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OPTIMIZATION OF MACHINING PARAMETERS ON WEDM FOR TITANIUM GRADE 2

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ABSTRACT

This paper presents an experimental investigation of wire electro-discharge machining (WEDM) of titanium. The objective is to investigate the effect of seven process parameters including pulse width, servo reference voltage, pulse current, and wire tension on process performance parameters. A Taguchi L16 design of experiment (DOE) has been applied. All experiments have been conducted using WEDM. It was also found that the cutting speed increases with peak current and pulse interval. Surface roughness was found to increase with pulse width and decrease with pulse interval. The *Analysis of Variance (ANOVA*) also indicated that voltage, injection pressure, wire feed rate and wire tension have non-significant effect on the cutting speed. WEDM is extensively used in tool and dieindustries. Precision and intricate Machining are the strengths. While machining time and surface quality stillremains as major challenges. The main objective of thisstudy is to obtain higher material removal rate (MRR) andlower surface roughness (SR). Ton, T off, Gap voltage and wire feed rate are the four control factors taken each at various levels. The taguchi optimization tool is used to find the factors level that create a low surface roughness in WEDM

I. INTRODUCTION

Accompanying the development of mechanical industry, the demands for alloy materials having high hardness,toughness and impact resistance are increasing. Wire EDM machines are used to cut conductive metals of any hardness or that are difficult or impossible to cut with traditional methods. The consistent quality of parts being machined in wire electrical discharge machining is difficult because the process parameters cannot be controlled effectively. These are the biggest challenges for the researchers and practicing engineers. Keeping in view the applications of materialtitanium, it has been selected and has been machined on wire-cut EDM. Wire cut electrical discharge machining (WEDM) or Electrical discharge wire cutting is a spark erosion process used to produce two and three dimensional complex shapes through electrically conductive work piecesIn WEDM process, a small diameter wire ranging from 0.05to 0.25mm is applied as the tool electrodeA DC power supply delivers high-frequency pulses of electricity to the wire and the workpiece. The gap between the wire and workpiece is flooded with deionized water which acts as the dielectric fluid in the machining process.

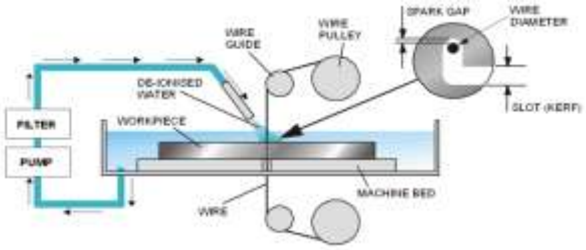


Fig. 1: Wire electrical discharge machining (WEDM)

II.MATERIAL SELECTION

Titanium is a metal with excellent corrosion resistance, fatigue resistance, a high strength-to -weight ratio that is maintained at elevatedtemperature. Titanium and its alloys are attractive and important materials in modern industry due to their unique properties that are mentioned [1,2]. Titanium is a very strong and light metal. Thisproperty causes that titanium has the highest strength-to-weight ratio in comparison the other metal that are studied to medical use. Titanium is also incredibly durable and long-lasting. When titanium cages, rods, plates and pins are inserted into the body, they can last for upwards of 20 years. Titanium non-ferromagnetic property is another benefit, which allows patients with titanium implants to be safely examined with MRIs and NMRIs [3,4,5].Titanium and its alloys are used in many different industries such as biomedicalapplications, automobile, aerospace, chemical field, electronic, gas and food industry [6].In recent decades, titanium is applied widely in biomedical and medical field because it is absolutely a proper joint with bone and other body tissue, immune from corrosion, strong, flexible and compatible with bone growth. Titanium is used in different medical applications such as dental implants, hip and knee replacement surgeries, external prostheses and surgical instruments [4,7,8].On the other hand, there is some limitation for titanium use because of its initial high cost, availability, inherent properties and manufacturability [9].Machining titanium and its alloys byconventional machining methods has somefacilities such as high cutting temperature and high tool wear ratio. Thus, titanium and its alloys are classified as’’difficult-to-machine” materials.Therefore,unconventional machining processes areintroduced for machining titanium and its alloys[2,6].

O max	Fe max	C max	N max	H max
0.25%	0.30%	0.08%	0.03%	0.015%

Table.1 Chemical composition of material

II.METHODOLOGY

a. Taguchi Method

Taguchi, a Japanese scientist, developed a technique based on Orthogonal Array of experiments theassimilation of DOE with parametric optimization of the process can be accomplished in the Taguchi method. An OA gives a set of well-balanced experiments, and Taguchi's signal-to-noise (S/N) ratio,that are logarithmic functions of the craved output, serve as an objective functions for optimization. It comforts to learn the whole parameter space with a small number (minimal experimental runs) of experiments. OA and S/N ratios are used to study the effects of control factors and noise factors and to determine the best quality characteristics for particular applications. The optimal process parameters obtained from the Taguchi method are insensitive to the variation of environmental conditions and other noise factors. However,Taguchi method was most suitable in the case
to optimize single performance characteristic.

3.1 signal-to-noise ratio (S/N ratio)

In the Taguchi method, the term "signal‟ denotes the desirable value (mean) for the output characteristic and the term "noise ‟represents the undesirable value (S.D)for the output characteristic. Therefore, the S/N ratio is the ratio of the mean to the S.D. S/Ratio is used to estimate the quality characteristic deviating from the desired value (8-9). The S/N ratio η is defined as

1 Larger the Better: S/N = -10 log (1/n)--------------------------(1)

2 Smaller the Better:

S/N = -10 log (1/n)----------------- (2)

Where n = no of repetition

3.2Material Removal Rate (MRR*)*

This is a production term usually measured in mm3/s. Increasing the MRR will obviously get a part done quicker, but increasing thematerial removal rate is often accompanied by increases in tool wear, poor surface finishes. The material MRR is expressed as theratio of the difference of weight of the work piece before and after machining to the machining time and density of the material. Therefore, the MRR
for the WEDM operation is calculated asMRR=kerf width X thickness of the work piece X machine speed

3.3Surface Roughness measurement

The surface roughness is measured using the surface tester SE-1200 measures roughness and evaluate parameters according to the following standards: ISO 4287, ISO 12085 (MOTIF or CNOMO), DIN, ASME, and JIS. There are two storing modes available in surfcorder, they are Memo and statistics. With the Memo mode the measurements are stored, in order to display and/or print them. With the Statistics the measurements stored on a maximum of 12 parameters to perform variousstatisticalanalysison graphs and histograms can be displayed or printed out. Initially the job whose surface roughness has to be tested is mounted on the V-block and then a motorized arm which holds the stylus moves along the vertical column. And finally as the stylus comes in contact with the surface of the job. The high resolute printer will provide the details about the surface roughness in a printed form.

IV.Experimental Details

The experiments were planned according to Taguchi's L16 orthogonal array [10]. The experiments were carried out on ELEKTRA SPRINTCUT 734 four axis wire cut EDM machine. The basic parts of the WEDM machine consists of a wire Electrode, a work table, and a servo control system, a power supply and dielectric supplysystem. The following Fig shows the

ELEKTRA SPRINTCUT 734 of wire EDM

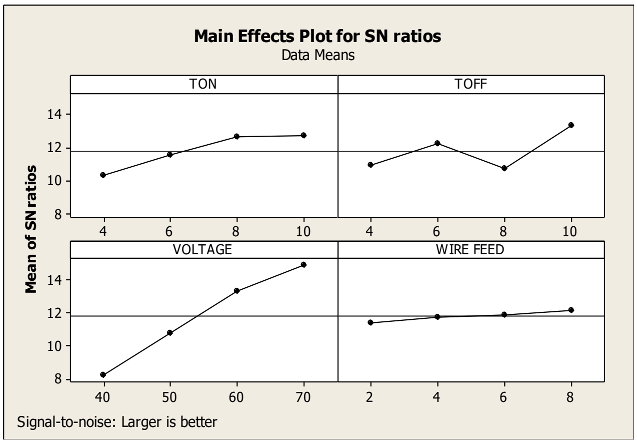
Fig.2 CNC Wire cut EDM is used for experimentation

Control parameters	units	Symbol
Pulse on	µs	A
Pulse off	µs	B
Peak current	Amperes	C
Wire tension	Kg-f	D
Servo voltage	volts	E
Servo feed	mm/min	F

TABLE.2:Process parameters of ELECTRONICA SPRINT CUT 734 CNC WEDM

S.N O	T on	T off	Voltage	Wire feed	Current	Machine speed	Time	Kerf width	Ra	MRR	S/N ratio (RA)	S/N ratio (MRR)
1	4	10	40	2	1.5	0.8	14:14:98	0.318	2.201	2.544	-6.852	8.110
2	4	8	50	4	1.1	1	17:29:51	0.329	1.909	3.296	-5.616	10.344
3	4	6	60	6	1.2	1	17:50:12	0.331	2.262	3.310	-7.090	10.397
4	4	4	70	8	1	1.2	23:51:76	0.348	1.886	4.176	-5.511	12.415
5	6	10	50	6	1.7	1.2	13:31:50	0.317	2.797	3.804	-8.934	11.605
6	6	8	40	8	1.9	0.8	10:40:00	0.326	2.373	2.608	-7.506	8.326
7	6	6	70	2	1	1.5	20:21:84	0.328	2.094	4.920	-6.420	13.839
8	6	4	60	4	1.5	1.3	13:41:16	0.319	2.090	4.147	-6.403	12.355
9	8	10	60	8	1.2	2.2	16:37:02	0.312	2.200	6.864	-6.848	16.732
10	8	8	70	6	1.1	2.1	19:54:61	0.313	2.181	6.573	-6.773	16.355
11	8	6	40	4	2	0.8	08:34:03	0.299	2.628	2.342	-8.393	7.575
12	8	4	50	2	2	1	08:28:16	0.313	2.589	3.130	-8.263	9.911
13	10	10	70	4	1.1	2.1	18:40:94	0.332	2.373	6.973	-7.506	16.867
14	10	8	60	2	1.5	1.6	13:43:67	0.304	2.375	4.864	-7.513	13.740
15	10	6	50	8	1.9	1.2	09:39:16	0.302	2.716	3.624	-8.679	11.184
16	10	4	40	6	2.1	0.9	09:01:16	0.315	2.789	2.835	-8.909	9.051

TABLE 3: Experimental results of output parameter



V.Main Effects Plot for SN ratios MRR

Main Effects Plot for SN ratios SR

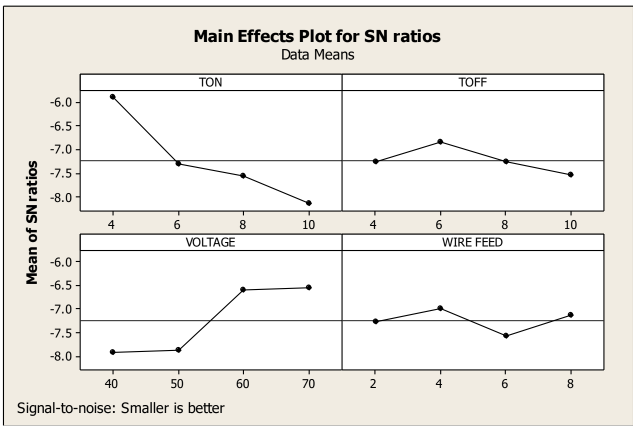


TABLE .4 ANOVA (MRR)

Source	DF	SS	MS	F	P	P%
IP	1	218.91	218.91	136.64	0	48.33
Ton	2	161.63	80.81	50.45	0	34.23
T off	2	1.27	0.63	0.4	0.68	….
SV	2	9.89	4.94	3.09	0.12	1.48
WF	2	1.76	0.88	0.55	0.60	….
IP*Ton	2	46.55	23.27	14.53	0.005	9.64
Error	6	9.61	1.60			5.41
Total	17	449.65				100

TABLE.5ANOVA (SR)

Source	DF	SS	MS	F	P	P%
IP	1	32.85	32.85	98.14	0	45.13
Ton	2	16.15	8.07	24.13	0.001	21.50
T off	2	0.40	0.20	0.61	0.574	….
SV	2	16.40	8.20	24.51	0.001	21.84
WF	2	0.38	0.19	0.58	0.589	….
IP*Ton	2	3.82	1.91	5.71	0.041	4.37
Error	6	2.00	0.33			7.16
Total	17	72.04				100

VI.CONFIRMATION EXPERIMENT:

The confirmation experiment is the final step in any design of experiment process. comparison of the predicted value with the new experimental value for the selected combinations of the machining parameters., the experimental values agree reasonably well with predictions because an error is for the S/N ratio of MRR and 16.867mm3/minfor the S/N ratio of surface roughness and 2.373µm.The experimental result confirms the optimization of the machining parameters using orthogonal array method using S/N Ratio for enhancing the machining performance.

VII.CONCLUSION

In this research, three different analyses are employed to obtain the following goals. Evaluating the effects on machining parameters on volume material removal rate, evaluating the effects on machining parameters on surface roughness and presenting the optimal machining conditions. Taguchi Analysis determines the factors which have significant impact on volume material removal rate. Equations which correlate machining parameters with material removal rate and the optimal setting is found by the S/N ratio analysis. Further research might attempt to consider the other performance criteria, such kerf, surface roughness, dimensional error as output parameters. This technique can also be applied for the various conventional machining operations and for machining of advanced materials like to improve the performance characteristics simultaneously. The present work was carried out by Taguchi analysis; further this work can be extended by considering any combination of fuzzy control, Grey relational analysis with Taguchi's orthogonal array technique, response surface methodology techniques.

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