
BC	0.000	0			
BD	0.000	0			
CD	0.052	1	0.052	0.15	0.7215
ABC	0.000	0			
ABD	0.000	0			
ACD	0.000	0			
BCD	0.000	0			
Residual	1.02	3	0.34		
Total	1.42	8			

FINAL EQUATION IN TERMS OF CODED FACTORS:

SR = 3.24 + 0.38 * A - 0.72 * C + 1.02 * D - 0.31 * A * C -1.07*C*D

- A = Pulse on Time,
- C = Servo Voltage,
- D = Time.

FINAL EQUATION IN TERMS OF ACTUAL FACTORS:

Not available for ALIASED models.

The Diagnostics Case Statistics Report has been moved to the Diagnostics Node. In the Diagnostics Node, Select Case Statistics from the View Menu.

Proceed to Diagnostic Plots (the next icon in progression). Be sure to look at the:

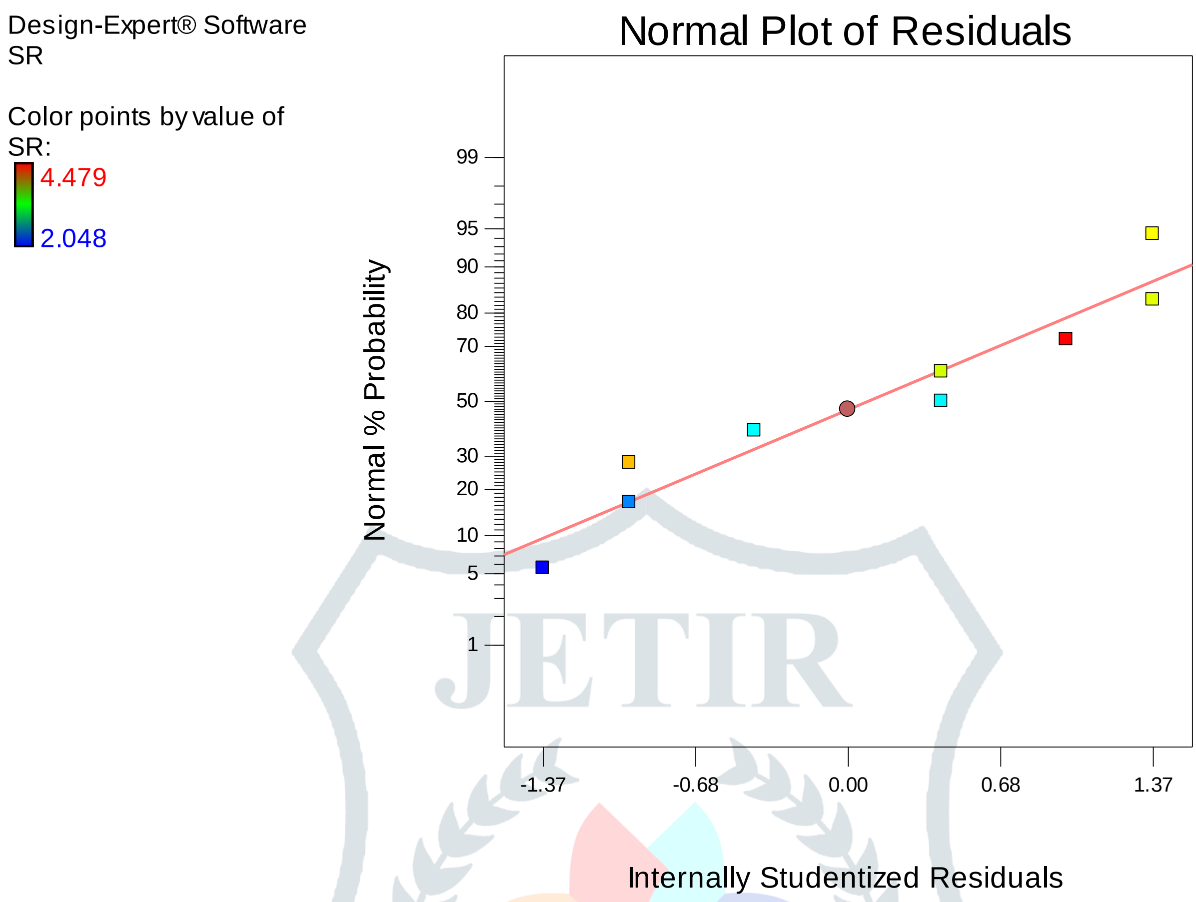
1)Normal probability plot of the studentized residuals to check for normality of residuals.

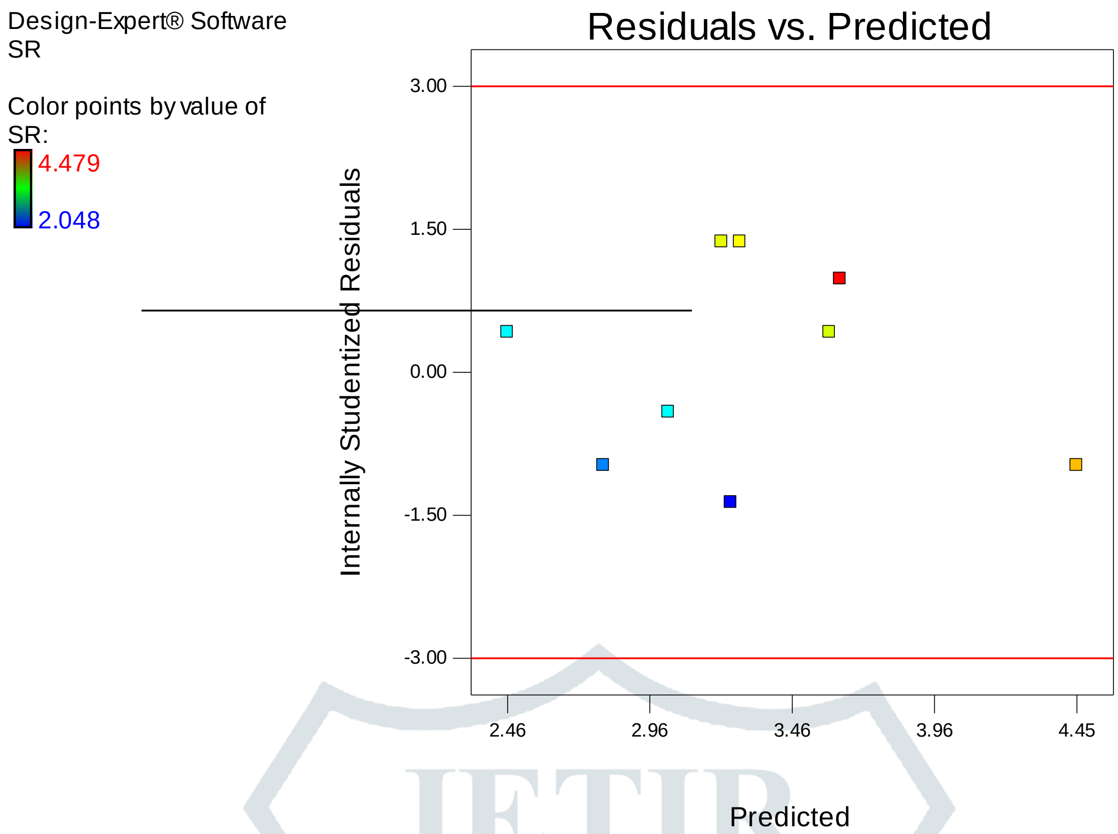
2)Studentized residuals versus predicted values to check for constant error.

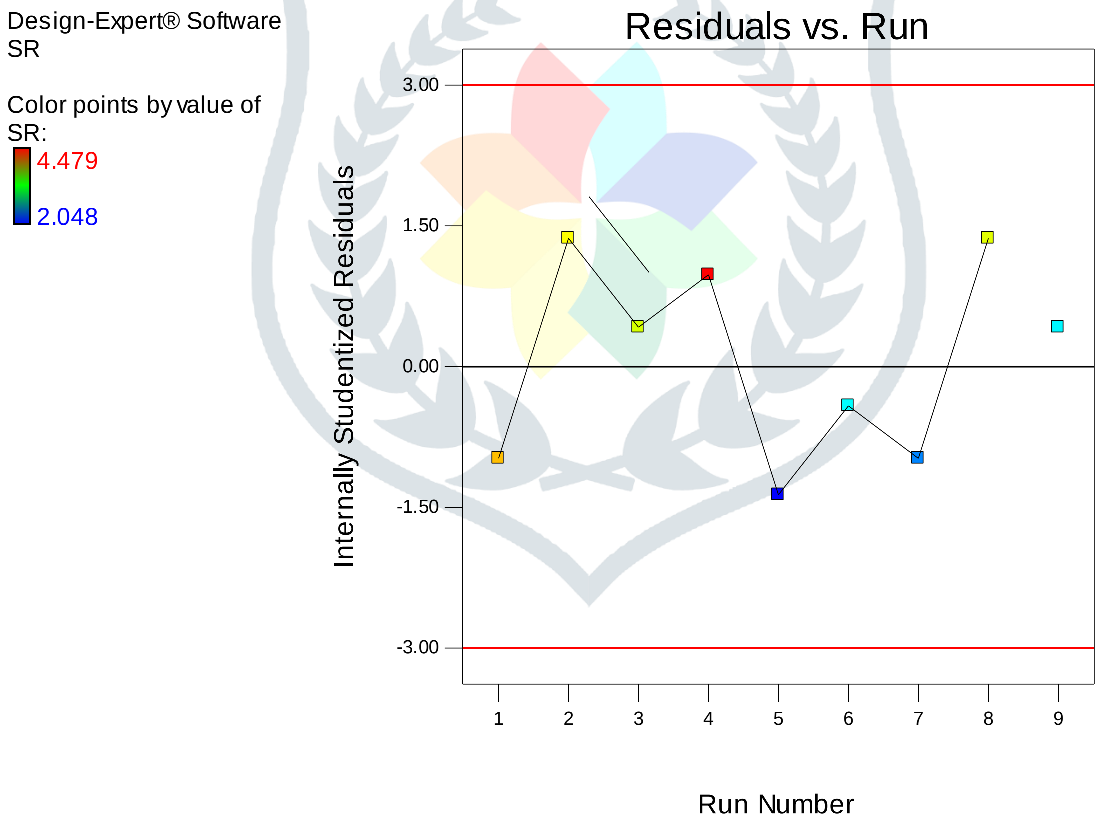
3)Externally Studentized Residuals to look for outliers, i.e., influential values.

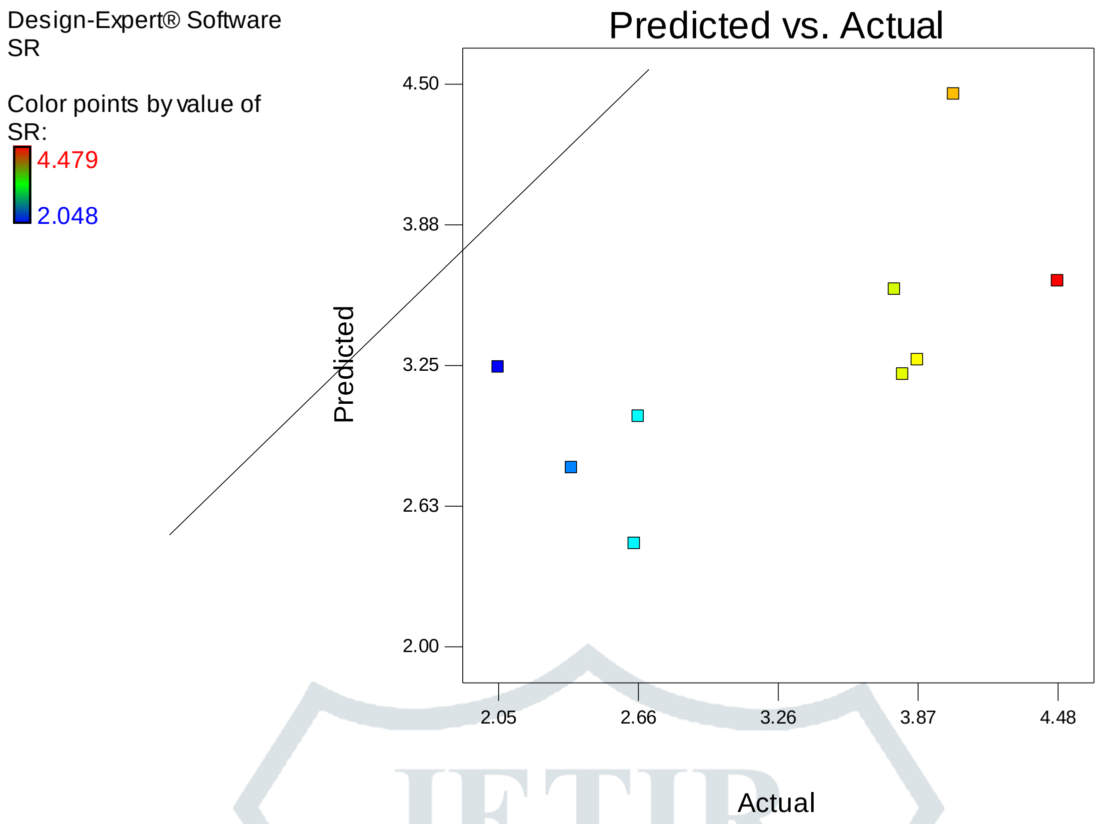
4)Box-Cox plot for power transformations.

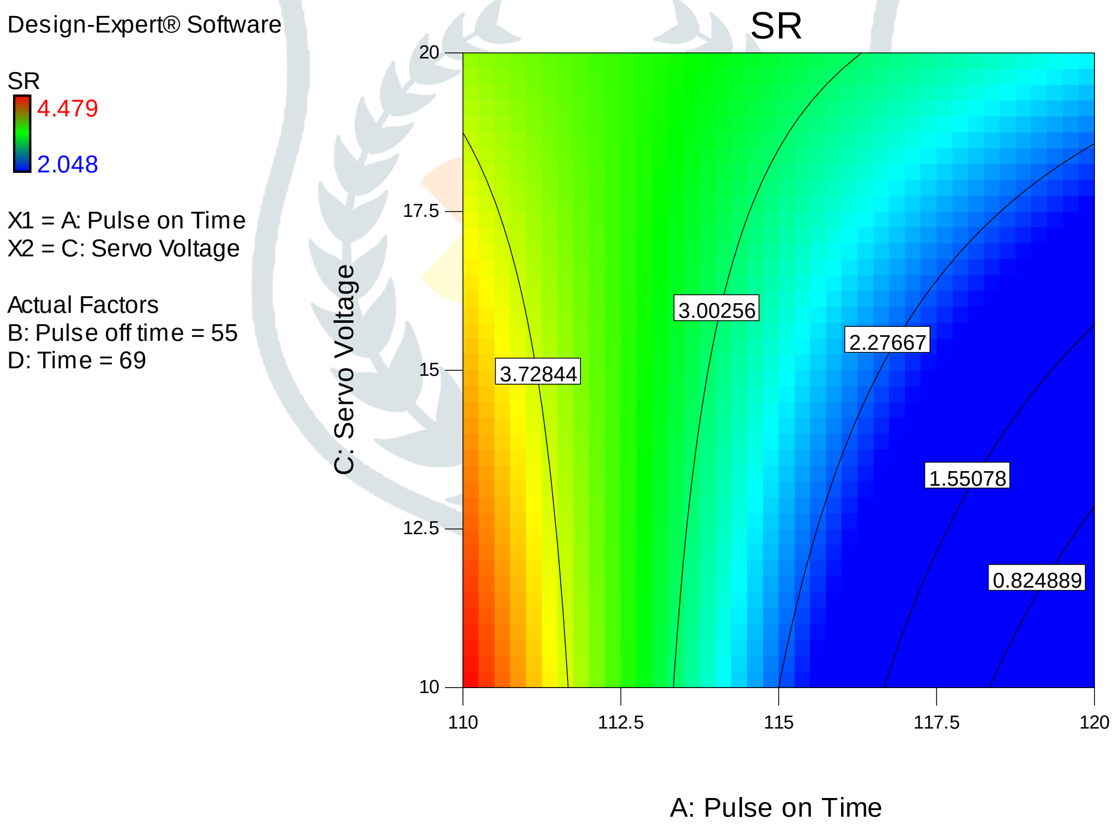
f all the model statistics and diagnostic plots are OK, finish up with the Model Graphs icon.

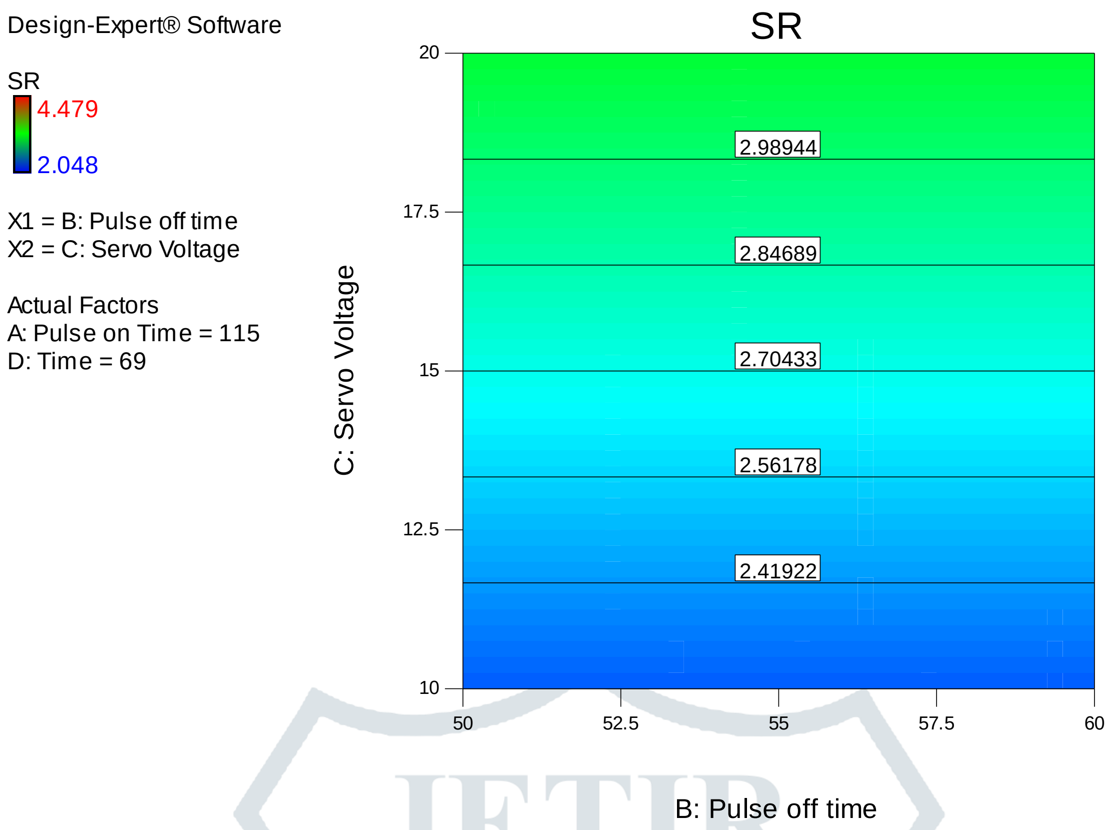


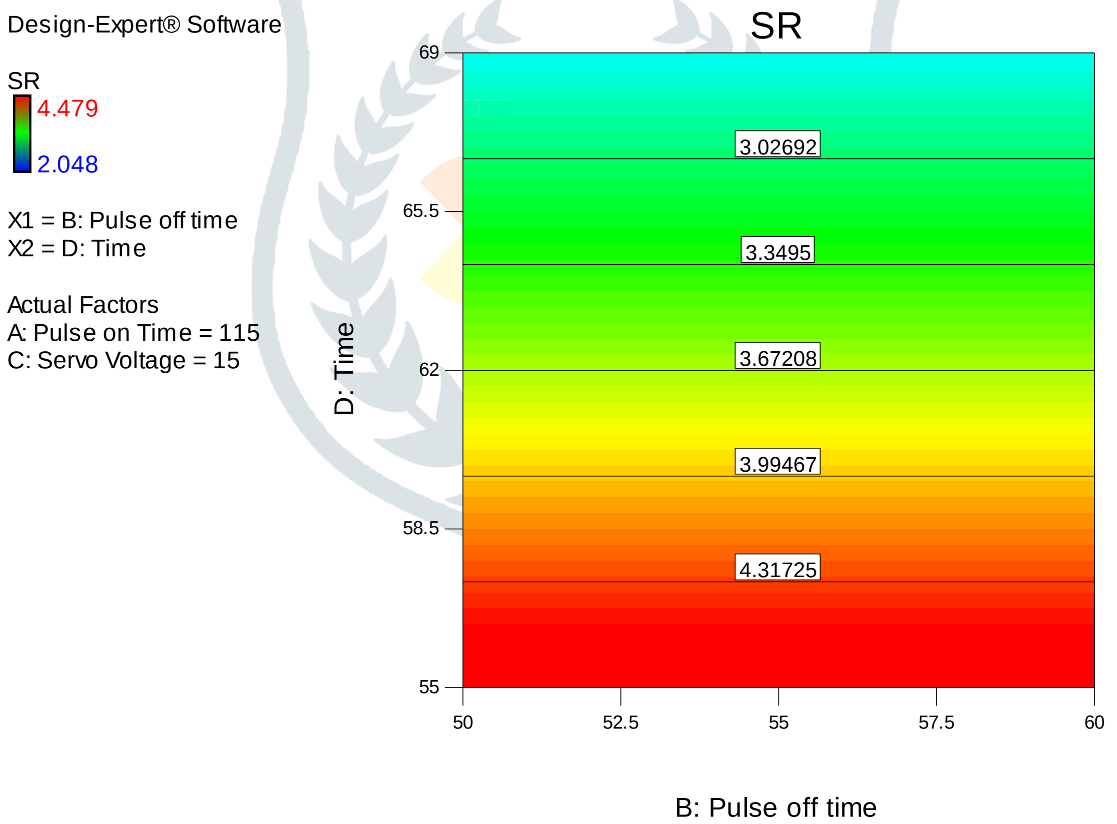

Design-Expert® Software
SR
Color points by value of SR:
4.479
2.048
Residuals vs. Predicted
Internally Studentized Residuals
3.00
1.50
0.00
-1.50
-3.00
2.46
2.96
3.46
3.96
4.45
Predicted

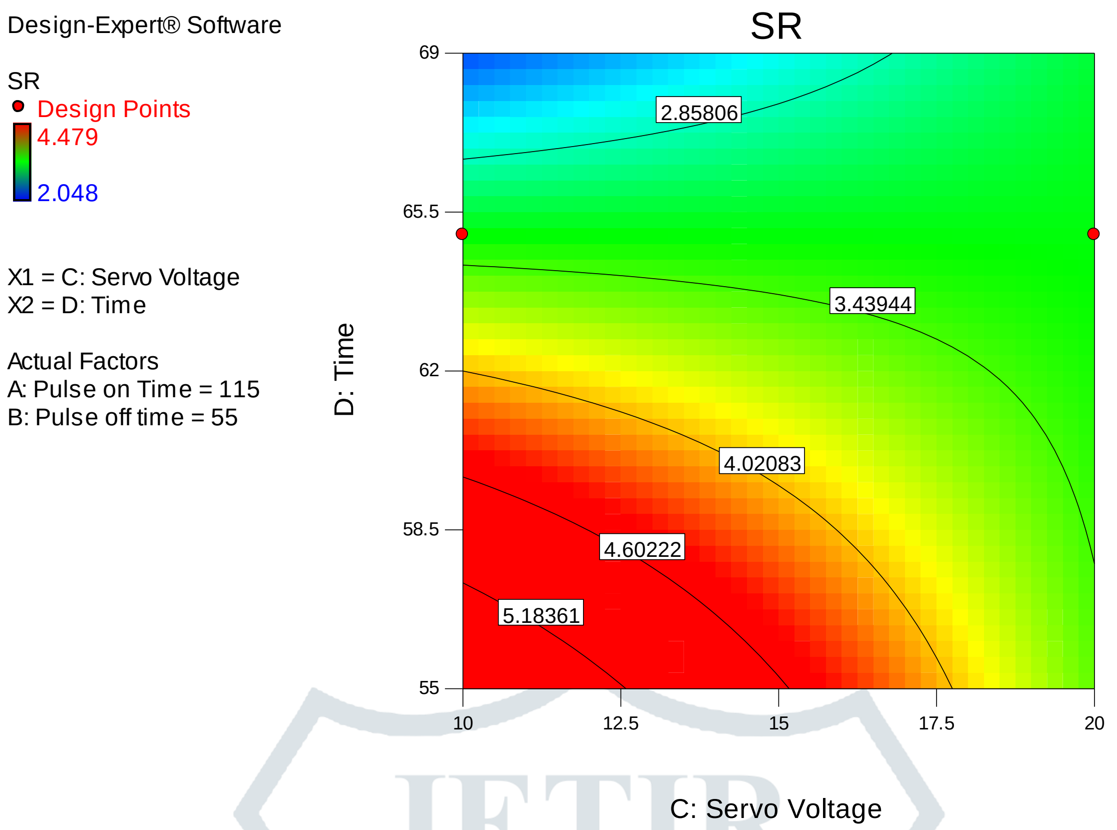

Design-Expert® Software
SR
Color points by value of SR:
4.479
2.048
Residuals vs. Run
Internally Studentized Residuals
3.00
1.50
0.00
-1.50
-3.00
1
2
3
4
5
6
7
8
9
Run Number


Design-Expert® Software
SR
Color points by value of
SR:
4.479
2.048
Predicted vs. Actual
4.50
3.88
3.25
2.63
2.00
Predicted
2.05
2.66
3.26
3.87
4.48
Actual


Design-Expert® Software
SR
4.479
2.048
X1 = A: Pulse on Time
X2 = C: Servo Voltage
Actual Factors
B: Pulse off time = 55
D: Time = 69
SR
20
17.5
15
12.5
10
C: Servo Voltage
3.72844
3.00256
2.27667
1.55078
0.824889
110
112.5
115
117.5
120
A: Pulse on Time


Design-Expert® Software
SR
4.479
2.048
X1 = B: Pulse off time
X2 = C: Servo Voltage
Actual Factors
A: Pulse on Time = 115
D: Time = 69
SR
2.98944
2.84689
2.70433
2.56178
2.41922
C: Servo Voltage
20
17.5
15
12.5
10
50
52.5
55
57.5
60
B: Pulse off time


Design-Expert® Software
SR
4.479
2.048
X1 = B: Pulse off time
X2 = D: Time
Actual Factors
A: Pulse on Time = 115
C: Servo Voltage = 15
SR
3.02692
3.3495
3.67208
3.99467
4.31725
D: Time
69
65.5
62
58.5
55
50
52.5
55
57.5
60
B: Pulse off time



11. CONCLUSION

In this work, we concentrated on optimizing the input parameters for machining one of the toughest materials, oil hardening non-shrinking steel, using wire cut electrical discharge machining. Nine sample workpieces of SS-304 material are machined. The wire tool utilized is zinc-coated brass wire with a diameter of 0.25 mm, and the dielectric fluid is distilled water. Nine work parts are machined with various input parameters to determine the optimal input values. After machining, the Surface Roughness test was performed. Based on the results, the workpiece with input parameters Pulse On Time - 115, Pulse Off Time - 55, Input Current 230 Amps, and Servo Voltage 10V has a better surface finish than the other workpieces. The Taguchi Method is used to optimize all of the input parameters for all nine work parts.

12. REFERENCES

[1] Pandey P. C. and Shan H. S, Modern Machining Processes, Tata McGraw-Hill Publishing Company, 1980, pp. 79-80.

[2] Li, L.; Dong, C. F.; Xiao, K.; Yao, J. Z.; Li, X. G. Effect of pH on Pitting Corrosion of Stainless Steel Welds in Alkaline Salt Water. Constr. Build. Mater. 2014, 68, 709-715.

[3] Sui, R. J.; Liu, Y.; Wang, W. Q.; Qu, Y. P.; Su, C. G.; Chang, F. Failure Analysis of Austenitic Stainless Steel Pipes in Amine Liquid Regeneration Unit of a Desulfurizer. Eng. Failure Anal. 2015, 57, 164-170.

[4] Zhiming, L.; Laimin, S.; Shenjin, Z.; Zhidong, T.; Yazhou, J. Effect of High Energy Shot Peening Pressure on the Stress Corrosion Cracking of the Weld Joint of 304 Austenitic Stainless Steel. Mater. Sci. Eng, A 2015, 637, 170-174.

[5] Hsu, C.-H.; Huang, K.-H.; Lin, Y.-H. Microstructure and Wear Performance of Arc-deposited Ti-N-O Coatings on AISI 304 Stainless Steel. Wear 2013, 306 (12), 97-102.

[6] Lidija C´ urkovic´ a,⇑ , Helena Otmacˇic´ C´ urkovic´ b , Sara Salopek c , Marijana Majic´ Renjo a , Suzana Šegota, " Enhancement of Corrosion Protection of AISI 304 Stainless Steel by Nanostructured Sol-Gel TiO2 Films. Corros. Sci. 2013, 77, 176-184.

[7] Xing, X. G.; Han, Z. J.; Wang, H. F.; Lu, P. N. Electrochemical Corrosion Resistance of CeO2-Cr/Ti Coatings on 304 Stainless Steel via Pack Cementation. J. Rare Earths 2015, 33 (10), 1122-1128.

[8] T. Hryniewicz, R. Rokicki, and K. Rokosz. Corrosion Characteristics of Medical- Grade AISI Type 316L Stainless Steel Surface after Electro polishing in a Magnetic Field,January 2016.