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Effect of Wire Cut EDM Parameters on Material Removal Rate

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Abstract: *Wire cut EDM is an advance fabrication process of contouring intricate shapes from bulk material. Wire EDM provides high surface finish with hard to cut new materials. The existing works deals with the optimization of process parameters while machining Titanium Alloy (6Al-4V) on Wire cut EDM. Titanium alloy is used in dental implant and other surgeries related to bones due to its excellent biocompatibility. Wire EDM an unconventional way of non contact machining is very useful to fabricate miniature size components. In order to predefine the values of parameters which have dominance over output parameter .the impact of input and output parameters is found with the help of MINITAB software Input parameters considered were Peak current, Pulse on time, Pulse off time and Wire speed and output Parameter is Material removal rate.*

Keywords -Wire EDM, pulse on time (T_{ON}) , pulse off time (T_{OFF}) and Material removal rate(MRR) MINITAB.

1. Introduction

Wire was developed in 1960s to cut tool dies, extrusion dies of good accuracy and tolerance. Wire EDM is an unusual non contact process for metal removal. In Wire Cut EDM the metal is cut by thermal heat of the spark In this system wire acts as electrode which moves uninterruptly through the workpiece. Generally wire diameter ranges from 0.25-0.3 mm. WEDM provides effective solution to fabrication new materials having high strength at elevated temperature. The materials of space application such as titanium, cemented carbides, conduct ceramics can be cut very easily with the help of wire EDM .This process has good capability to cut intricate shapes and sizes with a very low value of surface roughness.

The mechanism of material removal is formation of plasma channel between the wire electrode and the workpiece formed due to the dielectric breakdown of the dielectric. As the interelectrode gap reduces to about 0.2mm spark occurs and a high temperature of about 8000-10,000 ◌̊C. Huge amount temperature and pressure causes melting of metal. The debris is carried away by the dielectric fluid (deionised water). The wire electrode also is set in motion to ensure that the wire rupture does not occur. The path of wire is operated by CNC controller in manner as shape required to be cut. The wire is continuously changed with every time spark occurring on fresh piece of wire. The dielectric fluid used wire EDM is deionised water.

Wire EDM machine consists of power supply system, dielectric flow system, wire drive system and positioning system. Besides the common factors Tension of wire is an significant parameter in material removal If the wire tension is high enough the wire stays straight otherwise wire drags behind. This helps to keep the wire free from vibration. It is because if there is improper tension, it will produce vibration in the wire, which will further lead to in accuracy of the process. The wire is kept intact in one position with help of rolls. Nihat Tosun et.al [1] investigated on the effect of machining parameters on the kerf width and material removal rate (MRR) in wire electrical discharge machining (WEDM) operations. The experiments were conducted under varying pulse time, circuit voltage, wire travel speed and dielectric flushing pressure. Hewidy et al [2] developed mathematical models to find interrelationship among various WEDM machining parameters peak current, duty factor, wire tension and dielectric pressure with metal removal rate. Mahapatra [3] studied the relationships between various control factors and responses like MRR, SF and kerf by means of nonlinear regression analysis, resulting in a valid mathematical model.Singh H. et.al [4] investigated the effect of different process parameters of WEDM on material removal rate. Different process parameters such as pulse on time T_{ON}, pulse off time, gap voltage, peak current, wire feed rate and wire tension were taken into account. Rao M.S. et.al [5] reviewed the impact of Wire EDM process parameters on output parameters and the various optimization methods applied by the researchers and outlined the future trends in WEDM research. Sivakiran S. et.al [4] studied the effect

of machining parameters such as pulse on time, pulse off time, bed speed and current on material removal rate in WEDM using EN 31 tool steel. Linear regression was used to develop the relationship between control parameters and output parameters. Was used for the experiment.

2. Design of Experiments

The method of design of experiment is necessary to remove the degree of biasness encounter while performing the experiment. The theory of design experiments was first proposed by Ronald Fisher in his book the arrangement of field experiment and Design of experiments. This systematic way of doing experiments makes easy to analyse the effect of input parameters on the output parameters. In this experiment we are using Taguchi based orthogonal array L27.Three levels have been specified for conducting experiment with the total number of process parameters Pulse on time pulse off time and pulse current. By Taguchi orthogonal array 3^3=27 number of experiments.

Table 1 Levels of process parameters

Factors	Parameters	Level 1	Level 2	Level 3
A	T_{ON}	15 µs	30 µs	60 µs
B	T_{OFF}	15 µs	45 µs	90 µs
C	IP	3A	6 A	9A

3. Experimental Setup

The experiment were conducted on conventional EDM machine with a setup of wire electrode. EDM oil kerosene was used as dielectric. The EDM machine is sparkonix. The material used for machining is titanium alloy (grade 5 6Al - 4V) which is biocompatible material. All the experiment were done for time duration of 15 minutes. The workpiece was weighed before machining and after machining to determine the material removal rate. The wire electrode is made of zinc coated brass of diameter 0.25 mm Work piece material composition the workpice material considered is Titanium alloy of grade 5. The dielectric used is kerosene oil. The dimension of specimen is 15mm10×mm×5mm.

Table 2 Material Composition

S.no	Element	Percentage Composition
1.	Titanium	90
2.	Aluminium	6
3.	Vanadium	4
4.	Iron	0.25
5.	Oxygen	0.2

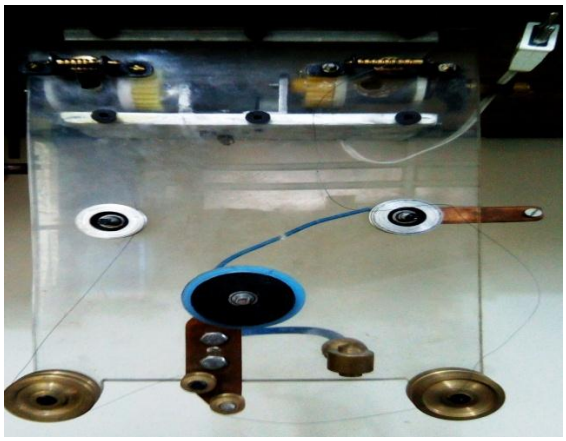

Fig.1 Wire EDM setup

4. Experimental Data

Table 3. Experimental Data

Sr. No.	Time (min)	Current (A)	Pulse on time T_{ON}	Pulse off Time(µs) T_{OFF}	MRR mg/min)
1	15	9	30	15	0.733
2	15	3	30	45	0.333
3	15	6	15	15	0.466
4	15	6	15	90	0.333
5	15	6	15	15	0.333
6	15	3	60	45	0.333
7	15	9	15	90	0.4
8	15	9	30	90	0.533
9	15	9	60	45	0.2
10	15	6	30	90	0.333
11	15	9	15	90	0.533
12	15	3	60	90	0.333
13	15	9	15	15	0.4
14	15	6	60	45	0.6
15	15	9	15	15	0.533
16	15	3	30	45	0.466
17	15	3	15	45	0.466
18	15	3	60	15	0.4
19	15	3	30	90	0.466

20	15	9	60	90	0.733
21	15	6	15	90	0.666
22	15	3	30	90	0.333
23	15	3	60	45	0.133
24	15	3	60	90	0.333
25	15	6	15	45	0.466
26	15	9	30	15	0.6
27	15	6	60	90	0.466

5. Results

The experimental data was fed to MINITAB statistical software to plot the effect of various parameters on material removal Rate. The experiments are based on one factor experiment strategy. In this only one input parameter was varied while keeping all others input parameters at constant values.

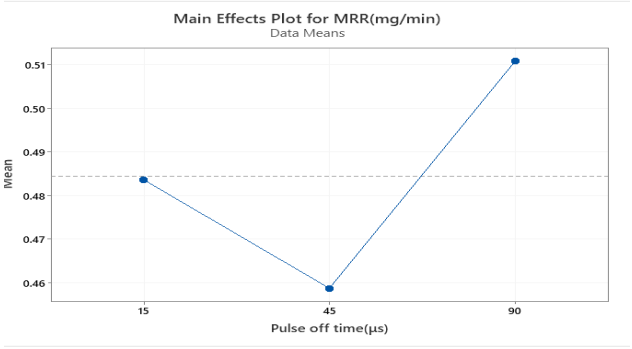

Chart 1 Effect of T_{ON} on MRR

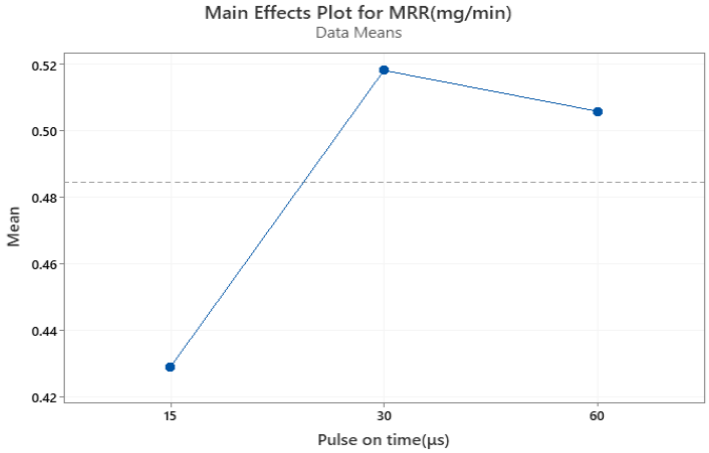

Chart 2 Effect of T_{OFF} on MRR

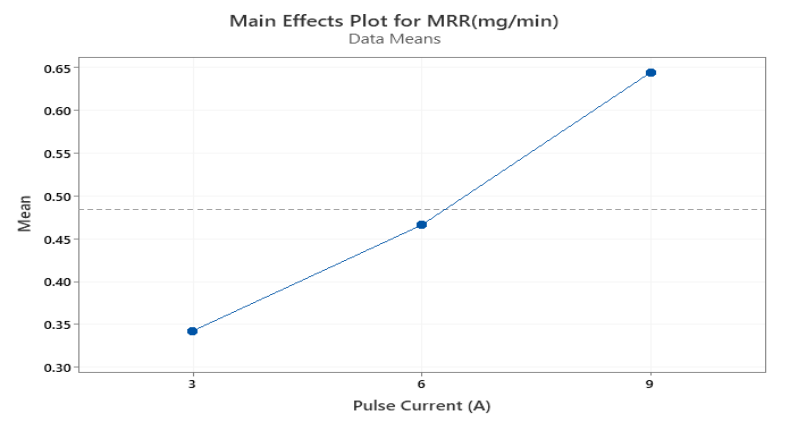

Chart 3 Effect of $_{Pulse}$ current on MRR

6. Conclusion

As seen from trend of graphs obtained for mean of MRR the direct effecting parameter is the Pulse current. As the input current rises the MRR due to the more heat encountered at high current. More heat generated due to high current can cause wire rupture. The pulse on time is the time during which spark occurs. Increasing on tine increases material removal rate. But some decrease is observed due to wire vibration and bubble formation. This graph depicts the same up to some extent after it stats declining due the lower off time available for material removal. The off time increment has a negative impact on material removal rate but wire vibrations are also reduced.

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