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Optimization of Process Parameters of Wire-Cut Electric Discharge Machining of A356.2 Aluminum Alloy

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Abstract

This paper presents the damping behavior of A356.2 alloy after wire electric discharge machining. The experimental work is depicted on the basis of Taguchi orthogonal L9(3^3) array, considering three input variables i.e., pulse on time (T_{on}),Pulse off time(T_{off}), peak current (IP)at three different levels where as Damping is considered as the experimental responses. The experimental analysis of damping behavior of specimens at constant frequency(1-100 Hz) were carried out by using dynamic mechanical analyzer 8000 (D.M.A) .The micro structural changes on the surface of work material were examined by means of SEM analysis. The thickness of the white layer and the recast layer formation increases with increases in the pulse-on time duration and decreases with increase in pulse off time.

Keywords--- WEDM,A356.2 ,Damping, Taguchi.

1. Introduction

Damping is the dissipation of energy of material under cyclic load. It is a measure how well a material can get rid of energy and how good a material will be absorbing energy.D.S.Prasad et al [1] showed that the white layer has influence on damping capacity on metal matrix composite. Subrahmanyam and Sarcar [2] optimized the machining parameters for the machining of H13 HOT DIE STEEL of 5mm thickness, with multiple responses Material Removal Rate (MRR), surface roughness (Ra) based on the Grey–Taguchi Method. Abolfazl et al[3] Golshan et al studied, two parameters of surface roughness and volumetric material removal rate are optimized based on computational intelligence method. Vishal Parashar et.al [4] performed experiments onStainless Steel grade 304L of 10mm thickness by different parameters like gap voltage, pulse ON time, pulse OFF time, wire feed and dielectric flushingpressure.

and discussed the analysis of variance (ANOVA) and mathematically modelled by using the regression analysis method. .J. Prohaszka et al [5] in their paper they have discussed about effect of electrode material on machinability in wire electro-discharge machining that will lead to the improvement of WEDM performance. Experiments have been conducted regarding the choice of suitable wire electrode

Materials and the influence of the properties of these materials on the machinability in WEDM. Y. S. Tarng, et al, [6] used a neural network model to estimate to the effects of parameters on the surface roughness as the response variable and machining speed. S. S.Mahapatra et al [7]showed that the development of a model and its application to optimize WEDM machining parameters. The results of confirmation experiment agree well the predicted optimal settings as an error of 4.062 % is found with MRR. Similarly, an error of 1.53 % was observed for SF.Haddad and Tehrani [8] performed turning operations using L18 orthogonal array on DIN X210 Cr 12 steel &derived mathematical model for material removal rate determination and its effect on surface roughness and roundness of machined surface. The die rotational speed, power and pulse off time exhibit significant effect on material removal rate.

II. Experimental Details

Aluminum alloy A356.2 alloy is used for the present investigation, It possess properties such as high oxidation resistance, good thermal shock resistance etc. It has distinct advantages for applications involving car brakes, car clutches, ceramic plates in bullet proof vests, etc.Its chemical composition is given in the Table 1.

Table 1: Composition of A356.2 alloy

Si	Fe	Cu	Mn	Mg	Zn	Ni	Ti
6.5-7.5	0.15	0.03	0.10	0.4	0.07	0.05	0.1

The experimental work is carried out on Wire electric discharge machine ,the Zinc coated wire with a copper brass alloy is used as a tool .after machining the damping behavior of the machined specimens are measured As shown in fig 1. The process parameters such as Pulse on time (T_{on}),pulse off time (T_{off}), Peak current (IP) are considered as the Controllable input variables in the present study. A series of experiments are conducted on wire electric discharge machine (WEDM) as per the Taguchi's standard L9 Orthogonal Array. The selected process parameters with their levels are given in the Table-2

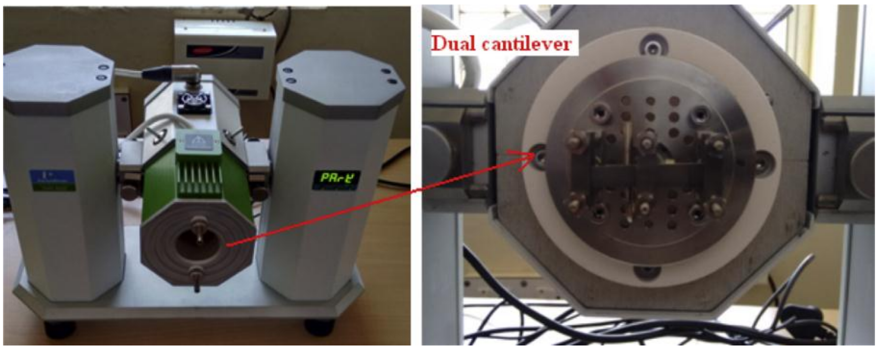

Fig 1. Dynamic Mechanical Analyzer

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Table 2: Design of Experiments

Levels	T_{on}(µsec)	T_{off}(µsec)	IP(A)
1	105	63	230
2	108	60	210
3	111	57	190

III. Results and Discussions

The experimental results of Damping Behavior are given in the Table 3 The single objective Taguchi method has been employed for the analysis of the results obtained.

Table 3: Experimental Results

S.no	T_{on}(µsec)	T_{off}(µsec)	Ip (A)	Damping
1	105	63	230	0.005000
2	105	60	210	0.006200
3	105	57	190	0.007500
4	108	63	210	0.009170
5	108	60	190	0.011358
6	108	57	230	0.012863
7	111	63	190	0.019863
8	111	60	230	0.025859
9	111	57	210	0.030433

The Taguchi result of Response table for means of Damping is given in the table 4.For the mean values obtained; the Main effect plot is drawn and shown in the figure 2. From the plot, it is observed that the damping value is increased gradually with an increase in the levels of the machining parameters and the main effect is observed due to the Pulse on time. The optimal combination of machining parameters is found at levels having high mean values i.e. T_{ON}111 –T_{OFF}57-IP 210.

Table 4: Response Table for Means of Damping

Level	T_{on} (µsec)	T_{off}(µsec)	IP (A)
1	0.006233	0.016932	0.012907
2	0.011130	0.014472	0.015268
3	0.025385	0.011344	0.014574
Delta	0.019152	0.005588	0.002361
Rank	1	2	3

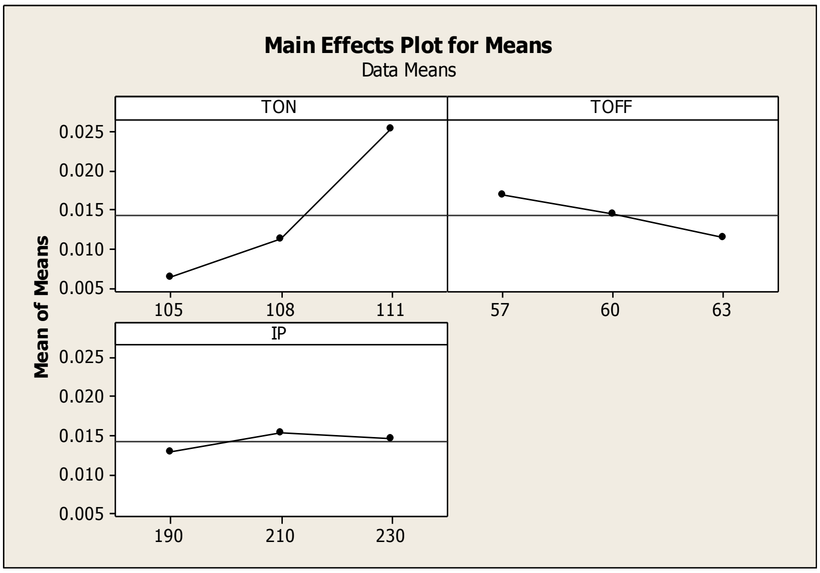

Fig 2: Main effects plot for means

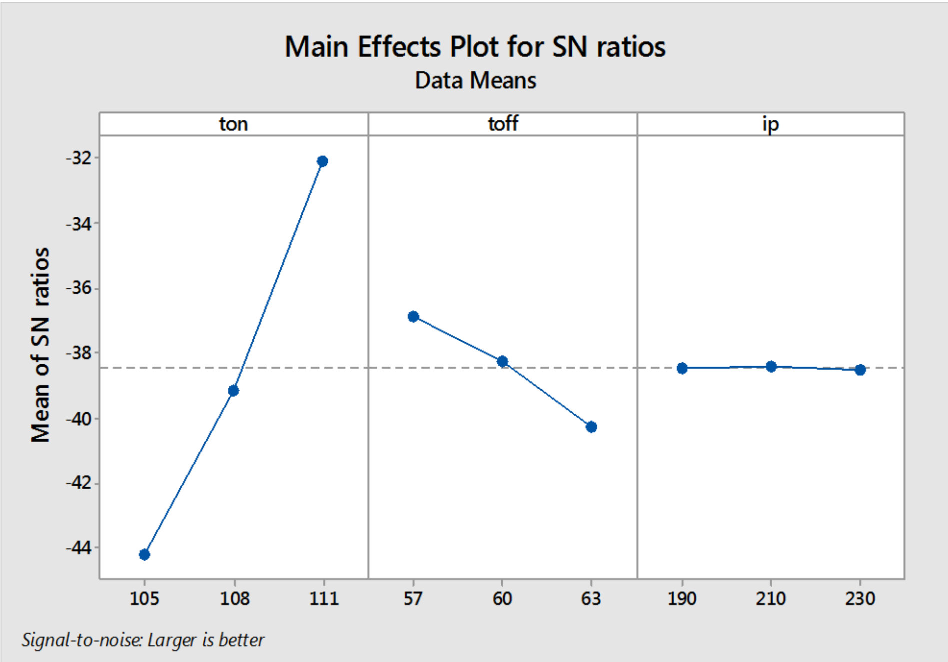

Fig 3: Main effects plot for S- N Ratio

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By using the s/n ratio the experimental data are analyzed. Based on the optimal parameters the maximum damping values are obtained and verified experimentally. Mathematically s/n ratio is can we written as

Higher-the-Better (HB): $\eta = -10\log10(Sum(1/Y**2/n)$

Where n is the mean square deviation for the output characteristic. Higher the better type of S/N ratio is in the analysis for better accuracy.

The analysis of the experiment data was carried out using MINITAB 15 software, which is used in the design of experiments (DOE) applications. The response data for signal to noise (S/N) ratio is shown in fig 2.The response data for mean damping capacity shown in Table 4 also arrived, giving the same results as S/N ratio results.

Pulse on time ($T_{on)}$	= 111
Pulse off time (T_{off})	=57
Peak current (IP)	= 210

IV. Mathematical Modeling

A mathematical model is developed for damping specimens of aluminum, A356.2 alloy and the overall equation is obtained using Regression analysis which is shown in equation 1

Damping = - 0.283 + T_{ON} (0.00319) - T_{OFF} (0.000931)- IP(0.000042) ………. (1)

The R square value 0.8757 is obtained. The value of R square is very near to the unity i.e. the relation between the Pulse on time, PulseOff Time and Peak Current ofWEDM calculated with maximum accuracy.

The R square value 0.8643 is obtained from regression analysis.

Finally scanning electron microscope (SEM) analysis is performed on the Damping Samples it is found that as the thickness of the white layer on the specimen increases the damping capacity decreases. Increase of the Pulse on time increases the Damping Capacity of specimen as the thickness of white layer decreases.

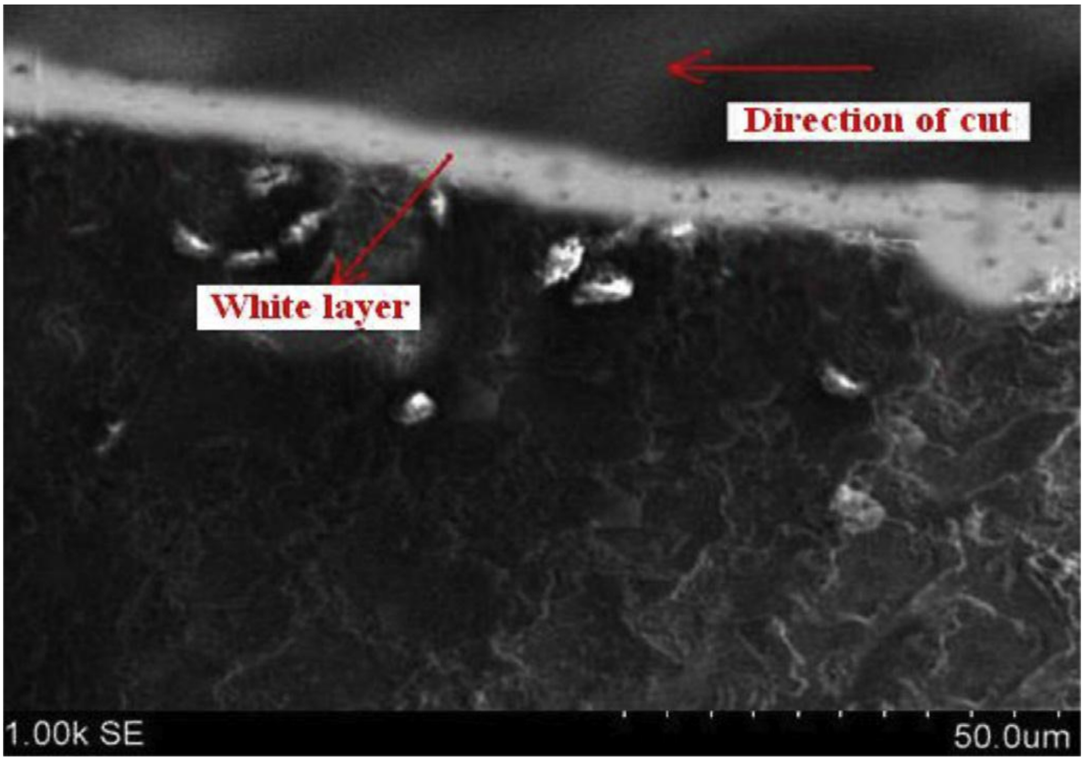

Fig. 4. Cross sectional SEM micrograph showing white layer at T_{ON} 111 µs, T_{OFF} 57 µs and IP 210 A.

V. Conclusion

From the experimental, Taguchi method the following conclusions are made

1. The optimal combination of process parameters of WEDM for maximum Damping is obtained at. Pulse on Time: level 3, 111 µm, Pulse off Time: level 1, 57 µm, Peak Current: level 2,210 A.
2. The increase of damping capacity is found which is due to the decrease of thickness of white layer on the Specimen.

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