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PARAMETRIC OPTIMIZATION ON GRAPHITE PLATE BY WEDM

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Abstract - ***WEDM is an emerging technology in the area of Micro-machining to manufacture very complicated micro machine .WEDM is a completely complex technique regarding the distinct method parameters ,within the present investigation an optimization of WEDM has been done the use of suitable approach.. Experimental investigation has been executed in multi-manner WEDM machine. WEDM technique is a highly complex, time varying & stochastic system, which is used in the fields of dies, molds; precision manufacturing and contour slicing and so forth especially for the aerospace and medical industries. Any complicated form can be generated with excessive grade of accuracy and floor end the usage of CNC WEDM. The output of the technique is affected by huge no of enter variables. Therefore suitable selection of enter variables for the twine electric discharge machining (WEDM) manner relies upon heavily on the operator's era & revel in. The literature survey has revealed that a little research has been conducted to obtain the optimal levels of machining parameters to machine graphite materials. The objective of optimization is to attain the minimum surface roughness and maximum MRR separately. The main objectives of this study investigate and evaluate the effect of different input process parameters (pulse on time, pulse off time, wire tension, current) on material removal rate, surface roughness as response parameters have been considered for each experiment. In this present study graphite is used as a work piece, brass wire of 0.25mm diameter used as a tool and dielectric is used as distilled water. Experimentation was planned as per Taguchi's L9 Orthogonal array during machining graphite work material. For each experiment surface roughness and MRR was determined by using contact type surface coder and screen of machine directly. Analysis using S/N and ANOVA were performed to find the optimum level and percentage of contribution of each parameter. By using S/N analysis the optimum machining parameters from the experimentation is obtained. Taguchi are applied to determine the suitable selection of machining parameters for wire cut EDM process.***

Key Words: *WEDM, Taguchi Method.*

1. INTRODUCTION

Wire electrical discharge machining (WEDM) is one of the important nontraditional machining processes which are used for machining difficult to machine materials like composites There are various material having high hardness that can be easily machined by generating sparks every few microseconds. There is sparking mechanism which generates the spark between wire electrode and work piece, where the temperature reaches to approximately 12,000_C.There is dielectric fluid is act as medium for passing of spark current from electrode to work piece. Typically the gap between wire and work piece for wire EDM varies from 0.025 to 0.05 mm and this gap is constantly monitored by a computer controlled system. Now a day the numerical control is mainly produced according to the customer requirement for machining. Recently it is widely used in the aerospace and automotive industries. However, selection of cutting parameters for obtaining higher cutting efficiency or accuracy in wire EDM is still not fully solved, even with the most up-to-date CNC WEDM machine. Main aim to optimize the process parameter to overcome irregularities

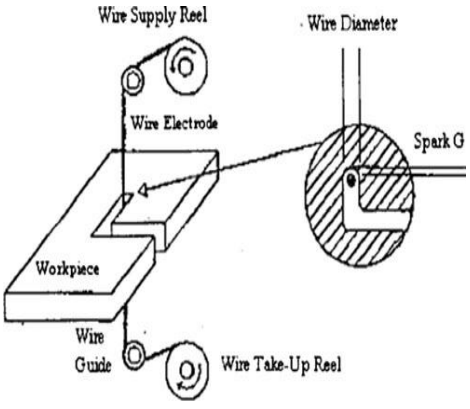


Fig.-1: Schematic diagram of WEDM

2. LITERATURE REVIEW

Ashish Srivastava , Amit Rai Dixit, Sandeep Tiwari performed associate degree experimental study on composite of Al2024 bolstered with attack, they select three levels of each parameters like current ,pulse on time and reinforcement proportion on surface finish and MRR. Response surface methodology (RSM) technique has been applied to optimize the machining parameters for minimum surface roughness and most MRR. It was determined that Surface roughness is can increase with the increase in peak current and pulse on time. Material removal rate is hyperbolic with the increase in Peak current. and pulse on time [1].

Adeel Ikram , Nadeem Ahmad Mufti, Muhammad Qaiser Saleem and Ahmed Raja Khan highlighted Associate in nursing improvement of eight management factors on material removal rate (MRR), surface roughness and kerf in wire discharge machining (WEDM) technique for steel D2. It has been found that pulse on-time is that the foremost vital parameter on surface roughness, kerf and material removal rate[2].

Neeraj Sharma & Rajesh Khanna & Rahul Dev Gupta & Renu Sharma complete that the aim of this the aim of this study is to analysis the impact of parameters on cutting speed and dimensional deviation for WEDM exploitation HSLA High-strength low-alloy steel HSLA.RSM is utilized to optimize the strategy parameter. It is seen that the foremost distinguished issue for cutting speed pulse-on time [3].

Pragya Shandilya, P.K.Jain, N.K. Jain optimize the strategy parameters throughout machining of Sic/6061 Al metal matrix composite (MMC) Four .input technique parameters of WEDM (namely servo voltage (V), pulse-on time (TON), pulse-off time (TOFF) and wire feed rate (WF)) on the cutting dimension (kerf) .RSM methodology is utilized. ANOVA results that voltage and wire feed rate are very vital parameters and pulse-off time could be a smaller quantity vital and to achieve the surface roughness and metal removal rate [4].

M. Durairaj, D. Sudharsunb, N. Swamynathan investigation on stainless-steel (SS304).They use brass wire of 0.25mm as conductor from this paper it is conclude that optimized input parameter combos to urge the minimum surface roughness square measure 40V gap voltage, 2mm/min wire feed, six µs pulse on time, 10 µs pulse off time and equally optimized conditions to urge the minimum kerf breadth square measure 50V gap voltage, 2mm/min Wire Feed, four µs pulse on time, six µs pulse off time [5] .

Chengmao Zhang highlighted the investigation on Tin/Si3N4 ceramic. The dependence of surface texture, surface roughness, and materials removal rate square measure take into consideration as output parameter. From this paper it is finished that the material removal rate to boot can increase with increase in power semiconductor numbers, plenty of pulse off-time finish in lower material removal rate [6].

R. Bagherian Azhiri & R. Teimouri & M. Ghasemi Baboly &Z. Leseman had given the work experimental investigation intelligent modeling and multi-characteristics improvement of dry WEDM technique whereas machining of Al/Sic metal matrix composite. Throughout this Taguchi L27 orthogonal array to analysis effects of pulse on time, pulse off time, gap voltage, discharge current, wire tension and wire make the most of cutting speed and surface roughness [7] .

Ravindranadh Bobbili, V. Madhu, and A. K Gogia renowned the influence of machining parameters on surface roughness (SR) and material removal rate (MRR) of high strength armor steel. Pulse-on time, Pulse-off time, wire feed, flushing pressure, spark voltage, and wire tension. Results show that pulse-on time, pulse-off time, and spark voltage square measure vital variables to MRR and surface roughness (SR) [8].

G. Rajyalakshmi & P. Venkata Ramaiah taguchi technique has been applied to experimental results of wire cut discharge machining (WEDM) on Inconel 825. Grey relative is to boot used to verify the only technique parameters that optimize the response measures. from result conclude that it square measure usually all over that the Taguchi technique is most ideal and applicable for the constant improvement of the wire cut EDM technique, once exploitation the multiple performance characteristics like MRR, surface roughness, and spark gap for machining the Inconel 825[9].

Yongfeng Guo1, Pengju Hou1, Dongxiang Shao1, Zongfeng Li1, Li Wang1, and Maya Lin Tang1high-speed wire discharge machining (HS-WEDM) of insulating oxide. The characteristics of this HS-WEDM technique supported the novel aiding conductor square measure investigated, that embrace the study of the results of pulse-on time on machining speed[10].

B. Kuriachen & K. P. Somashekhar & Jose Mathew investigated throughout this paper gap voltage, capacitance, feed rate, and wire tension on metal alloy (Ti-6AL-4V). Analysis of variance (ANOVA) is performed to identify the numerous factors, from this paper it has everywhere that formal logic system with response surface methodology is best method. It is found that if we tend to want max. MRR and minimum surface roughness need to be the input parameters gap voltage (113 V), capacitance (0.26 µF),feed rate (9 µm/s), and wire tension (10 gm.) [11].

Ibrahem Maher & Ahmed A. D. Sarhan & M. Hamdi targeted on the evolving technologies of EDM wire electrodes from exploitation copper to the wide used brass wire electrodes and from brass to the latest coated wire electrodes, that square measure developed and assist user demand and wishes in terms of most productivity and quantity. Special wire electrodes were introduced as abrasive, hot dip electrical, and porous wire electrodes.

The copper wire conductor was replaced by brass as a result of the low material removal rate and low wear or erosion resistance [12].

Dr. Joseph kunju Paul et.al. Evalutes the effect of voltage, dielectric pressure, pulse on time and pulse off-time on spark gap of Ti6AL4V alloy. It is found that the pulse on time, pulse off time, the interaction of dielectric pressure and pulse off time, and interaction of pulse on time and pulse off time are significant parameters which affect the spark gap of WEDM. Minimum spark gap can be obtained by adopting a low value of pulse on time (20μs) , a high value of dielectric pressure (15 kef/cm2), high value of pulse off time(50 μs) and voltage of 50V . Improper setting of pulse on time and pulse off time can lead to wire breakage which in turn leads to increase in machining time. The developed model agrees with the conformation results by less than 6% [13].

B.C. Khatri et.al. the study has been made to optimize the process parameters during machining of Inconnel-600 by wire electrical discharge machining (WEDM) using response surface methodology (RSM). Four input process parameters of WEDM (namely Peak Current (IP), Pulse on time (TON), Pulse off time (TOFF) and Wire Feed rate (WF) were chosen as variables to study the process performance in terms of Material Removal Rate (MRR). In the present work, the parametric optimization method using Taguchi's robust design is proposed for wire-cut electric discharge machining of Inconel-600. This material is gained dominance, where high strength and/or hardness is required at elevated temperatures. So, experimentation has been done by using Taguchi's Mixed L18 (21x33) orthogonal array. Finally it concluded the effects of Pulse On time, Pulse Off time, Peak Current, Wire Feed rate setting are experimentally investigated in machining of Inconel- 600 using CNC Wire-cut EDM process. The level of importance of the machining parameters on the material removal rate is determined by using ANOVA and it is shown that Pulse on, Pulse Off, Peak current are most significant [14].

Atul J Patel, Prof. Satyam P Patel et.al. had investigate the effects of the various WEDM process parameters on the machining quality of AISI 304 stainless steel and to obtain the optimal sets of process parameters so that the quality of machined parts can be optimized. The working ranges and levels of the WEDM process parameters are found using one factor at a time approach. The Taguchi technique has been used to investigate the effects of the WEDM Three levels of each of the factors will be taken and experiments are designed by Taguchi methodology. L9 Orthogonal Array is used and experiment will be performed as designed by Taguchi method. It can be concluded that Pulse on time, Input power, pulse off time and wire tension significantly effects on surface roughness. Pulse off time is found to have effect on surface roughness. Increase in pulse off time value of surface roughness is decrease. Pulse on time, Input power, pulse off time and wire tension significantly effects on MRR. Increase in Pulse on time, value of material removal rate is increase. [15] .

Narender Singh et.al. Present investigation is to optimize the process parameters for single response optimization using Taguchi's L18 orthogonal array. Experiments were carried out on H-21 die tool steel as work piece electrode and zinc coated brass wire as a tool electrode. Response parameters are cutting speed, surface roughness and die width. The feature which makes optimization most powerful in comparison to other methods is its ability to handle multiple performance parameters in the form of constraints. 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 optimal level of the process parameter is the level with the highest S/N ratio. A statistical analysis of variance (ANOVA) is performed to identify the process parameters that are statistically significant [16] .

Ahmed Raza Khan et.al. have conducted on "Parametric optimization for surface roughness, kerf and MRR in wire electrical discharge machining (WEDM) using Taguchi design of experiment" .The experimentation is performed under different cutting conditions of wire feed velocity, dielectric pressure, pulse on-time, pulse off-time, open voltage, wire tension and servo voltage by varying the material thickness using D2 tool steel material. It has concluded that the performance measures were statistically analyzed using analysis of variance (ANOVA) and signal-to-noise ratio to evaluate the effects of the selected variables and to determine the optimum machining performance for surface roughness, material removal rate and kerf width. It has been found the optimum level and the most significant factor affecting the surface roughness, kerf and material removal rate [17] .

S. B. Prajapatiet.al. Evaluates the effect of process parameter like Pulse ON time, Pulse OFF time, Voltage, Wire Feed and Wire Tension on MRR, SR, Kerf and Gap current is studied by conducting an experiment. Response surface methodology is used to analyze the data for optimization and performance. The AISI A2 tool steel is used as work piece material in the form of square bar. Finally concluded that for cutting rate and surface roughness, the pulse on and pulse off time is most significant. The spark gape set voltage is significant for kerf [18].

K. P. Rajurkaret.al. In this paper presents an experimental investigation of wire electro discharge machining (WEDM) of titanium alloy as work piece material. The objective is to investigate the effect of seven process parameters including pulse width, servo reference voltage, and pulse current, wire tension, cutting speed, wire rupture and surface integrity. A Taguchi L18 design of experiment (DOE) has been applied. The Analysis of variance also indicated that voltage, injection pressure, wire feed rate

and wire tension have non-significant effect on the cutting speed. Scanning Electron Microscopic (SEM) examination of machined surfaces was performed to understand the effect of different wires on work piece material surface characteristics. Experiments results of WEDM of titanium indicate peak current and pulse width have significant effect on cutting speed and surface roughness. It concluded that cutting speed of machining decreases with increasing time between two pulses and when wire tension increases surface roughness also increases. The wire breakage in machining of titanium is sensitive to electrical process parameters such as time between two pulses, pulse width, wire tension and injection pressure [19].

C Bhaskar , Reddy et.al. Also conducted the experiments in wire EDM based on L16Orthogonal array selecting EN19 and SS420 steel as work material with 0.18 mm Molybdenum wire as electrode. The experiments are conducted considering the above two materials for L16 and then the impact of each parameter is estimated by ANOAVA. Then the Regression analysis is carried-out to find the trend of the response of each material. Recommended better parameter settings to achieve higher MRR and better surface roughness. Based on the results; it is recommended that the EN 19 material is suitable for better MRR. Then the SS 420 material is recommended to obtain better surface [20].

Ramakrishna,,L. Karunamoorthy highlighted the WEDM applications in many areas like metal 718 by CNC WEDM process.It was determined that the with Taguchi's parameter vogue is also a simple, systematic, reliable and extra economical tool for optimizing multiple performance characteristics of WEDM technique parameters. The results of varied machining parameter like pulse on time, wire feed speed, delay time and ignition current were studied whereas machining of metal 718 [21].

2. METHODOLOGY

2.1. Design of Experiment

Design of Experiment methods are used in robust Design for obtaining product and process conditions. Taguchi methods are statistical methods developed by Genichi Taguchi to improve the quality of manufactured goods, and more recently also applied to engineering,

2.2. Signal-to-noise Ratio

The experimental results are then transformed into a signal-to-noise (S/N) ratio. Taguchi recommends the use of S/N ratio to measure the quality characteristics deviating from the desired values. The S/N ratio for each level of process parameters is computed based on the S/N analysis. Generally, there are three categories of quality characteristic in the analysis of the S/N ratio ,i.e. smaller-is-better, larger-is-better, and nominal-is better.

2.3 Plan of Experiment

In the present study L9 standard orthogonal array has been used which is attributed to its suitability for 3 level problems. On the basis of Taguchi method four factors with three levels of each are selected and, the L9 array has been made for calculating the MRR and SR

Table -1:WEDM process parameters and their levels

Process Parameter	Units	Level
Current	A	5,10,15
Ton	Micro-sec	3,5,7
Toff	Micro-sec	20,25,30
Wire tension	G	8,10,12

2.4 Experimental Setup

A WEDM machine, developed by ITRI (Industrial Technology Research Institute) and CHMER company Taiwan, was used for the experiment.

Brass wire with graphite Work-piece specimens having thickness 6 mm is used and square pieces of10 mm a side were cut by WEDM

Table -2:L9 array table for DOE based on Taguchi Method

No of runs	Current (a)	T on	Toff	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

Fig -2: WEDM machine used in experimentation

Fig -3: Actual Cutting of Graphite Plate by WEDM

Table -3: Specification of WEDM

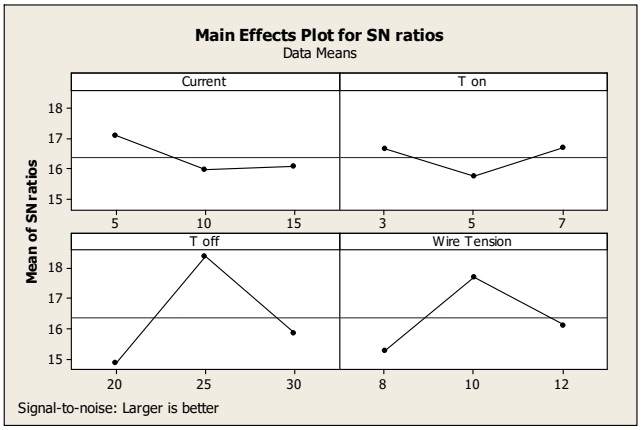
work piece (anode)	Graphite Plate
electrode (cathode)	00.25 mm brass wire
Dielectric fluid	Distilled water
X,Y axis mm	400*300
U,V,Z TRAVEL	60*60*220
maximum size of work piece(w *d*h)mm	720*600*215
Motor	AC servo motor
wire dia.mm	0.15-0.3
Max. wire feed	300
wire tension (Gm)	300-2500

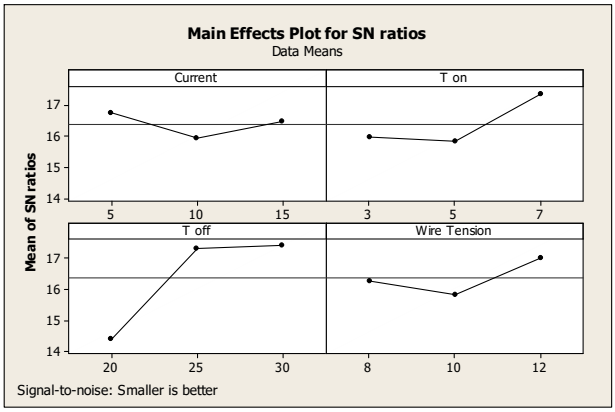
Table -4: Measurement of Response and their S/N ratio for all experiments

	Current	Ton	Toff	WT	MRR	SNRA 1	SR	SNRA 2
1	5	3	20	8	5.475	14.767	0.194	14.2440
2	5	5	25	10	6.78	19.812	0.148	16.5948
3	5	7	30	12	7.183	16.626	0.107	19.4123
4	10	3	20	12	9.794	18.028	0.140	17.0774
5	10	5	25	10	7.966	13.722	0.153	16.3062
6	10	7	30	8	4.853	16.098	0.191	14.3793
7	15	3	20	8	6.381	17.200	0.149	16.5363
8	15	5	25	12	7.246	13.702	0.187	14.5362
9	15	7	30	10	7.335	17.300	0.122	18.2728

3. RESULTS

Graph shows response effect for Signal-to-noise ratios of MRR and surface roughness. This results are achieved through Minitab software and their impact is discussed in conclusion.





From the graph and signal to noise ratio optimum parameter calculated as

	Current(A)	Tonμs	Toffμs	WT
MRR	5	7	25	10
SR(μm)	5	7	30	12

4. ANALYSIS OF VARIANCE (ANOVA)

This method was developed by Sir Ronald Fisher in the1930s as a way to interpret the results from agricultural experiments. ANOVA is a statistically based, objective decision making tool for detecting any differences in average performance of groups of items tested. The purpose of the ANOVA is to investigate which design Parameters significantly affect the quality characteristic. An ANOVA table consists of sum of squares, corresponding degree of freedom, the F ratio corresponding to the ratio of two mean square and the contribution proportions from each of the control factors. From the ANOVA analysis it is clear that parameters Pulse off time (T off) has significant effect on MRR and wire tension (WT) SR at 95% confidence level.

Table -9: ANOVA table for MRR

Factors	Sum of Square	DOF	Mean Squares	%P (Percentage Contribution)
Current	1.68	2	0.84	10.30
Ton	1.35	2	0.68	8.30
Toff	6.83	2	3.41	41.85

Table -06: ANOVA table for SR

Factors	Sum of Square	DOF	Mean Squares	%P (Percentage Contribution)
Current	0.41	2	0.20	1.32
Ton	7.94	2	3.97	25.71
Toff	2.69	2	1.34	8.70
Wire tension	19.85	2	9.92	64.27

5. CONCLUSION

Experimental investigation on wire electrical discharge machining On graphite material has been done using brass wire of 0.25mm. The following conclusions are made

- Based on taguchi optimization optimized input parameter combinations to get the minimum surface roughness are 5A current,7 pulse on time ,30bpulse off time,12 g wire tension.
- similarly to optimized conditions to get the maximum MRR are 5A current,7 pulse on time, 25 pulse off time, 10g wire tension.
- Increase in the pulse on-time leads to the increase in MRR.
- With the increase in all input parameter SR increases.
- The Analysis of Variance resulted that the Pulse off time has major influence on the MRR and Wire tension on surface roughness.
- The objectives such as surface roughness and MRR are optimized using a single objective taguchi method
- Eventually, mathematical models were developed using regression analysis for both MRR and SR to establish the relation between process parameters and response characteristics.
- The results of the ANOVA are represented in the table above, and from the table, it is clear that pulse off time is the major Influencing factor on MRR followed by wire tension and for SR wire tension play significant role followed by pulse on time.

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