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Experimental investigation for optimum process parameters on mrr and surface finish of titanium alloy grade 5 using wire cut edm machine

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ABSTRACT - Wire Electric Discharge Machining (WEDM) is one of the greatest innovations in the tooling and machining industry. This process has brought dramatic improvements in accuracy, quality, productivity and earnings. Before wire EDM, costly processes were often used to produce finished parts. Now with the aid of computer and wire EDM machines, extremely complicated shapes can be cut automatically, precisely and economically even in materials as hard as carbide. The selection of optimum machining parameters in WEDM is an important step. Improperly selected parameters may result in serious problems like short-circuiting of wire, wire breakage and work surface damage which is imposing certain limits on the production schedule and also reducing productivity. The objective of the present work is to investigate the effects of the various Wire cut EDM process parameters on the machining quality and obtain the optimal sets of process parameters so that the quality of machined parts can be optimized. Experiments will be conducted on the pieces by parameters. The material used for machining is Titanium alloy grade5. The process parameters considered will be Pulse Time on, Pulse Time off, Voltage, Input power are optimized to investigate their influence on material removal rate and Surface Roughness of Titanium alloy grade 5. The Machining process is carried out by L9 orthogonal array. Taguchi design analysis is employed to determine optimal combination of control parameters. The grey analysis is also applied to identify the optimal process parameters have been determined by the grey relational grade for multi performance characteristics that is MRR and surface roughness.

Key words: Wire cut EDM machine, Titanium alloy grade 5, MRR, Surface roughness, Taguchi analysis

I. INTRODUCTION

Wire Electric Discharge Machining (WEDM) is one of the greatest innovations in the tooling and machining industry. This process has brought dramatic improvements in accuracy, quality, productivity and earnings. Before wire EDM, costly processes were often used to produce finished parts. Now with the aid of computer and wire EDM machines, extremely complicated shapes can be cut automatically, precisely and economically even in materials as hard as carbide. The selection of optimum machining parameters in WEDM is an important step. Improperly selected parameters may result in serious problems like short-circuiting of wire, wire breakage and work surface damage which is imposing certain limits on the production schedule and also reducing productivity. The objective of the present work is to investigate the effects of the various Wire cut EDM process parameters on the machining quality and obtain the optimal

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Multi-response optimization The has been applied to identify the significance of developed model. The experiment results showed Surface Roughness ranged from 2.48µm to 2.62µm the minimum surface roughness was obtained from the results of ANOVA it has been obtained the most significant parameters with respect to response variables are Pulse on time, Pulse off time, Peak current and Spark gap voltage. Vamsi Krishna Pasam [2] in his work has studied the behavior of 8 control parameters such as Ignition pulse current, Short pulse duration, Time between two pulses, Servo speed, Servo reference, Voltage, Injection pressure, Wire speed and Wire tension on Wire cut EDM of Titanium alloy . Surface finish was studied using Taguchi parameter design an attempt made to optimize the surface roughness prediction model using Genetic Algorithm (GA), Surface roughness model with Regression analysis and the developed model is optimized by GA. Surface roughness of 1.85 µm is obtained. M.Manjaiah and S.Narendranath, S.Basavarajappa, VN.Gaitonde [3] had explored the effect of three process parameters such as Pulse on time, Pulse off time and Servo voltage in Wire cut EDM of Ti50 Ni40 Cu10 Shape memory alloy using Zinc coated Brass wire electrode on Material removal rate and Surface roughness using Response surface methodology (RSM) based mathematical model. The results which achieved are the Pulse on time and Pulse off time have greater interaction effects on the Surface roughness the Surface roughness increases with increased Pulse on time up to 126µs and there after it reduces the optimal pressure parameter setting was found to be 136 µs of Pulse on time, 48 µs of Pulse off time and 36.16 of SV achieve greater Material removal rate and Surface roughness. Danial Ghodsiyeh, Ali Davoudinejad, Mohammad Hassan Hashemzadeh, Navid Hosseininezhad and Abolfazl Golshan [4], There research aims to investigate the behavior of three control parameters according to Design of Experiment (DOE) method while WEDM of titanium alloy (Ti6Al4V) is being examined.

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The sample was cut by an electrode instrument made of brass wire of 0.25 mm diameter. Analysis of Variance (ANOVA) technique was used to find out the parameters affecting the Surface Roughness (SR), Material Removal Rate (MRR) and Sparking Gap (SG). Assumptions of ANOVA were discussed and carefully examined using analysis of residuals. This study has been established as a secondorder mathematical model based on the Response Surface Methodology (RSM) Several optimal conditions can be gotten from the analysis, including the multi-objectives condition which can be set by Pulse on time: 1.5 µs, pulse off time 4 µs, peak current: 4.5 A. The predicted result is sparking gap 0.00399 mm and surface roughness: 1.144 µm and material removal rate 0.0156 mm3/s. Nihat Tosun [5] In his study, variations of cutting performance with pulse time, open circuit voltage, wire speed and dielectric fluid pressure were experimentally investigated in Wire Electrical Discharge Machining (WEDM) process. Brass wire with 0.25 mm diameter and AISI 4140 steel with 10 mm thickness were used as tool and work materials in the experiments. The cutting performance outputs considered in this study were surface roughness and cutting speed. It is found experimentally that increasing pulse time, open circuit voltage, wire speed and dielectric fluid pressure increase the surface roughness and cutting speed. The variation of cutting speed and surface roughness with cutting parameters is modeled by using a regression analysis method. Then, for WEDM with multi-cutting performance outputs, an optimization work is performed using this mathematical models. In addition, the importance of the cutting parameters on the cutting performance outputs is determined by using the variance analysis (ANOVA). The results obtained are based on ANOVA method the effective parameters on cutting speed are Open circuit voltage, Pulse duration and Wire speed. The effective parameters on Surface roughness are Open circuit voltage and Pulse duration. Kannachai Kanlayasiri, Boonmung [6] DC53 is a new die steel, only little information is available in literature for its machining characteristics. This paper presents an investigation of the effects of machining variables on the surface roughness of wire-EDMed DC53 die steel. In this study, the machining variables investigated were pulsepeak current, pulse-on time, pulse-off time, and wire tension. Analysis of variance (ANOVA) technique was used to find out the variables affecting the surface roughness. Results from the analysis show that Pulse on time and Pulse peak current are significanr variables to thesurface roughness of Wire EDMed D(53) diesteel. The surface roughness of the test specimen increases when these two parameters increases. Lately, a mathematical model was developed using Multiple regression method to formulate the Pulse on time and Pulse peak current to the surface roughness the developed model was validated with a new set of experimental data, and the maximum prediction error of the model was less than7% A large number of studies were carried out on Abrasive water jet machining. Many researchers has done this Wire cut EDM machining on brittle material and some material like Inconel 718, 800H, D2 steel, glass/graphite/epoxy, cooper, composite

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materials and non ferrous metals. Some Rare researchers has done experimentation on Ti 6AL-4V alloy. Danial Ghodsiyeh, Ali Davoudinejad, Mohammad Hassan Hashemzadeh, Navid Hosseininezhad and Abolfazl Golshan has done research on Ti 6AL-4V considering three control parameters according to Design of Experiment (DOE) method, Analysis of Variance (ANOVA) technique was used to find out the parameters
affecting the Surface Roughness (SR), Material Removal Rate (MRR) and Sparking Gap (SG).

II. EXPERIMENTAL WORK

2.1 Materials In this experimental investigation, the work material Titanium alloy grade 5(Ti-6Al-4V) was used. Titanium alloy grade 5 is a Alpha and beta alloys, which are meta stable and generally include some combination of both alpha and beta stabilizers, and which can be heat treated. Titanium alloys are metals that contain a mixture of titanium and other chemical elements. Such alloys have very high tensile strength and toughness (even at extreme temperatures). They are light in weight, have extraordinary corrosion resistance and the ability to withstand extreme temperatures. However, the high cost of both raw materials and processing limit their use to military applications, aircraft, spacecraft, bicycles, medical devices, jewelry, highly stressed components such as connecting rods on expensive sports cars and some premium sports equipment and consumer electronics. However, these alloys are very difficult to machine by conventional methods because of the heterogeneous property of Titanium alloy structure and may cause discontinuity in the fibre.

Titanium (Ti)	90%
Aluminium(Al)	6%
Vanadium(V)	4%
Carbon (C)	<0.10%
Oxygen (O)	<0.20%
Nitrogen (N)	<0.05%
Hydrogen (H)	<0.0125%
Iron (Fe)	<0.3%

Table.2 Design structure of experiment of parameters and levels

S.No	Parameters	Levels		
1	Pulse on time(T_{on})(µsec)	110	113	116
2	Pulseoff time(T_{off}) (µsec)	59	61	63
3	Voltage	18	19	20
4	Input power	210	220	230

Fig.1 Wire cut EDM machine

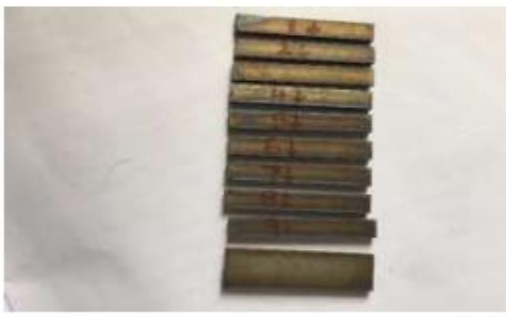

Fig 2. Titanium alloy cutting pieces

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III. RESULTS AND DISCUSSIONS

The following discussion focuses on the different process parameters to the observed values Metal Removal Rate, Surface Finish based on the Taguchi methodology. Once the series of experiments are completed, considering process parameters such as Pulse on time, Pulse off time, Voltage and Input power as input variables, the output characteristics such as metal removal rate, Surface roughness are recorded. The analysis of the each result obtained by Taguchi analysis. The results obtained from the experiments are discussed in table 2. The S/N ratio for the metal removal rate is considered with "Larger the Best" criteria and for surface finish "Smaller the Best" criteria is considered for optimization. Observed process parameter characteristics during machining are extracted and noted with respect to MRR and Surface roughness are represented in table 2.

Table 3. Response table for metal removal rate

Level	Pulse on time	Pulse off time	Voltage	Input power
1	-19.96	-19.79	-19.73	-19.59
2	-18.73	-19.45	-19.73	-19.66
3	-20.20	-19.65	-19.43	-19.69
Delta	1.48	0.34	0.31	0.15
Rank	1	2	3	4

Table.2 EXPERIMENTAL RESULTS

S NO	T on (µs)	T off (µs)	Voltage (V)	Input power (W)	Machining time (min)	Before weight (Wb) gm	After weight (Wa) gm	Material Removal Rate (MRR) (cm3/min)	Surface Roughness (µm)
1	110	59	18	210	17.13	71.52	64.055	0.0985	2.567
2	110	61	19	220	16.88	64.055	56.512	0.1010	2.434
3	110	63	20	230	16.43	56.512	49.105	0.1019	2.618
4	113	59	19	230	16.04	49.105	41.195	0.1113	2.295
5	113	61	20	210	14.08	41.195	33.582	0.1223	2.160
6	113	63	18	220	14.55	33.562	26.192	0.1138	2.246
7	116	59	20	220	17.56	26.192	18.592	0.0978	2.728
8	116	61	18	230	17.23	18.592	11.135	0.0979	2.693
9	116	63	19	210	16.24	11.135	4.15	0.0973	2.361

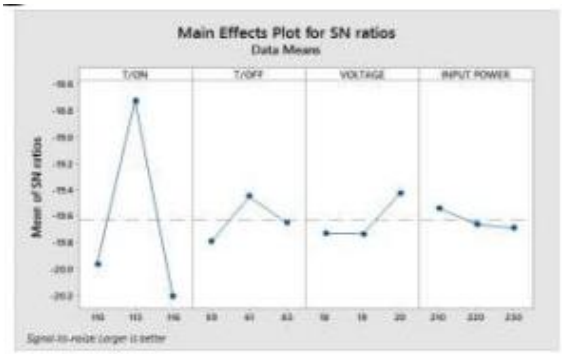

Fig 5. Effect of process parameters on MRR for S/N ratio

From the graph, we determine the optimum parameters.

T(ON) - 113 µs
T(OFF) - 61 µs
VOLTAGE – 20 V
INPUT POWER – 210 W

Table 4. Response table for surface roughness

Level	Pulse on time	Pulse off time	Voltage	Input power
1	-8.093	-8.091	-7.942	-7.448
2	-6.979	-7.675	-7.469	-7.824
3	-8.262	-7.618	-7.923	-8.061
Delta	1.283	0.423	0.474	0.613
Rank	1	4	3	2

The following Table 4 shows the effect of each process parameter on Surface roughness by using Taguchi method and the predicted values of Signal-to-Noise Ratio(S/N). It resulted by the Taguchi method that, the highest Signal-toNoise Ratio(S/N) value of the Pulse on time 1.283 yield good Surface roughness. The highest value of S/N resembles as a most significant parameter among the remaining values.

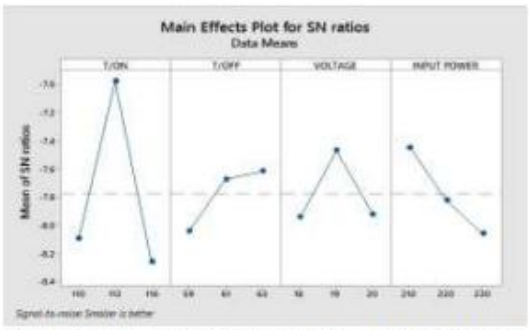

Fig 6. Effect of process parameters on Surface Roughness for S/N ratio

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IV.CONCLUSIONS

This paper presents the Optimization of process parameters namely Pulse on time, Pulse off time, Voltage and Input power in cutting of Titanium alloy grade 5. The Taguchi method is used to determine the wire cut EDM parameters with optimization of individual quality characteristics, is studied in this project. Then the optimal process parameters with less surface roughness and high MRR are obtained and these parameters are used for confirmation results. the optimum parameter combination to achieve high metal removal rate(MRR) are Pulse on time –113 µs, Pulse off time– 61 µs, Voltage– 20V and Input power- 210W and after confirmation test is done by using above combination parameters the optimum response value of MRR is 7.48 cm3 /min which is greater than the 7.34 cm3 /min and optimum parameter combination to achieve better Surface finish are Pulse on time –116 µs, Pulse off time– 59 µs, Voltage– 18V and Input power- 230W and after confirmation test is done by using optimum parametric combination the optimum response value of surface finish is 1.697µm. Pulse on time is the most influence parameter on MRR and surface finish.

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