Parametric Optimization Of Graphite Plate By WEDM

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Abstract- *Wire electrical discharge machining is an emerging technology in the area of machining to very complex micro products. WEDM is a completely complex technique regarding the distinct method. Experimental investigation has been carried out in multi process micro EDM machine. WEDM technique is a highly complex, time varying & stochastic system, which is used in the fields of dies, molds, precision manufacturing and contour cutting etc. It is especially used for the aerospace and medical industries. The complex shape can be generated with high degree of accuracy and surface finish using CNC WEDM. Hence suitable selection of input variable for the WEDM process depends heavily on the operator's technology & experience. In this present study the work piece of graphite plate is used. The Brass wire of 0.25mm diameter is used as a tool and distilled water is used as dielectric. The experimentation was planned as per Taguchi's L9 Orthogonal array for machining of graphite material. For each experiment surface roughness and MRR is determined by using contact type surface coder and display screen of machine directly.*

Keywords- WEDM, MRR, SR, RA, T ON, T OFF

I. INTRODUCTION

The Wire electrical discharge machining is one of the important non-traditional machining processes. There are various materials having high hardness that can be easily machined by generating sparks at every few microseconds. There is sparking mechanism which generates the spark between wire electrode and work piece, where the temperature reaches to about 12,000°C. The dielectric fluid acts as medium for passing of spark current from electrode to the work piece. Typically the gap between wire and work piece for WEDM varies from 0.025 to 0.05 mm and this gap is constantly monitored by a computer controlled system. Now days the numerical control is mainly used according to the customer requirement for machining. It is widely used in the aerospace and automotive industries. However, the selection of cutting parameters for obtaining higher cutting efficiency or accuracy in wire EDM is still not widely focused, even with the most up-to date CNC WEDM machine. The main aim to optimize the process parameter is to overcome irregularities and to achieve the surface roughness and metal removal rate.

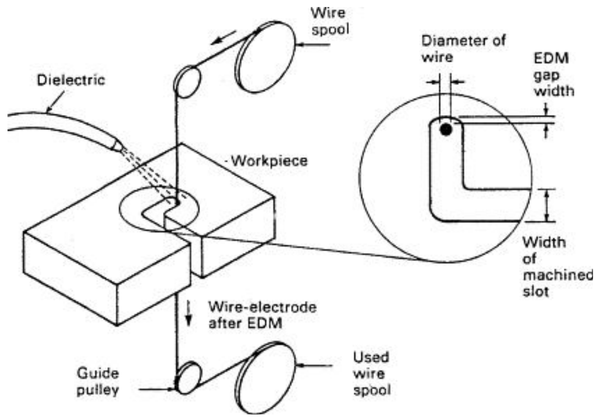

Fig -1: Schematic diagram of WEDM

II. LITERATURE REVIEW

Kannachai Kanlayasiri et. al. [1] has studied on composite material of wire EDM K460 tool steel. Investigation of cutting variables cutting speed, peak current and offset distance is encompassed. Box–Behnken design was employed as the experimental strategy, and multiple response optimization on dimensional accuracy and surface roughness was performed using the desirability function. Results shows that both peak current and offset distance have a significant effect on the dimension of the specimen while peak current alone affects the surface roughness. They have used chemical composition of K 460 tool steel (C -0.55, Cr-0.55, W- 0.55, Si-0.25, Mn-1.10, V-0.10, and Fe- Remains). The study was performed on trim cut 3, which was the finishing cut of wire-EDM process of the die-making for manufacturing moving parts of the watch of a watch manufacturer. In the trim cut 3, only three controlled variables were available on the machine controller to be varied, i.e., cutting speed, peak current, and offset distance.

Ali Vazini Shayan and Reza Teimourib [2] have studied on dry wire EDM (WEDM) process of cemented tungsten carbide. Experiments have been conducted using air as dielectric medium to investigate effects of pulse on time, pulse off time; gap set voltage, discharge current and wire tension on cutting velocity (CV) surface roughness (SR) and oversize (OS). Firstly, a series of exploratory experiments were carried out to identify appropriate gas and its pressure. Afterward, preliminary experiments were conducted to investigate effects of process parameters on dry WEDM characteristics and find appropriate ranges for each factor. Then a central composite rotatable method was employed to design experiments based on response surface methodology (RSM). Empirical models were developed to create relationships between process factors and responses by considering to analysis of variances (ANOVA). The cemented tungsten carbide is a hard and tough composite with noticeable wear resistance that satisfies growing demands of material with higher mechanical properties and lower weight. Due to high wear resistance and hardness of this material, it cannot be machine with conventional machining process. Among non-conventional machining methods wire electrical discharge machining process (WEDM) is a potential electro-thermal process, which is useful for machining such difficult-to-cut electrically conductive materials. The material removal mechanism of WEDM process is really like to die sinking EDM process with a little difference in tool electrode shape.

K. Shivkumar et. al. [**3**] have studied on experimental investigation and parameter optimization of near-dry wire-cut electrical discharge machining using multi-objective evolutionary algorithm. It was focus on the non-polluting ways to cut the materials and to meet the technical requirements like high material removal rate (MRR) and low surface roughness (Ra). In the near-dry WEDM, the finite discrete periodic series sparks between the wire electrode and conducting work material separated by minimum quantity of deionized water mixed with compressed air (air-mist) as a dielectric medium. In the present research, parametric analysis of the process has been performed with the molybdenum wire tool and high speed steel (HSS-M2) work piece. Experiments have been performed using air-mist as the dielectric medium to study the impact of gap voltage, pulse-on time, pulse-off time, air mist pressure and discharge current on the MRR and Ra using the mixed orthogonal (L18) array-Taguchi method. Taguchi based analysis of variance test was performed to identify the significant parameters. The gap voltage, pulse-on time, discharge current and air-mist pressure were found to have momentous effects on MRR and Ra. The best regression models For MRR and Ra have been developed by regression analysis. The optimal rough and finish cutting parameters have been predicted by Pareto-front using the multi-objective evolutionary. Experiments have been conducted on computer aided automatic three axis fuzzy controlled CNC-E3-MCJ Wire-cut EDM machine. The hydro-pneumatic circuit has been developed for the near-dry WEDM. It is made by a fluid tank, bi-axial hoses, a nozzle, flow control valves and the pressure gauges. Mixing of a minimum quantity of liquid mixed with the compressed air (air-mist) has been accomplished by this circuit. The mixing of compressed air with demineralised water is a dielectric medium and its temperature has been maintained as 7 °C at the nozzle outlet. The digital thermometer is used to ensure the outlet temperature of the air-mist at the nozzle outlet and is maintained.

Imtiaz Ali Khan and Tikam Singh Rajput et.al. [**4]** have studied on Modelling of Wire Electrical Discharge Machining of Alloy Steel (HCHCr) This study provides predictive models for the functional relationship between input and output variables of wire cut electrical discharge machine (WEDM) environment using alloy steel (HCHCr). Multi- objective optimization of the process parametric combinations is attempted by modelling WEDM process by use of artificial neural networks (ANN). This work provide an optimized Input data set to WEDM system and the results show improvement with better productivity, reduced cutting time and product cost at the cutting speed and surface finish. At experimental result, the surface quality decreases as cutting speed increases and 1.371 mm/min becomes the maximum cutting speed obtained with good surface finish of 0.387 micron. In this work single pass cutting of alloy steel (HCHCr) was considered where cutting speed and surface finish were of prime importance. The WEDM process generally consists of several stages i.e. a rough-cut stage, a rough-cut with finishing stage and a finishing stage. During rough-cut and finishing phase, the cutting speed and surface finish both are of primary importance. This indicates that rough cut with finishing phase is the most challenging one because both have to be considered simultaneously. Hence, rough-cut with finishing phase machining environment was explored in this work.

Anish Kumar Rana et. al. [5] have investigated Output parameter which is to be optimized is the dimensional deviation and input parameters are wire feed, pulse off time and servo voltage. Taguchi method was used to optimize the parameter. 'L18' orthogonal array was used for statistical analysis. Increasing the wire feed rate decreases the dimensional deviation. Increasing the pulse off time initially, dimensional deviation increases and further, it decreases. Increasing servo voltage decreases dimensional deviation. Among the three parameters, servo voltage has the greatest effect on dimensional deviation and is followed by pulse off time, and wire feed rate.

III. EXPERIMENTAL DETAILS

A WEDM machine, developed by ITRI (Industrial Technology Research Institute) and CHMER company Taiwan, is used for the experiment. The graphite Work-piece specimens having thickness 6 mm and square pieces of 10 mm a side were cut by WEDM using Brass wire. WEDM machine used for experiments is electronic sprint cut; It is incorporated with a coordinate worktable, wire running system, wire frame, Microcomputer based control cabinet and dielectric supply system.

Fig -2: WEDM Machine

Brass wire is used to perform cutting operation and wire is wound and stored on a wire drum, which can rotate at a speed of 1500 rpm. Guide pulleys are mounted on a wire frame and wire can run through these guide pulleys at a speed of 11 m/sec in reversible directions alternatively.

The Work piece is mounted on the worktable with the help of clamps and bolts and the micro controller delivers the pulse signals to the servomotors, which rotates accordingly, and through the variable gears, lead screws and nut**.** In WEDM, the electrode is a constantly transferring wire and the superb electrode is the work piece. The sparks will generate among carefully spaced electrodes below the effect of a dielectric liquid. Water issued as dielectric in WEDM, because of its low viscosity and speedy cooling.

Four control factors were chosen at three levels-

I. Current, Pulse on time, Pulse off time, Wire Tension.
II. Two response parameters were measured.
III. Surface Roughness and MRR.

The work material specification, electrode, and the other machining conditions are taken as follow.

Table -1: Specification of WEDM

work piece (anode)	Graphite Plate
electrode (cathode)	00.25 mm brass wire
Dielectric fluid	Distilled water
X,Y axis mm	400×300
U,V,Z TRAVEL	60×60×220
maximum size of work piece (W×D×H)mm	720×600×215
Motor	AC servo motor
wire dia. Mm	0.15- 0.3
Max. wire feed	300
wire tension (gm)	300-2500

Table -2: WEDM process parameters and their levels

Process Parameter	Units	Level
Current	A	5,10,15
Ton	µs	3,5,7
T off	µs	20,25,30
Wire tension	GM	8,10,12

Table -3: L9 array table for DOE based on Taguchi method

No. of runs	Current(a)	T on	T off	Wire Tension
1	5	3	20	8
2	5	5	25	10
3	5	7	30	12
4	10	3	20	12
5	10	5	25	10
6	10	7	30	8
7	15	3	20	8
8	15	5	25	12
9	15	7	30	10

IV. EXPERIMENTATION

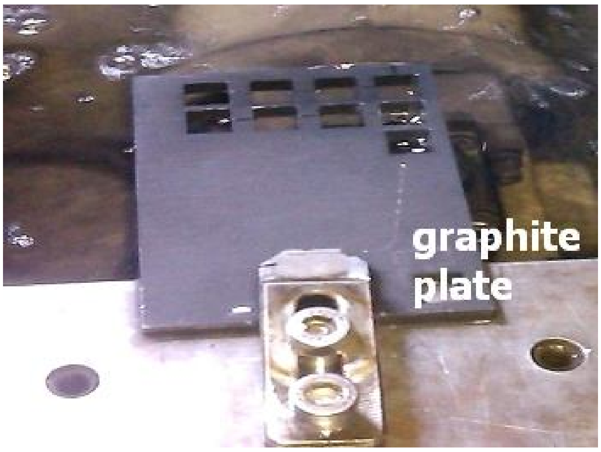

Fig -3: The cutting of graphite plate by WEDM

The wire is continually being feed vertically through the work piece while the work piece is moved along a horizontal plane. The resultant motion along this horizontal plane cuts a slot through the work piece that is slightly larger than the diameter of the wire. Wire is typically perpendicular to the surface of the work piece, except when tapers are being machined in which case the wire can pass through the material at an angle of up to 30°c. Orthogonal arrays are special standard experimental design that requires only small number of experimental trials to find the main factor an effect on output. According to the Taguchi design method L9 Orthogonal array was chosen for the optimization of the process.

Wire selection depends on the properties of work piece material, however, an ideal wire electrode should possess following characteristics, i.e. High electrical conductivity, sufficient mechanical strength (tensile strength, elongation etc.) Orthogonal arrays are special standard experimental design that requires only a small number of experimental trials to find the main factor effects on output. Before selecting an orthogonal array, the minimum number of experiments to be conducted shall be fixed which is given by:

Taguchi = 1+ NV (L – 1)

Where,

N Taguchi = Number of experiments to be conducted,
NV = Number of variables = Number of levels.

In this way, the experimental array is prepared using Minitab software. MINITAB is a powerful statistical software package used in the areas of mathematics, statistics, economics, sports, and engineering. It is highly interactive software, which makes entering data, conducting a regression analysis. ANOVA analysis, designing experiments using DOE, performing Taguchi analysis, drawing control charts for processes, performing reliability/survival tests, multivariate tests, plotting time series plots, etc. very easy and time-saving. It is the best tool for data have driven quality improvement programs.

The material selected for this dissertation work is graphite. It has High electrical conductivity, sufficient mechanical strength (tensile strength, elongation etc.) Therefore, I have decided to take a graphite plate. Graphite archaically referred to as plumb ago, is a crystalline allotrope.

The name of graphite fibers is sometimes used to refer to carbon fiber or carbon fiber- reinforced polymer.

V. TAGUCHI METHOD

Taguchi method uses a special design of orthogonal array to study the entire parameter space with only a small number of experiments. The experimental results are then transformed into a signal to noise ratio(S/N) ratio. The S/N ratio can be used to measure the deviation of the performance characteristics from the desired value. The lower the better, the higher the better, and the nominal the better. The S/N ratios and loss function confound location (mean) and dispersion (variance) effects.

Following mean Signal/Noise ratio graphs are obtained for different process parameters using MINITAB software.

Table -4: Measurement of Response

Sr.No.	Current	Ton	T off	wire tension	MRR	Surface roughness
1	5	3	20	8	5.475	0.194
2	5	5	25	10	6.78	0.148
3	5	7	30	12	7.183	0.107
4	10	3	20	12	9.794	0.140
5	10	5	25	10	7.966	0.153
6	10	7	30	8	4.853	0.191
7	15	3	20	8	6.381	0.149
8	15	5	25	12	7.246	0.187
9	15	7	30	10	7.335	0.122

VI. RESULT AND DISCUSSION

The Signal/Noise ratio graphs are obtained for different process parameters using MINITAB software.

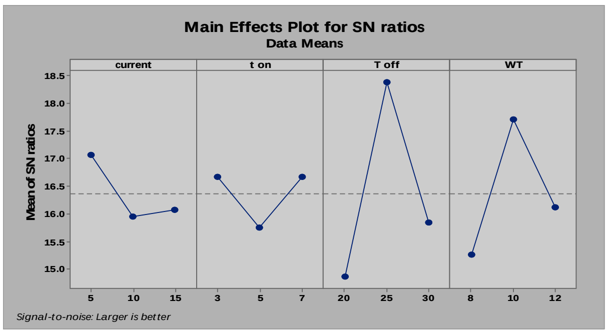

Fig -4: Graph of Main effect plot for Machining Speed

Figure 4, Pulse on time indicated the effect on Machining Speed its decreases from 3 to5, again increase from 5 to 7.The pulse off time increase from 20 to 25, machining speed increase again decrease from 25-30. The wire tension from the graph 4, we get the optimum value by selecting highest S/N ratio.

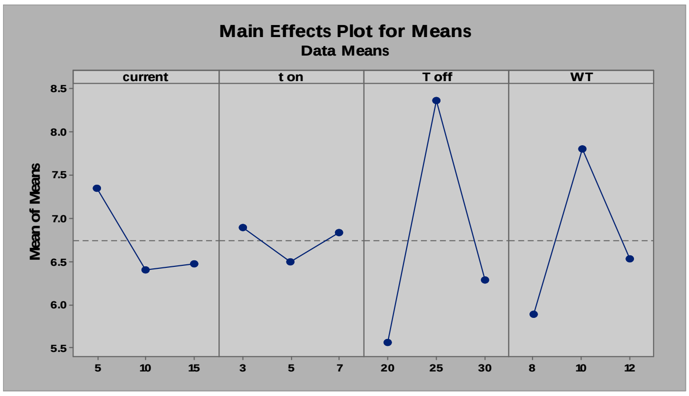

Fig -5: Main effects plots for data mean

Also from Fig. 5, we get the behavior of Input parameter on Machining speed.

1) From graph, it is clearly shown that with increase in current, Machining. When current increases from 5 to 10 µs, Machining Speed decreases and again increases.
2) Again increases from 5to 7 µs then machining speed further increases. It is clearly shown that with increase in pulse off time, material removal rate decreases.
3) The third graph shows the effect of pulse off time on machining speed when pulse off time increases from 20 to 25 µs, machining speed increases. When pulse off time again increases from 25 to 30 µs then machining speed further decreases.
4) The fourth graph indicates the effect of wire tension on machining speed. It is also observed that if wire tension increases from 8 to 10 Gms then Machining speed increases now, if wire tension further increases from 10 to 12 Gms then also there is decrease in Machining speed.
5) From the graph and signal to noise ratio optimum parameter calculated as below:

Table -5: Standard parameters

Parameter	Current(A)	Ton	T off	WT
MRR	5	5	25	10
SR(µm)	5	7	30	12

VII. CONCLUSION

Experimental investigation on wire electrical discharge machining on graphite material has been done using brass wire of 0.25mm. In this dissertation work, various cutting parameters like a pulse on time, Pulse of time, Wire tension, and input power have been evaluated to investigate their influence on surface roughness and material removal rate.

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