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Experimental Investigating Of Machining Parameters For EDM Using U-Shaped Electrode Of AISI P20 Tool Steel

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Abstract

The correct selection of manufacturing conditions is one of the most important aspects to take into consideration in the majority of manufacturing processes and, particularly, in processes related to Electrical Discharge Machining (EDM). It is a capable of machining geometrically complex or hard material components, that are precise and difficult-to-machine such as heat treated tool steels, composites, super alloys, ceramics, carbides, heat resistant steels etc. being widely used in die and mold making industries, aerospace, aeronautics and nuclear industries.AISI P20 Plastic mould steel that is usually supplied in a hardened and tempered condition. Good machinability, better polishability, it has a grooving rang of application in Plastic moulds, frames for plastic pressure dies, hydro forming tools These steel are categorized as difficult to machine materials, posses greater strength and toughness are usually known to create major challenges during conventional and non- conventional machining. The Electric discharge machining process is finding out the effect of machining parameter such as discharge current, pulse on time and diameter of tool of AISI P20 tool steel material. Using U-shaped cu tool with internal flushing. A well-designed experimental scheme was used to reduce the total number of experiments. Parts of the experiment were conducted with the L18 orthogonal array based on the Taguchi method. Moreover, the signal-to-noise ratios associated with the observed values in the experiments were determined by which factor is most affected by the Responses of Material Removal Rate (MRR), Tool Wear Rate (TWR) and over cut (OC).

Keywords*- U shaped cu tool, Metal removal rate (MRR), Tool wear rate (TWR), Over cut (OC), Taguchi Method, Diameter of the tool (D), Pulse duration (Ton), Discharge current (Ip).)*

I. INTRODUCTION

All The history of EDM Machining Techniques goes as far back as the 1770s when it was discovered by an English Scientist. However, Electrical Discharge Machining was not fully taken advantage of until 1943 when Russian scientists learned how the erosive effects of the technique could be controlled and used for machining purposes. When it was originally observed by Joseph Priestly in 1770, EDM Machining was very imprecise and riddled with failures. Commercially developed in the mid 1970s, wire EDM began to be a viable technique that helped shape the metal working industry we see today. In the mid 1980s.The EDM techniques were transferred to a machine tool. This migration made EDM more widely available and appealing over traditional machining processes.

The new concept of manufacturing uses non-conventional energy sources like sound light, mechanical, chemical, electrical, electrons and ions. With the industrial and technological growth, development of harder and difficult to machine materials, which find wide application in aerospace, nuclear engineering and other industries owing to their high strength to weight ratio, hardness and heat resistance qualities has been witnessed. New developments in the field of material science have led to new engineering metallic materials, composite materials and high tech ceramics having good mechanical properties and thermal characteristics as well as sufficient electrical conductivity so that they can readily be machined by spark erosion. Non-traditional machining has grown out of the need to machine these exotic materials. The machining processes are non-traditional in the sense that they do not employ traditional tools for metal removal and instead they directly use other forms of energy. The problems of high complexity in shape, size and higher demand for product accuracy and surface finish can be solved through non-traditional methods. Currently, non-traditional processes possess virtually unlimited capabilities except for volumetric material removal rates, for which great advances have been made in the past few years to increase the material removal rates. As removal rate increases, the cost effectiveness of operations also increase, stimulating ever greater uses of nontraditional process. The Electrical Discharge Machining process is employed widely for making tools, dies and other precision parts.

The correct selection of manufacturing conditions is one of the most important aspects to take into consideration in the majority of manufacturing processes and, particularly, in processes related to Electrical Discharge Machining (EDM). It is a capable of machining geometrically complex or hard material components, that are precise and difficult-to-machine.Such as heat treated tool steels, composites, super alloys, ceramics, carbides, heat resistant steels etc. being widely used in die and mold making industries, aerospace, aeronautics and nuclear industries. AISI P20 Plastic mould steel that is usually supplied in a hardened and tempered condition.

Good machinability, better polishability, These steel are categorized as difficult to machine materials, posses greater strength and toughness are usually known to create major challenges during conventional and non-conventional machining. Using U-shaped cu tool with internal flushing. Parts of the experiment were conducted with the L18 orthogonal array based on the Taguchi method.

Moreover, the signal-to-noise ratios associated with the observed values in the experiments were determined by which factor is most affected by the Responses of Material Removal Rate (MRR), Tool Wear Rate (TWR) and over cut (OC).

II. PRINCIPLE OF EDM

In this process the metal is removing from the work piece due erosion case by rapidly recurring spark discharge taking place between the tool and work piece. Show the mechanical set up and electrical set up and electrical circuit for electro discharge machining. A thin gap about 0.025mm is maintained between the tool and work piece by a servo system shown in fig 1.1. Both tool and work piece are submerged in a dielectric fluid. Kerosene/EDM oil/deionized water is very common type of liquid dielectrical though gaseous dielectrics are also used in certain cases

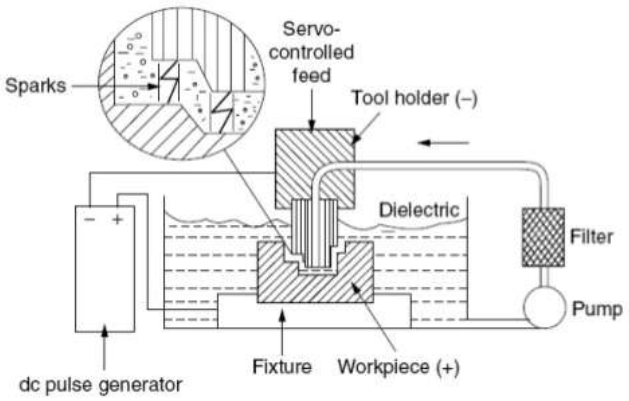

Figure 1 - Set-up of Electro Discharge Machining

III. SPECIFICATION OF EDM

Mechanism of Process	Controlled erosion (Melting & Evaporation)through a series of electric spark
Spark Gap	0.010- 0.500 mm
Spark frequency	200 - 500 kHz
Peak voltage across the gap	30- 250 V
Metal removal rate(max.)	5000 mm^3/min
Specificpower consumption	2-10 W/mm^3/min
Dielectric fluid	EDM oil, Kerosene liquid paraffin, silicon oil, deionized water etc.
Tool material	Copper, Brass, graphite, Ag-W alloys, Cu-W alloys .
MRR/TWR	0.1-10
Materials that can be machined	All conducting metals and alloys.
Shapes	Microholes, narrow slots, blind cavities
Limitations	High specific energy consumption, non conducting materials can't be machined.

Table-1 Specification of EDM

IV. OBJECTIVE OF THE PRESENT WORK

The objective of the present work is an attempt to finding feasibility of machining AISI P-20 tool steel using **U-shaped tubular copper** electrode and internal flushing.

The machining parameter selected for discharge current, pulse on time, and diameter of the tool using **Taguchi design** approach analyzing the responses **MRR, TWR,** and **Over cut.**

V. MAIN PARTS OF EDM

Figure 2- Electro Discharge Machine

Figure 3- Dielectric Reservoir

- ✓ Dielectric reservoir,
- ✓ pump and circulation system.
- ✓ Power generator and control unit.
- ✓ Working tank with work holding device.
- ✓ X-y table accommodating the working table.
- ✓ The tool holder.
- ✓ The servo system to feed the tool

Figure 4 Tool holder with workpiece and tool

VI. FLOW CHART OF EXPERIMENT

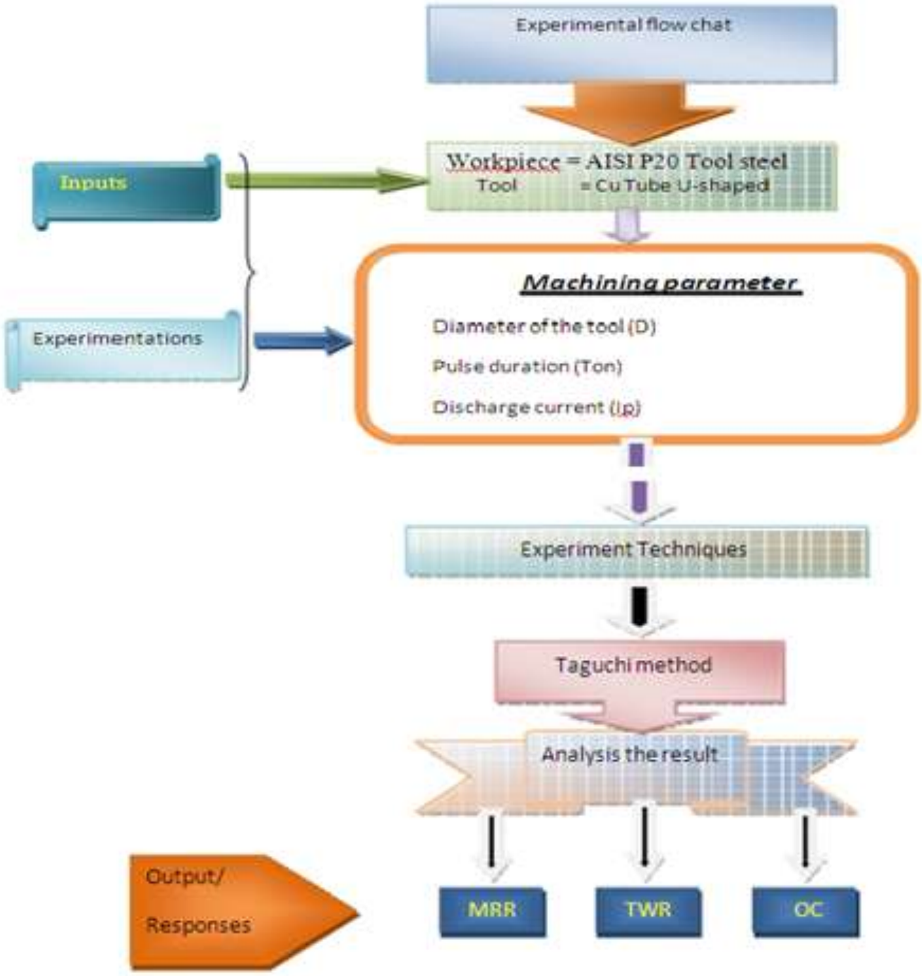

Figure 5 – Flow chart of the experiment

VII. CONDUCT OF EXPERIMENT

Experiments were conducted according to method by using the machining set up and the designed **U-shaped tubular electrodes with internal flushing**. The control parameters like **diameter of electrode (D) , discharge current (Ip) and pulse duration (Ton) conductivity** were varied to conduct 18 different experiments and the weights of the work piece and Tool and dimensional measurements of the cavity were taken for calculation of MRR , TWR and over cuts

VIII. DESIGN MATRIX AND OBSERVATION TABLE

Run	Dia (mm)	Ip (A)	Ton (µs)	Wt of workpiece (gm)		Wt of tool (gm)		Cavity dia. (gm) Djt
				Wjb	Wja	Wtb	Wta	
1	4	1	50	266.510	266.220	18.976	18.974	5.724
2	4	1	500	266.220	266.109	18.974	18.970	5.393
3	4	1	1000	266.109	266.093	18.970	18.969	4.736
4	4	3	50	266.093	264.914	18.969	18.941	5.882
5	4	3	500	264.914	264.483	18.941	18.926	5.743
6	4	3	1000	264.488	264.395	18.926	18.925	5.445
7	4	5	50	264.395	262.983	18.925	18.836	5.895
8	4	5	500	262.983	262.146	18.836	18.827	5.785
9	4	5	1000	262.146	262.061	18.827	18.801	5.964
10	6	1	50	81.783	81.491	22.214	22.196	6.143
11	6	1	500	81.922	81.783	22.224	22.214	6.089
12	6	1	1000	81.955	81.922	22.225	22.224	6.071
13	6	3	50	82.984	82.556	22.240	22.238	6.158
14	6	3	500	82.769	82.245	22.238	22.233	6.130
15	6	3	1000	82.245	81.955	22.233	22.225	6.144
16	6	5	50	269.264	267.862	22.196	22.187	6.180
17	6	5	500	267.862	266.807	22.187	22.161	6.137
18	6	5	1000	266.807	266.510	22.161	22.173	6.024

Table 2- Design matrix and observation table

IX. RESPONSE TABLE FOR MRR, TWR AND OC

Run	Dia	Ip	Ton	MRR	TWR	OC
(mm)	(A)	(µs)	(mm³/min)	(gm/min)	(mm)	
1	4	1	50	1.0400	0.0170	0.8620
2	4	1	500	0.2360	0.0030	0.6965
3	4	1	1000	0.0360	0.0006	0.3680
4	4	3	50	3.9890	0.0660	0.9410
5	4	3	500	0.9040	0.0150	0.8715
6	4	3	1000	0.7970	0.0130	0.7225
7	4	5	50	2.9980	0.0400	0.9295
8	4	5	500	1.7770	0.0290	0.8790
9	4	5	1000	0.8000	0.0030	0.9820
10	6	1	50	0.6140	0.0103	0.1435
11	6	1	500	0.2950	0.0040	0.0895
12	6	1	1000	0.0700	0.0010	0.0710
13	6	3	50	3.0000	0.0500	0.5790
14	6	3	500	1.1120	0.0180	0.5650
15	6	3	1000	0.9738	0.0356	0.5720
16	6	5	50	2.9700	0.0490	0.5900
17	6	5	500	2.2390	0.0370	0.5680
18	6	5	1000	1.3000	0.0105	0.5120

Table 3- Response table for MRR, TWR, OC

X. INFLUENCE ON METAL REMOVAL RATE (MRR)

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Dia	1	5.94	5.94	5.944	3.38	0.140
Ip	2	1222.40	1222.40	611.198	347.29	0.000
Ton	2	683.05	683.05	341.524	194.06	0.000
Dia*Ip	2	2.17	2.17	1.087	0.62	0.584
Dia*Ton	2	30.98	30.98	15.491	8.80	0.034
Ip*Ton	4	163.28	163.28	40.820	23.19	0.005
Residual Error	4	7.04	7.04	1.760		
Total	17	2114.86				

Table 4 - Analysis of Variance for S/N ratios for MRR

10.1 RESPONSE FOR S/N RATIONS LARGER IS BETTER (MRR)

Level	Diameter	Ip	Ton
1	-2.1459	-13.1689	6.1093
2	-0.9966	3.2340	-1.8508
3	0.0054	5.2212	-8.9721
Delta	1.1493	18.3901	15.0841
Rank	3	1	0

Table 5- Response for S/N Rations Larger is better

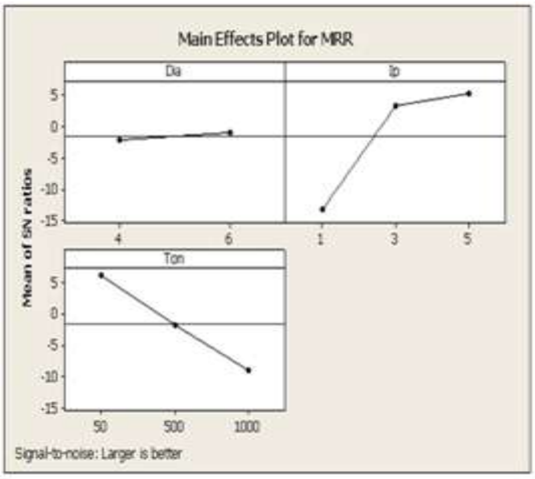

Figure 6- Main Effect Plot for S/N Rations (MRR)

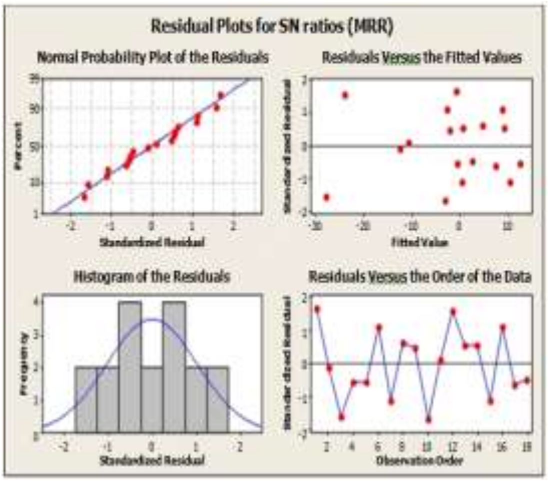

Figure 7- Residual plots for S/N rations (MRR)

10.1.1 Residual Plot indicates:

1. Normal probability plot indicates the data are normally distributed and the variables are influencing the response. Outliers don’t exist in the data, because standardized residues are between -2 and 2.
2. Residuals versus fitted values indicate the variance is constant and a nonlinear relationship exists as well as no outliers exist in the data.
3. Histogram proves the data are not skewed and not outliers exist.
4. Residuals versus order of the data indicate that there are systematic effects in the data due to time or data collection order.

XI. INFLUENCE ON TOOL WEAR RATE (TWR)

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Dia	1	35.46	35.46	35.465	17.02	**0.015**
Ip	2	1185.01	1185.01	592.506	284.31	**0.000**
Ton	2	871.24	871.24	435.618	209.03	**0.000**
Dia*Ip	2	12.42	12.42	6.209	2.98	0.161
Dia*Ton	2	71.66	71.66	35.828	17.19	**0.011**
Ip*Ton	4	243.68	243.68	60.921	29.23	**0.003**
Residual Error	4	8.34	8.34	2.084		
Total	17	2427.81				

Table 6- Analysis of Variance for S/N ratios for TWR

11.1 RESPONSE TABLE FOR SIGNAL TO NOISE RATIOS SMALLER IS BETTER (TWR)

Level	Diameter	Ip	Ton
1	39.70	49.66	29.82
2	36.89	31.28	38.20
3	33.93	46.86	25.40
Delta	2.81	18.36	17.04
Rank	3	1	2

Table 7 Response table for signal to noise ratios smaller is better (TWR)

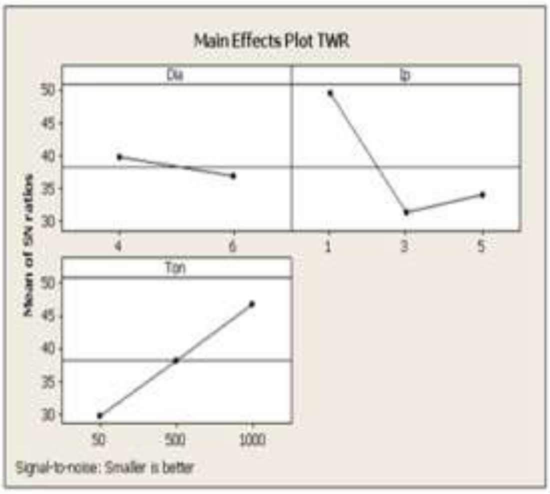

Figure 8- Main Effect Plot for S/N Rations (TWR)

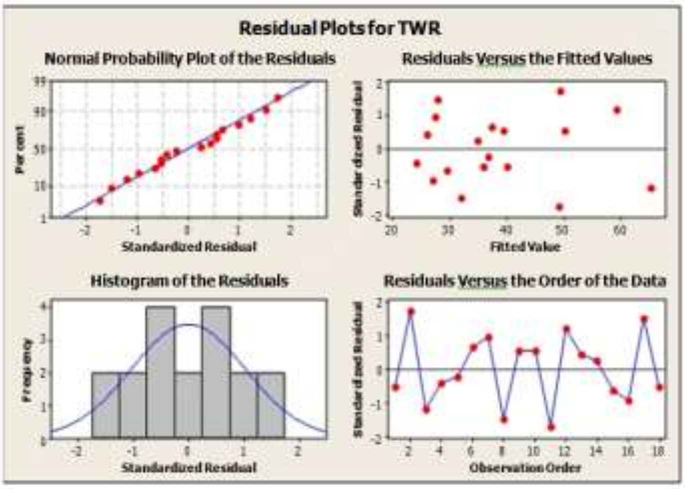

Figure 9- Residual plots for S/N rations (TWR)

11.2 Residual Plot indicates:

1. Normal probability plot indicate outlines don't exist in the data, because standardized residues are between -2 and 2.
2. Residuals versus fitted values indicate the variation is constant.
3. Histogram shows the data are not skewed and not outline exist.
4. Residual versus order of the data indicates that systematic effects in the data due to time of data collection order.

XII. INFLUENCE ON OVER CUT (OC)

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Dia	1	280.812	280.812	280.812	242.40	**0.000**
Ip	2	345.662	345.662	172.831	149.19	**0.000**
Ton	2	23.182	23.182	11.591	10.01	**0.028**
Dia*Ip	2	144.814	144.814	72.407	62.50	**0.001**
Dia*Ton	2	0.965	0.965	0.482	0.42	0.685
Ip*Ton	4	24.310	24.310	6.077	5.25	0.069
Residual Error	4	4.634	4.634	1.158		
Total	17	824.379				

Table 8 - Analysis of Variance for SN ratios (OC)

12.1 RESPONSE FOR S/N RATIONS SMALLER IS BETTER (OVER CUT

Level	Diameter	Ip	Ton
1	2.175	12.319	4.774
2	10.074	3.184	6.049
3		2.871	7.551
Delta	7.900	9.449	2.777
Rank	2	1	3

Table 9- Response for S/N Rations smaller is better (Over cut)

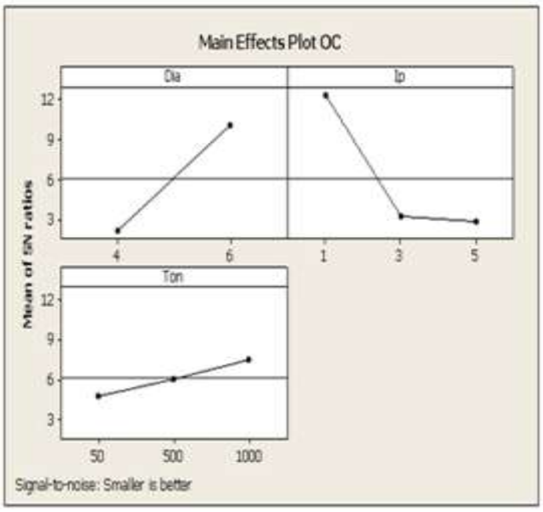

Figure 10- Main Effect Plot for S/N Rations (OC)

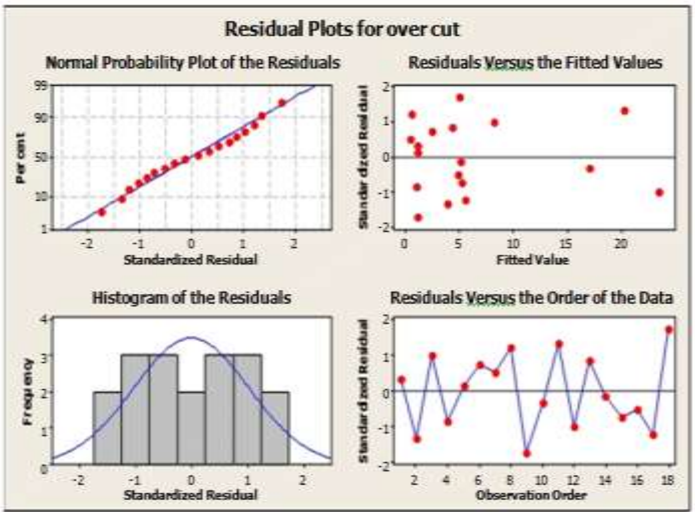

Figure 11- Residual plots for S/N rations (OC)

12.2 Residual Plot indicates:

1. This residual plot in the graph for normal probability plot indicates the data are normally distributed and variables are influencing the response.
2. The Residuals versus fitted value indicate the variation is constant.
3. The Histogram proved the data are not skewed and not outline exist.
4. And Residual versus order of the data indicates that there are systematic effects in the data due to time or data collection order.

XIII. CONCLUSION

1 Finding the result of MRR discharge current is most influencing factor and then pulse duration time and the last is diameter of the tool. MRR increased with the discharge current (Ip). As the pulse duration extended, the MRR decreases monotonically

2 In the case of Tool wear rate the most important factor is discharge current then pulse on time and after that diameter of tool.

3 In the case of over cut the most important factor of discharge current then diameter of the tool and no effect on pulse on time .

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