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Experimental Investigation for Optimum Process Parameters in Wire Cut Edm Process Using Taguchi Method Duplex Steel 2507

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ABSTRACT

In this project, experiments and analysis have been conducted to investigate the effect of process parameters of Wire-cut EDM on the performance measures such as material removal rate (MRR) and surface finish. The input parameters selected are pulse on time, pulse off time, discharge current and wire feed. An optimization technique namely, grey taguchi method has been employed to identify the optimum parameters of the wire-cut EDM process for cutting 2507 grade duplex stainless steel. The effects of each control parameter on the performance measure have been studied individually using the plots of signal to noise ratio. Response surface methodology has been applied to generate a mathematical model for each output parameter in terms of the input parameters. A detailed description of the microstructure of the material used has been given which explains the properties of the material.

INTRODUCTION

Motivation

There are several materials whose acceptance and use is widely increasing in the present scenario. Mild steels, ceramics, polymers, carbides etc. are some of them. Amongst them in the steel family, duplex steels are widely being used in areas where corrosion resistance is a major factor. They contain a mixture of austenite and ferrite phases of steels. They have high strength, corrosion resistance, and enhanced resistance to stress corrosion cracking. Due to their high hardness, machining of duplex steels using conventional methods is not feasible and so on conventional methods like wire cut EDM are used for this purpose. Duplex stainless steels are called "duplex" because they have a two-phase microstructure consisting of grains of ferrite and austenitic stainless steel. When duplex stainless steel is melted it solidifies from the liquid phase to a completely ferrite structure.

CHEMICAL COMPOSITION

Cr	**Ni**	**Mo**	**C**	**N**	**Mn**
24.0-26.0	6.0-8.0	3.0-5.0	0.030 Max	.24-.32	1.20 Max
Si	**Cu**	**P**	**S**	**Fe**	
0.80 Max	0.50 Max	0.035 Max	0.020 Max	Balance	

LITERATURE SURVEY

DanialGhodsiyeh et al. [1] have discussed the current Research Trends in Wire Electrical Discharge Machining (WEDM). This paper reviews the research trends in WEDM on relation between different process parameters, which include pulse on time, pulse off time, servo voltage, peak current, dielectric flow rate, wire speed, wire tension on different process responses such as material removal rate (MRR), surface roughness (Ra), sparking gap (Kerf width), wire lag (LAG) and wire wear ration (WWR) and surface integrity factors. Furthermore, different types of WEDM methods have been introduced and discussed. In addition the paper highlights different modelling and optimization methods and discusses their advantage and disadvantage. The final part of the paper includes some recommendations about the trends for future WEDM researches.

2. Siva Prasad Arikatla et al. [2] have conducted an experimental investigation of Wire Electric Discharge Machining (WEDM) of Titanium alloy. Their objective was to investigate the effect of wire electric discharge machining process parameters including pulse on time, input power, servo reference voltage, wire feed rate, wire tension, dielectric fluid pressure and server feed rate on process performance parameters such as kerf width, cutting speed, material removal rate and overcut. Experimental results reveals that, as the pulse on time/ pulse duration, input power, server voltage, wire feed and wire tension increases, the kerf width also increases. Lower feed rate gives bigger kerf width and as the feed rate increases kerf width decreases. Other results have also been discussed.

3. Datta and Mahapatra [3] have proposed a quadratic mathematical model and conducted experiments by taking six WEDM process parameters are discharge current, pulse duration, pulse frequency, wire speed, wire tension and dielectric flow rate. Experiments were carried out on D2 Tool Steel using a Zinc coated Copper wire electrode. The response parameters noticed for each experiment were MRR, Surface Roughness and Kerf. A statistical analysis has been carried for each result and responses have been utilized to fit the quadratic model which represents the above said six parameters. Grey based Taguchi technique has been utilized to evaluate optimal parameter combination to achieve maximum MRR, minimum roughness value and minimum width of cut; with selected experimental domain. It has been found out that for continuous quality improvement Grey based Taguchi method is a very reliable method to predict optimal parameter values and all the parameters involved in the experimentation are independent of each other.

4. Neeraj Sharma et.al. [4] Have discussed the significant process parameters along with the percentage contribution of each parameter. ANOVA is used to find the percentage contribution of significant process parameters. Response surface methodology is used for the planning of experiments and D-2 tool steel is used as a work-piece. D- 2 tool steel used in tools, punches and die industries. The analysis of results indicates that pulseon servo voltage have the maximum effect in single parameter compared to pulse off time and peak current during the investigation of cutting rate on WEDM for D-2 tool steel.

5. Dr. Josephkunju Paul et.al.[5] Evaluated the effect of voltage, dielectric pressure, pulse ontime and pulse off-time on spark gap of Ti6AL4V alloy. It is found that the pulse on time, pulse off time, the interaction of dielectric pressure and pulse off time, and interaction of pulse on time and pulse off time are significant parameters which affect the spark gap of WEDM. Minimum spark gap can be obtained by adopting a low value of pulse on time (20 μs), a

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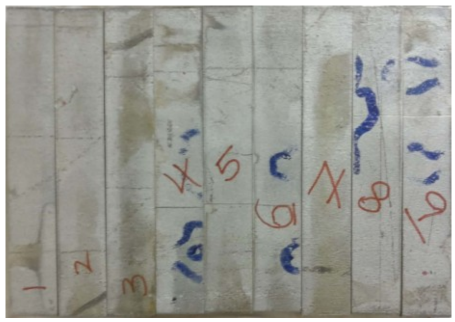
high value of dielectric pressure (15 kef/cm2), high value of pulse off time (50 µs) and voltage of 50V.

Properties of the electrodes are tabulated below.

Element	Cu	Fe	Pb	Zn
Wt%	89-91	<=0.05	<=0.05	10

Composition of Brass Wire



Work Pieces after Machining

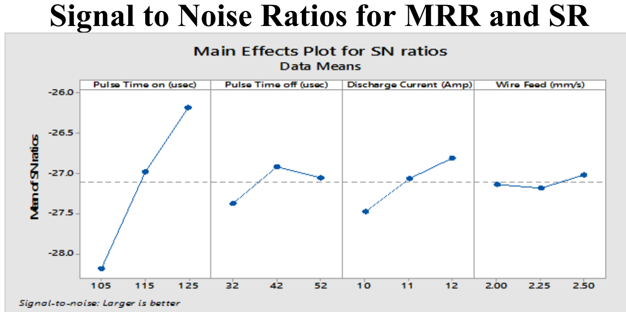
Experimental table for input parameters generated using Minitab software is shown below:

EXP NO.	PULSE TIME ON (T_{ON}) (µsec)	PULSE TIME OFF (T_{OFF}) (µsec)	DISCHARGE CURRENT (Amp)	WIRE FEED (mm/s)
1	105	32	10	2.00
2	105	42	11	2.25
3	105	52	12	2.50
4	115	32	11	2.50
5	115	42	12	2.00
6	115	52	10	2.25
7	125	32	12	2.25
8	125	42	10	2.50
9	125	52	11	2.00

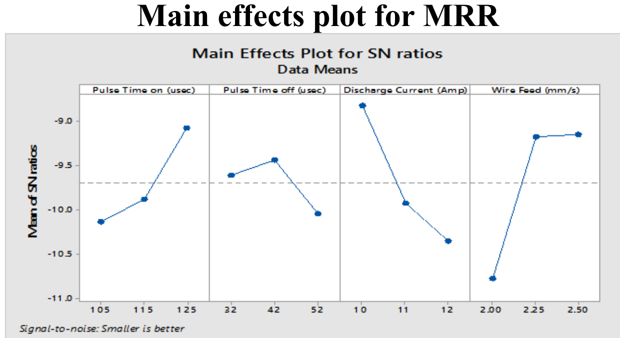
Experimental inputs based on orthogonal array

EXP NO	S/N OF MRR	S/N OF SR
1	-28.8258	-10.2443
2	-28.0023	-9.5742
3	-27.7232	-10.5819
4	-27.0916	-9.4610
5	-26.5028	-11.3600
6	-27.3509	-8.8213
7	-26.1961	-9.1091
8	-26.2494	-7.3732
9	-26.0904	-10.7261

Signal to Noise Ratios for MRR and SR



Main effects plot for MRR



Main effects plot for surface roughness

Generating the Grey Relational Coefficient and Grade

As the units of the performance characteristics MRR and SR are different we need to normalize the data using grey relational generating in GRA.

Exp.no	**MRR (mm^3/min)**	**SR (Ra)**
1	0	0.3274

2	0.2686	0.5048
3	0.3656	0.2327
4	0.5970	0.5335
5	0.8283	0
6	0.5	0.6885
7	0.9552	0.6202
8	0.9328	1
9	1	0.1912

Normalized Data (Grey relational Analysis)

The grey relational coefficient $\mathcal{E}i$ **(k)** for the **kth** performance characteristics in the **ith** experiment is

$\mathcal{E}\mathbf{i}(\mathbf{k}) = (\Delta\mathbf{min} + \phi\Delta\mathbf{max})/(\Delta\mathbf{oi} + \phi\Delta\mathbf{max})$

$\Delta\mathbf{oi} = || x^{*}0\ (\mathbf{k}) - x^{*}i\ (\mathbf{k}) ||$

$\mathbf{min} = \mathbf{min}\ || x * \mathbf{0}\ (\mathbf{k}) - x * i\ (\mathbf{k}) ||$

$\mathbf{max} = \mathbf{max}\ || x * \mathbf{0}\ (\mathbf{k}) - x * i\ (\mathbf{k}) ||$

ϕ is 0 to 1, in general $\phi = 0.5$

Exp.no	**MRR (mm^3/min)**	**SR (Ra)**
1	1	0.6726
2	0.7314	0.4952
3	0.6344	0.7673
4	0.4030	0.4665
5	0.1717	1
6	0.5	0.3115
7	0.0448	0.3798
8	0.0672	0

9	0	0.8088

Deviation Sequences for the Data

	Grey Relational Coefficient		Grey Relational Grade γ_i	Rank
Job No.	MRR $\xi_i(1)$	SR $\xi_i(2)$		
1	0.3333	0.4264	0.3798	9
2	0.4060	0.5024	0.4542	7
3	0.4407	0.3945	0.4176	8
4	0.5537	0.5173	0.5355	5
5	0.7443	0.3333	0.5388	4
6	0.5	0.6161	0.5131	6
7	0.9177	0.5683	0.7430	2
8	**0.8815**	**1**	**0.9407**	**1**
9	1	0.3820	0.6910	3

Overall grey relational grades

According to performed experiment design, it is clearly observed from Table No: that the 'wire cut EDM process parameters' setting of experiment no. 08 has the highest grey relation grade. Thus, the eighth experiment gives the best multi-performance characteristics among the 9 experiments.

The optimal values obtained from the analysis are - **pulse on time 125µs, pulse off time 42µs, current at 10 amps and the wire feed rate at 2.5 mm/s.**

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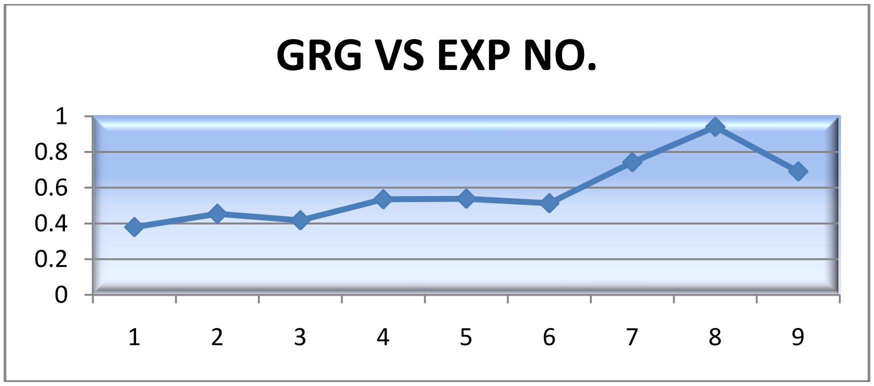
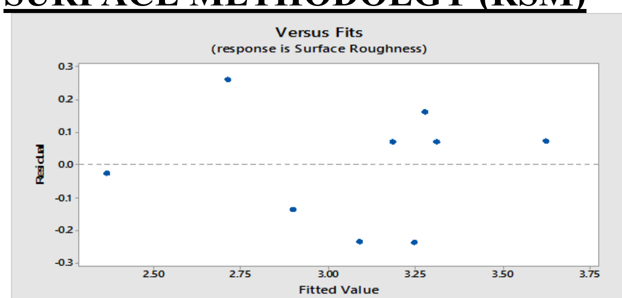


Scatter Plot of Grey Relational Grade Vs Experiment No.

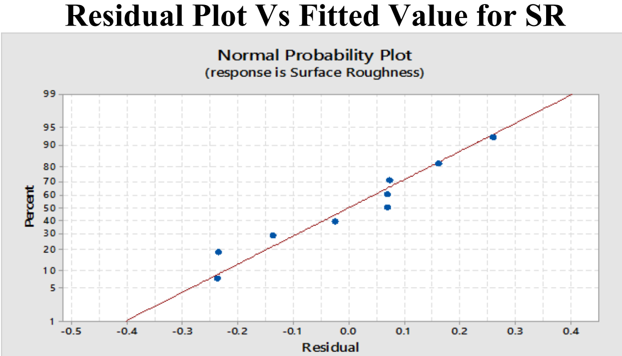
Level	Ton	T off	Ip	Wire feed
Level 1	0.4172	0.6057	0.6112	0.5365
Level 2	0.5291	0.6445	0.5602	0.5701
Level 3	0.7915	0.5405	0.5664	0.6312
Delta	0.3743	0.1040	0.051	0.0947
Rank	**1**	**2**	**4**	**3**

Average Grey Relational Grades

PREDICTIVE MODELS FOR MRR AND SR THROUGH RESPONSE SURFACE METHODOLGY (RSM)



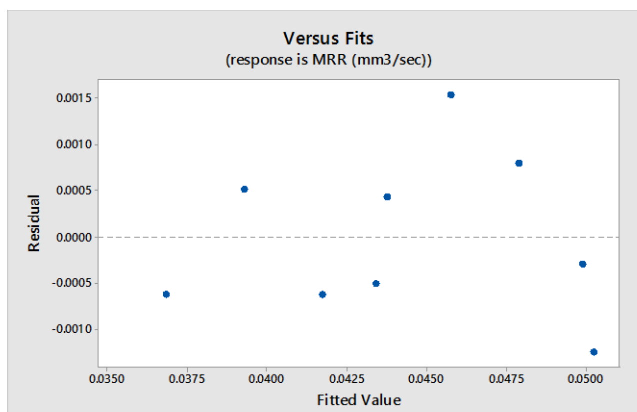
Residual Plot Vs Fitted Value for SR



Normal Plot of Residuals for Surface Roughness

Analyze RSM For MRR:

In the same manner as mentioned above the analysis is carried for MRR and the results obtained are as follows:



Residual Vs Fits for MRR

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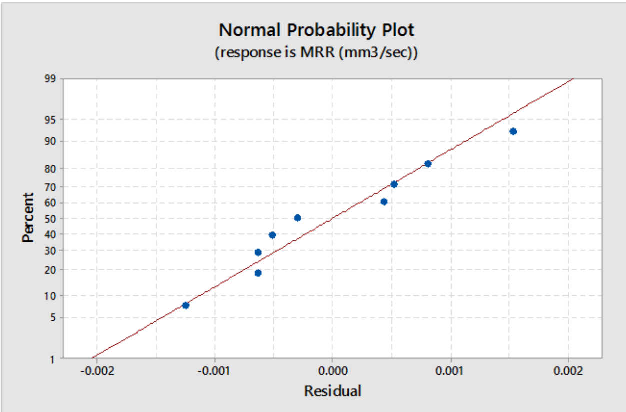
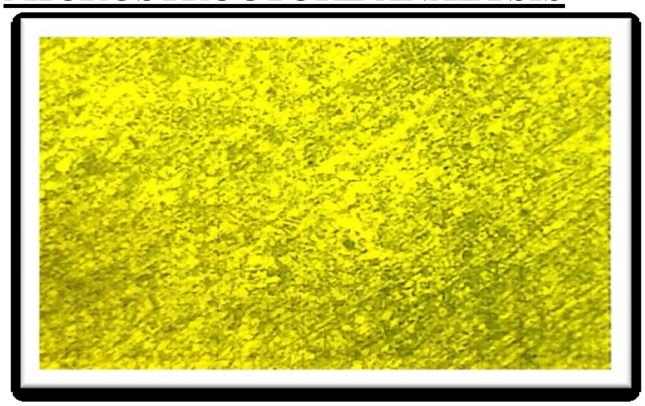
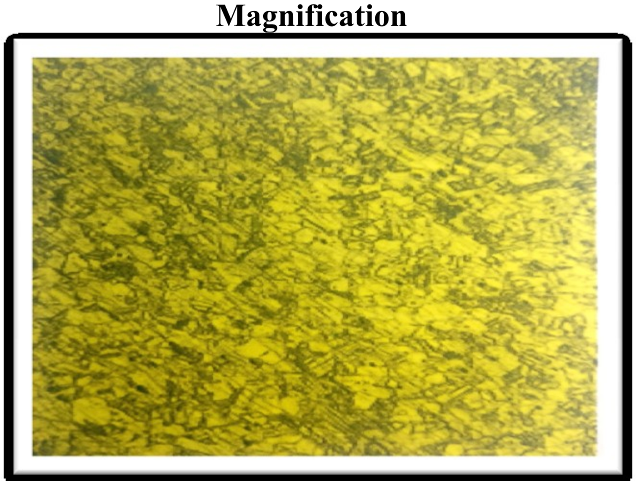


Normal Plot of Residuals for MRR

MICROSTRUCTURE ANALYSIS



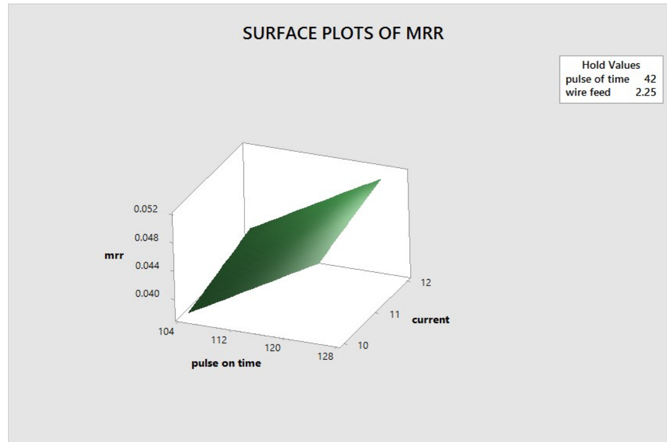
Microstructure Of Material At 100x Magnification



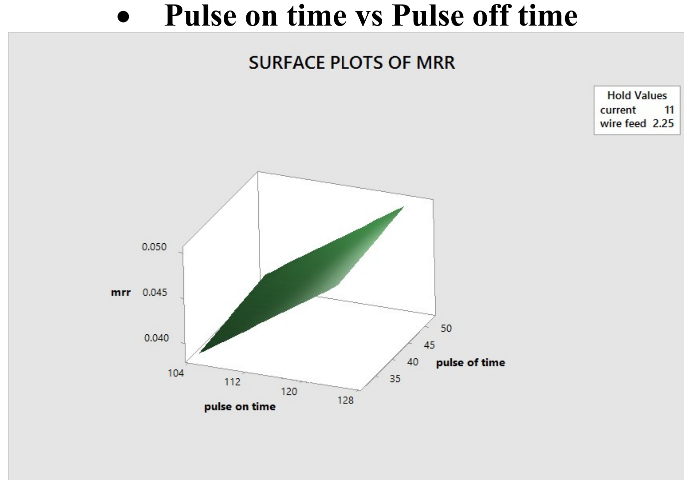
Microstructure Of The Material At 200x Magnification

SURFACE PLOTS OF MRR

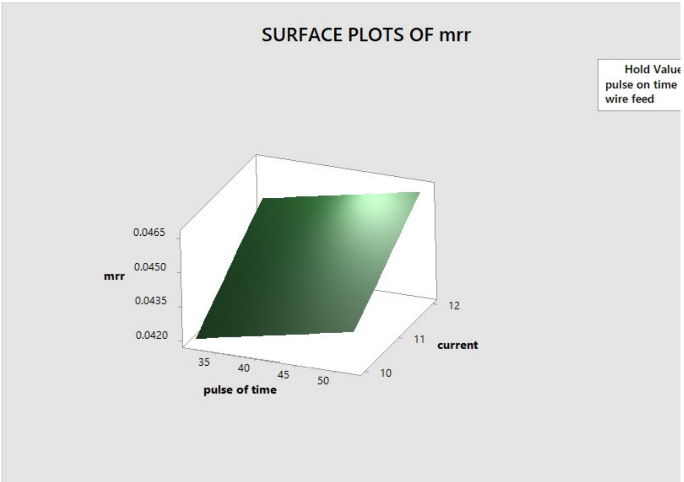
- **Current vs Pulse on time**



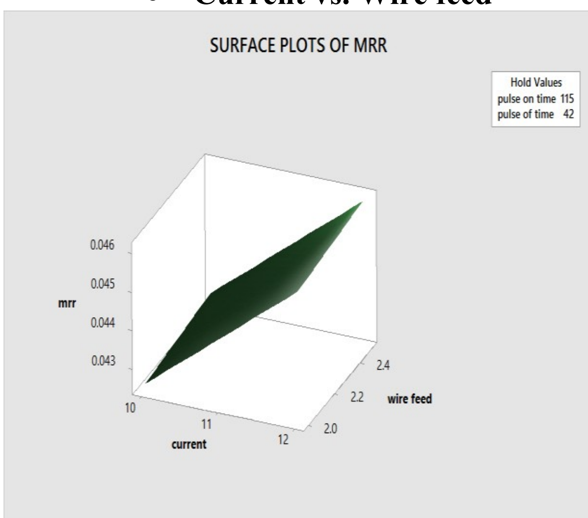
- **Pulse on time vs Pulse off time**



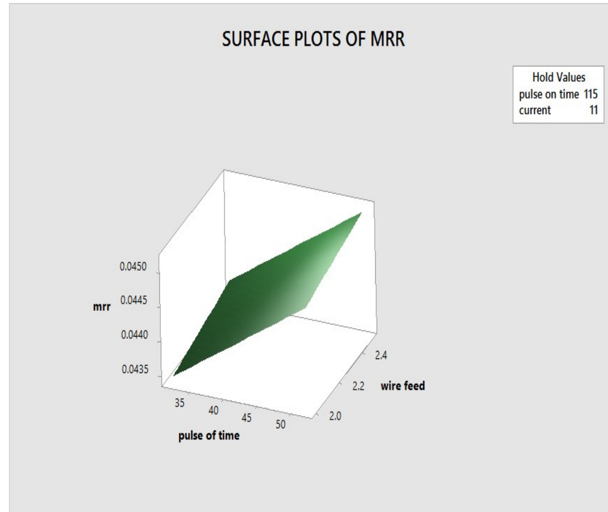
- **Current vs Pulse off time**



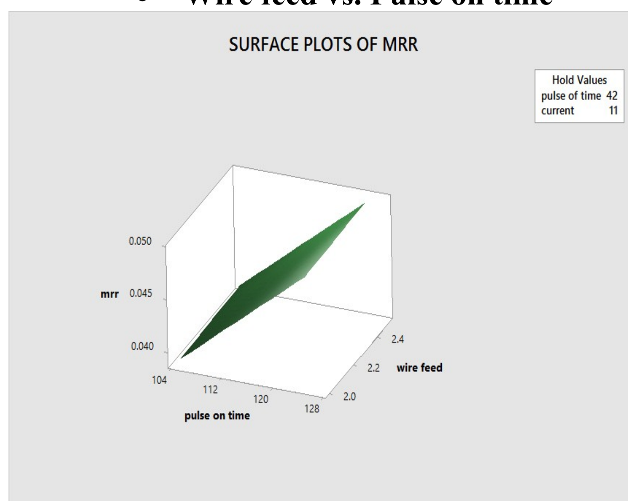
- **Current vs. Wire feed**



- **Pulse off time vs Wire feed**



- **Wire feed vs. Pulse on time**



<u>SURFACE PLOTS OF SR</u>

- **Current vs Pulse off time**

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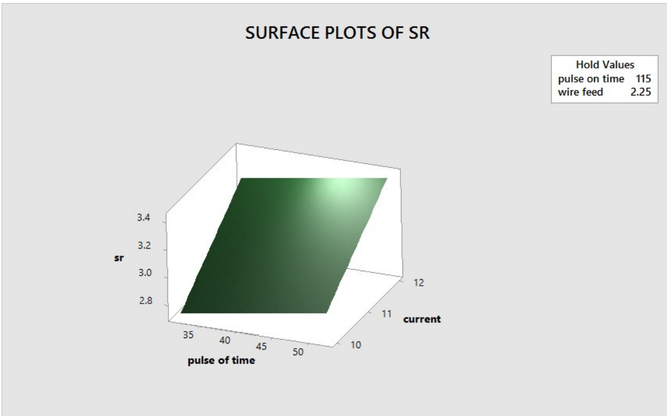
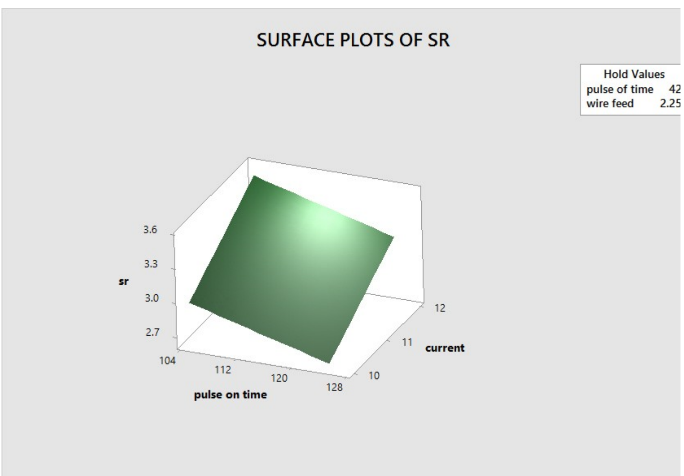
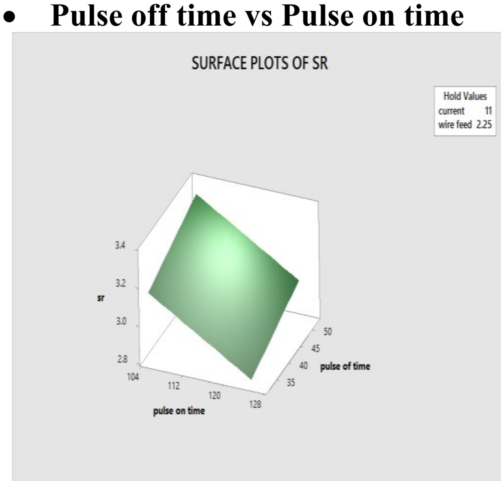


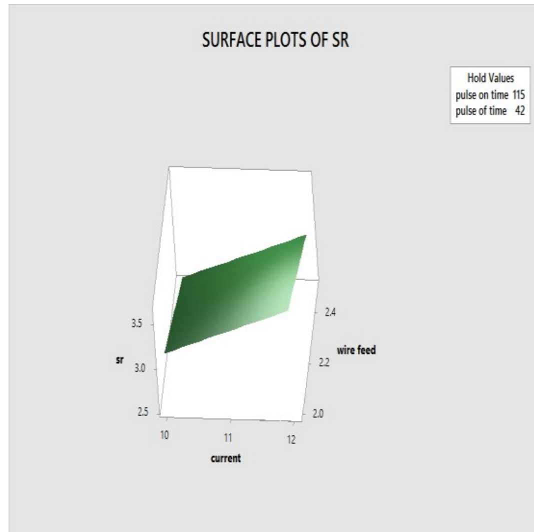
- **Current vs. Pulse on time**



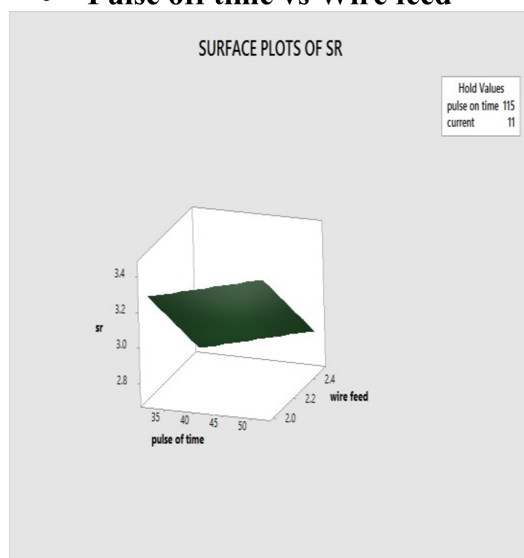
- **Pulse off time vs Pulse on time**



- **Current vs Wire feed**



- **Pulse off time vs Wire feed**



- **Wire feed vs. pulse on time**

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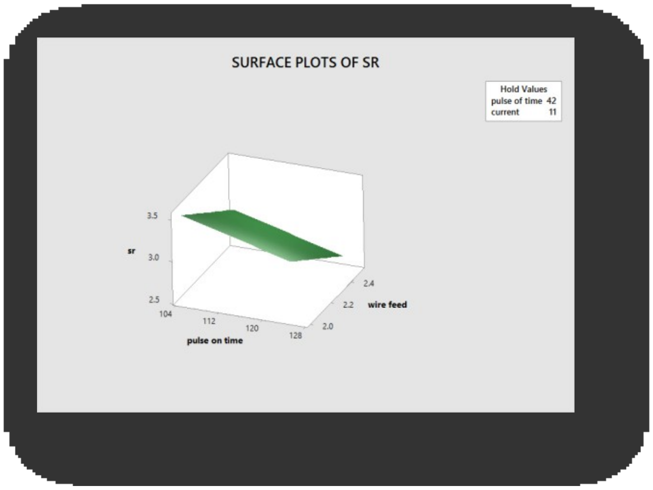

CONCLUSION

1. In this study, optimal values for a multi response system are found out using grey relational analysis. It is found that experiment 8 in the L9 array gives the optimal values for MRR and SR.
2. The plots of S/N ratios obtained give a clear picture of the influence of the input parameters on the desired output when they are considered individually.
3. Predictive models are developed using response surface methodology to estimate material removal rate and surface roughness with four input factors.
4. Surface plots for MRR and SR have been given which give the effect of the parameters on the output two at a time while the other two are kept constant.

REFERENCES

DanialGhodsiyeh, AbolfazlGolshan and Jamal AzimiShirvanehdeh, "Review on Current Research Trends in Wire Electrical Discharge Machining (WEDM)", Indian Journal of Science and Technology, 4128-4137, pp. February (2013).

[2] Siva Prasad Arikatla, Dr.ArkantiKrishnaiah and Dr.K Tamil Mannan, "Influence of Servo Voltage and Dielectric Fluid Pressure in Wire Electrical Discharge Machining of Titanium Alloy", International Journal of Engineering Research& Management Technology, 2(6), pp. 69-77, November(2015).

[3] S. Datta and S. S. Mahapatra, "Modelling, Simulation and Parametric Optimization of Wire EDM Process Using Response Surface Methodology Coupled with Grey-Taguchi Technique", International Journal of Engineering, Science and Technology, pp. 162-183 (2010).

[4] LokeshGoyat, Rajesh Dudi and Neeraj Sharma, "Investigation of Process Parameters Contribution and their Modeling in WEDM for D-2 Tool Steel Using ANOVA", Global Journal of Engineering, Design andTechnology, 2(3), pp. 41-46(2013),

[5] Kuriachen Basil, Josephkunju Paul and JeojuM.Issac, "Spark Gap Optimization of WEDM Process on Ti6Al4V", International Journal of Engineering Science and Innovative Technology (IJESIT) 2(1), pp. 364-369(2013).[6] C.D. Shah, J.R.Mevada and B.C.Khatri, "Optimization of Process Parameter ofWireElectrical Discharge Machine by Response Surface Methodology on Inconel-600", International Journal of Emerging Technology and Advanced Engineering, 3(4), pp. 2250- 2459(2013).

[7] Atul J Patel, Prof.Satyam P Patel, "Parametric Optimization of Wire Cut EDM Machine on Hard Steel Alloy with Multiple Quality Characteristics", 4(2), pp. 74-77(2013).

[8] GauravSachdeva, RavinderKhanna, ParveenYadav, Amit Nara and Narender Singh, "Experimental study of H-21 punching dies on wire-cut electric discharge machine using Taguchi's method", International Journal of Scientific & Engineering Research, 4(5),pp. 559- 567(2013).

[9] Ahmed Raza Khan, AdeelIkram, Nadeem Ahmad Mufti, Muhammad QaiserSaleem, "Parametric optimization for surface roughness, kerf and MRR in wire electrical discharge

machining (WEDM) using Taguchi design of experiment", Journal of Mechanical Science and Technology ,27 (7) , pp. 2133-2141, (2013)

[10]S.B. Prajapati and N. S. Patel, "Effect of Process Parameters on Performance Measures of Wire EDM for AISI A2 Tool Steel", International Journal of Computational Engineering Research, 03, pp. 274-278 (2013).

[11] K.P.Rajurkar, FarnazNourbakhsh, A.P.Malshe, Jian Cao, "Wire electro-discharge machining of titanium alloy", The Authors. Published by Elsevier B.V., pp. 2212-8271, (2013).

[12] C.Bhaskar Reddy, "Experimental Investigations on MRR and Surface Roughness of EN 19 & SS 420 Steels in Wire EDM Using Taguchi Method" International Journal of Engineering Science and Technology (IJEST), ISSN: 0975-5462, Vol. 4 No.11 (2012).

[13] S.Balasubramanian, Dr.S.Ganapathy, and "Grey Relational Analysis to determine optimum process parameters for Wire Electro Discharge Machining (WEDM)" International Journal of Engineering Science and Technology, ISSN: 0975-5462 Vol. 3 No. 1(2011).

[14] V. K. Pasam, S. B. Battula, P. M. Valli and M. Swapna, "Optimizing Surface Finish inWEDM Using the Taguchi Parameter Design Method", Journal of the Brazilian Society of Mechanical Science & Engineering, 32 (2), pp. 107-113(2010).

[15] Kuo-Wei Lin, Che-Chung Wang, "Optimizing Multiple Quality Characteristics of Wire Electrical Discharge Machining via Taguchi method-based Gray analysis for Magnesium Alloy" Journal of C.C.I.T., VOL.39, NO.1, May 2010.

[16] www.outokumpu.com.