International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463
Vol. 4 Issue 6, June-2015, pp: (538-551), Impact Factor: 1.252, Available online at: www.erpublications.com

Optimization of EDM Parameters for Dimensional Accuracy using Taguchi's Method

Parjeet Hooda[1], Vijay Kumar[2]
[1]M.Tech Research Scholar, Sat Priya Institute of Engineering and Technology, Rohtak, Haryana
[2]Assistant Professor, Mechanical, Engg. Deptt, Sat Priya Institute of Engineering and Technology, Rohtak, Haryana

Abstract: The EDM process that we know today is a result of various researches carried out over the years. EDM researchers have explored a number of ways to improve the sparking efficiency with various experimental concepts. Despite a range of different approaches, every new research shares the same objectives of achieving high metal removal rate with reduction in tool wear and improved surface quality. This study is mainly focused on aspects related to surface quality and metal removal rate which are the most important parameters from the point of view of selecting the optimum condition of processes as well as economic aspects. It reports the research trends in EDM. Electrical discharge machining (EDM) is a process for shaping hard metals and forming deep complex shaped holes by arc erosion in all kinds of electro-conductive materials. Electrical Discharge Machining (EDM) is a nontraditional manufacturing process based on removing material from a part by means of a series of repeated electrical discharges (created by electric pulse generators at short intervals) between a tool, called electrode, and the part being machined in the presence of a dielectric fluid . Analysis of variance (ANOVA) is used to study the effect of process parameters on machining process. This procedure eliminates the need for repeated experiments, saves time and conserves the material. The machining parameters investigated are Discharge current, Pulse Duration and Pulse control. The selection of the mild steel was made taking into account its use in almost all industrial applications. An orthogonal array has been used to conduct the experiments and raw data and S/N ratio are employed to analyze the influence of three parameters on dimensional accuracy. The main objective is used to find the important factors and combinations of factors influencing the machining process to achieve the best dimensional accuracy (Nominal value of the size of drilled hole) the cutting of Mild Steel using electro-discharge machining (EDM) with a graphite electrode by using Taguchi methodology has been reported. The Taguchi method is used to formulate the experimental layout, to analyse the effect of each parameter on the machining characteristics, and to predict the optimal choice for each EDM parameter such as peak current, voltage, pulse duration and interval time. It is found that these parameters have a significant influence on machining characteristic such as metal removal rate (MRR), electrode wear rate (TWR) and surface roughness (SR). The analysis of the Taguchi method reveals that, in general the peak current significantly affects the TWR and SR, while, the pulse duration mainly affects the MRR. Experimental results are provided to verify this approach.

Keywords: EDM, Process parameters, metal removal rate (MRR), electrode wear rate (TWR) and surface roughness (SR) etc.

1. INTRODUCTION

EDM is an unconventional electro thermal machining process used for manufacturing geometrically complex or hard material parts that are extremely difficult-to-machine by conventional machining process. The mechanism of material removal of most widely established EDM process is the conversion of electrical energy it into thermal energy. The sparks are produced between work piece and tool during the process of machining. The Taguchi technique involves reducing the variation in a process through robust design of experiments The overall objective of the method is to produce high quality product at low cost to the manufacturer. The Taguchi method was developed by Dr. Genichi Taguchi of Japan who maintained that variation. Taguchi developed a method for designing experiments to investigate how different parameters affect the mean and variance of a process performance characteristic that defines how well the process is functioning.

The experimental details when using the Taguchi method are described. Jeswani M.L [1]: Machining in distilled water resulted in higher MRR and lower wear ratio than in kerosene when high pulse Energy range was used. Erden [2] proposed that material removal mechanism relating to three phases of sparking, namely breakdown, discharge and erosion. Also, it was found that reversing the polarity of sparking alters the material removal phenomenon with an appreciable amount of electrode material depositing on the work piece surface. S. Tariq Jilani et al [3]: The best machining rates have been achieved with tap water as the dielectric medium; zero TWR possible when using Cu tool with negative polarities. Saito et al. [4] have conducted a comparative investigation between solid electrode and wire frame electrode for producing cubic cavities. The authors have reported improvement in flushing conditions, material removal rate and machining efficiency.

They recommended application of frame type tooling for the work piece shapes having linear or axis symmetrical swept surfaces when high material removal rate is desired. Pandit, S.M., Mueller [5] established optimum process conditions for in rough machining phase using the Taguchi method with graphite powder. They reported that addition of an appropriate amount of the powder into the dielectric causes considerable improvement in MRR. Koenig W. et al [6]: The erosion process in water based media consequently possesses higher thermal stability & much higher power input can be achieved especially under critical condition. Use aqueous solution of organic compounds as medium for EDM sinking almost completely excludes any fire hazard, permitting safe operation of plant.EDM sinking process can be made more cost effective through the use of water based media, significantly improving competitiveness with other process. Puertas and Luishas [8] define the optimization of machining parameter for EDM of Boron carbide of conductive ceramic materials.

It is these conditions that determine such important characteristics as surface roughness, electrode wear, and MRR. In this article, a review of the state of art of the die-sinking EDM processes for conductive ceramic materials, as well as a description of the equipment used for carrying out the experiments, are presented. Analysis of variance on the collected data from the Taguchi design of experiments can be used to select new parameter values to optimize the performance characteristic. The data from the arrays can be analyzed by plotting the data and performing a visual analysis. Taguchi's parameter design is an important tool for robust design. It offers a single and systematic technique to optimize the design performance, quality and cost. Two major tools used in robust design are (Phadke, [7]; Uanl and Dean, [9]). a. Signal to noise ratio (S/N), which measures quality with emphasis on variation and b. Orthogonal arrays, which accommodate many design factors simultaneously.

When a critical quality characteristics deviates from the target value it causes a loss. Continuously pursuing variable reduction from the target value in critical quality characteristics is the key to achieve high quality and reduce cost. Therefore, the Taguchi method Glen [11], which is a powerful tool for parametric design of performance characteristics, is used to determine the optimal machining parameters for minimum electrode wear ratio, maximum material removal rate and minimum surface roughness in the EDM operations. Iqbal& Khan [13] Influence of Process Parameters on Electrical Discharge Machined Job Surface Integrity. Stainless steel AISI 304.

W. Konig [12], A machine tool maker has established technologies for water-immersion machining, greatly improved the surface finish so that post process manual polishing is not required. Bayramoglu and Duffill [10,14] Investigated frame type cutting tool with CNC EDM for generation of linear, circular and curved contours. Mild steel Copper Voltage, current, on- time, off –time Non Wong et al.[15]. Although the Implementation of Taguchi Method on EDM Process of Tungsten Carbide 610 study of these parameters has been performed by many researchers, most of the studies do not much consider both engineering phylosophy (DOE) and mathematical formulation (ANOVA) Roy,[16], particularly in machining very hard materials such as Tungsten Carbide. Therefore, the Taguchi method, which is a powerful tool for parametric design of performance characteristics, is used to determine the optimal machining parameters for minimum electrode wear ratio, maximum material removal rate and minimum surface roughness in the EDM operations. Investigated the influence of flushing on the efficiency and stability of machining condition.

AISI 01 tool steel Copper Pulse current, pulse-on time, pulse-off time, gap voltage and polarity Flushing rate.Chen et al.[17]. In addition, mechanical and physical properties of tungsten carbide such as hardness, toughness, high wear resistance has made it an important material for engineering components particularly in making moulds and dies. Since the EDM process does not involve mechanical energy, the removal rate is not affected by either hardness, strength or toughness of the workpiece material Yan, [19]. Investigated machining characteristics with kerosene and distilled water as the dielectrics. Titanium alloy (Ti–6A1–4V) Copper Current, Pulse duration Type of dielectric Fluid Ghoreishi and Atkinson [20]compared the effects of high and low frequency forced axial vibration of the electrode, rotation of the electrode and combinations of the methods (vibro-rotary) in respect of MRR, TWR & SQ in EDM die sinking and found that vibro-rotary increases MRR by up to 35% compared with vibration EDM and by up to 100% compared with rotary EDM in semi finishing. Harpuneet Singh[18] Investigating the Effect of Copper Chromium and Aluminum Electrodes on EN- 31 Die Steel on Electric Discharge Machine Using Positive Polarity.

2. EXPERIMENTAL WORK

2.1 INTRODUCTION

In this chapter we are going to discuss about the experimental work which is consist about formation of the L-18 orthogonal array based on Taguchi design, orthogonal array is reduces the total on of experiment, in this experiment total 18 run. And Experimental set up, selection of workpiece, tool design, and taking all the value and calculation of MRR, TWR, and OC.

2.2 EXPERIMENTAL SET UP

For this experiment the whole work can be down by Electric Discharge Machine, model ELECTRONICA-ELECTRAPULS PS 50ZNC (die-sinking type) with servo-head (constant gap) and positive polarity for electrode was used to conduct the experiments. Commercial grade EDM oil (specific gravity= 0.763, freezing point= 94°C) was used as dielectric fluid. With internal flushing of U-shaped cu tool with a pressure of 0.2 kgf/cm .Experiments were conducted with positive polarity of electrode. The pulsed discharge current was applied in various steps in positive mode.

2.3 SELECTION OF THE WORK PIECE

It is capable of machining of hard material component such as heat treated tool steels, composites, super alloys, ceramics, carbides, heat resistant steels etc. The higher carbon grades are typically used for such applications as stamping dies, metal cutting tools, etc. AISI grades of tool steel is the most common scale used to identify various grades of tool steel. Individual alloys within a grade are given a number; for example: A2, O1, D2, P20 etc. In this experiment using AISI P20 tool steel material this **P-20 tool** steel material is a pre hardened high tensile tool steel which offers ready machine ability in the hardened and tempered condition, therefore does not require further heat treatment. Subsequent component modifications can easily be carried out. Plastic mould steel (P-20 tool steel) that is usually supplied in a hardened and tempered condition. Good machine ability, better polish ability, compared to DIN 1.2312 (AISI P20+S). Plastic mould steel is used growing range of to Plastic moulds, frames for plastic pressure dies, hydro forming tools. And their composition of the tool is listed in this Table: 2.1, 2.2, 2.3 and 2.4.

Table 2.1 Composition of AISI P-20 tool steel material

elements	Weight limit%	Actual weight %
C	0.28-0.40	0.40
Mn	0.60-1.00	1.00
Si	0.20-0.80	0.40
Cr	1.40-2.00	1.20
Mo	0.30-0.55	0.35
Cu	0.25	0.25
P	0.03	0.03
S	0.03	0.03

Table 2.2 AISI P20 tool steel categories

Category	Steel
Class	Tool steel
Type	General mold steel
designations	Germany: DIN 1.2330
	U.S.:ASTM A681,UNS TS1620

Table 2.3 Mechanical properties of P20 steel

PROPERTIES		CONDITIONS($T^{O}C$)
DENSITY	7.85X1000KG/M^3	25
POISSON’S RATIO	0.27-0.30	25
ELASTIC MODULUS	190-210gpa	25

Table 2.4 Thermal Properties of P20 tool steel material

properties		CONDITIONS($T^{O}C$)
Thermal expansion($10^{-6}/^{o}c$)	12.8	4.-425 more

2.4 TAGUCHI DESIGN

Dr.Genichi Taguchi is regarded as the foremost proponent of robust parameter design, which is an engineering method for product or process design that focuses on minimizing variation and/or sensitivity to noise. When used properly, Taguchi designs provide a powerful and efficient method for designing products that operate consistently and optimally over a variety of conditions. Taguchi proposed several approaches to experimental designs that are sometimes called "Taguchi Methods." These methods utilize two-, three-, four-, five-, and mixed-level fractional factorial designs. Taguchi refers to experimental design as "off-line quality control" because it is a method of ensuring good performance in the design stage of products or processes. Experiments were conducted according to Taguchi 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 cut.

3. RESULT AND DISCUSSION

3.1 INTRODUCTION

In This chapter are related about influences of MRR, TWR, and OC and finding the result which factors discharge current , pulse duration, diameter of Cu tool , is most important with help of Taguchi method.

3.2 RESPONSE TABLE

The response table for MRR, TWR and OC are shown in Table 3.1 along with the input.

Table 3.1 Response table

Run	Dia (MM)	Ip(A)	Ton µs	MRR (MM^3/MIN)	TWR (GM/MIN)	OC(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

The experiments were conducted under various parameters setting of Discharge Current (Ip), Pulse On-Time (Ton), and diameter of the tool. L-18 OA based on Taguchi design was performed for Minitab software was used for analysis the result and theses responses were partially validated experimentally. The optimal result is found in 4^{th}Run where diameter of electrode (D) is 4, discharge current (Ip) is 3 and pulse duration (Ton) is 50 and in the result we get maximum material removal rate (MRR) is 3.9890 MM^3/MIN.

3.3 Influences on MRR

The S/N ratios for MRR are calculated as given in Equation 3.1. Taguchi method is used to analysis the result of response of machining parameter for larger is better criteria

Lb : $\eta = -10 \log[1/n \sum_{i=1}^{n} yi^{-2}]$ **. . . . . (3.1)**

Where η denotes the S/N ratios calculated from observed values, yi represents the experiment and n=1 is the repeated number of each experiment in L-18 OA is conducted. The analysis of variances for the factors is shown in Table 3.2 which is clearly indicates that the diameter of the tool is not important for influencing MRR and Ip and Ton are the most influencing factors for MRR and as well as the interaction Ip x Ton is significant (shown in bold). And other factors are not significant .The delta values are Dia. of tool, Ton and Ip are 1.1493, 15.0841 and 18.3901 respectively, depicted in Table 3.3. The case of MRR, it is "Larger is better", so from this table it is clearly definite that Ip is the most important factor then Ton and last is dia. of the tool.

Table 3.2 Analysis of Variance for S/N ratios for 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 x Ip	2	2.17	2.17	1.087	0.62	0.584
Dia x ton	2	30.98	30.98	15.491	8.80	0.034
Ip x 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 3.3 Response for S/N Rations Larger is better (MRR)

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

During the process of Electrical discharge machining, the influence of various machining parameter like Ip, Ton and Diameter of tool has significant effect on MRR, as shown in main effect plot for S/N ratio of MRR in **Fig 3.1**. The discharge current (Ip) is directly proportional to MRR in the range of 1 to 3A. This is expected because an increase in pulse current produces strong spark, which produces the higher temperature, causing more material to melt and erode from the work piece.

However, MRR decreases monotonically with the increase in pulse on time. The diameter of the tool has no significant effect on MRR. The interaction plot of MRR is shown in Fig 3.2, where each plot exhibits the interaction between three different machining parameters like Ip, Ton and dia. of tool. This implies that the effect of one factor is dependent upon another factor. It is also confirmed by the ANOVA table (Table 3.2).It is well known fact that the spark energy increases with Ton and hence, MRR increases with Ton in the range of 300 to 400 µs. MRR usually increases with Ton up to a maximum value after which that it starts to decrease. This is due to the fact that with higher Ton, the plasma formed between the Inter electrode gap (IEG) actually hinders the energy transfer and thus reduces MRR. In this experiment the value of pulse durations are 50, 500 and 1000 µs which miss the peak values. So, the plotted graph of pulse duration vrs MRR, as show decreasing trend only.

International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463
Vol. 4 Issue 6, June-2015, pp: (538-551), Impact Factor: 1.252, Available online at: www.erpublications.com

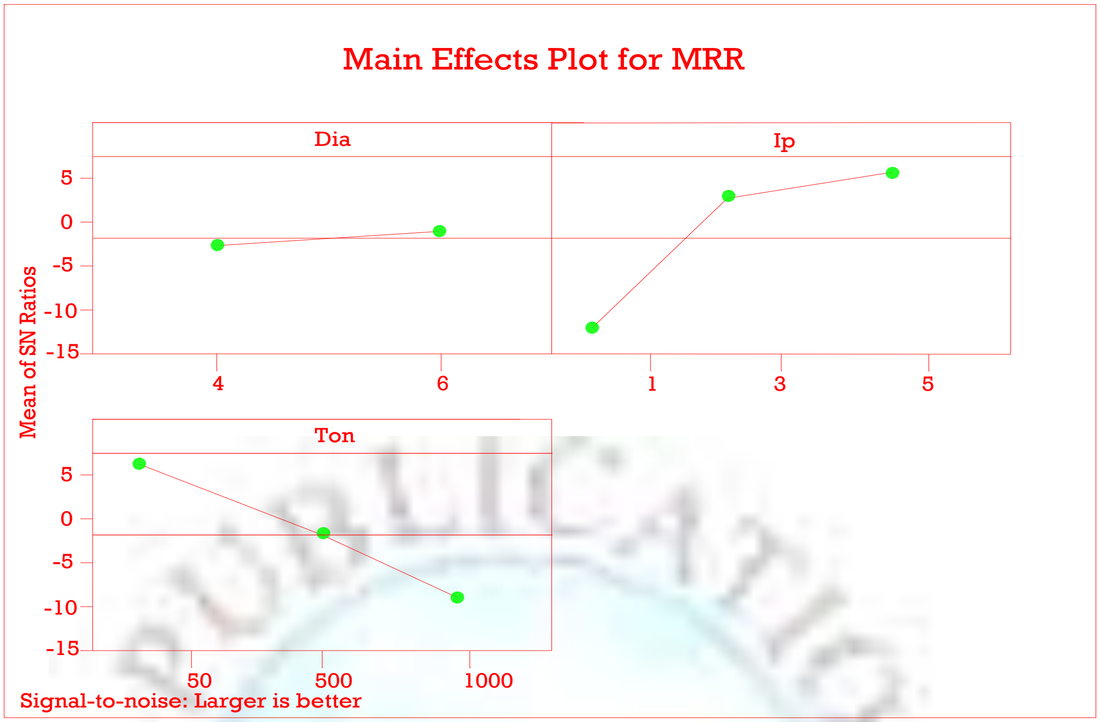

Fig. 3.1 Main effect plots for S/N ratios (MRR)

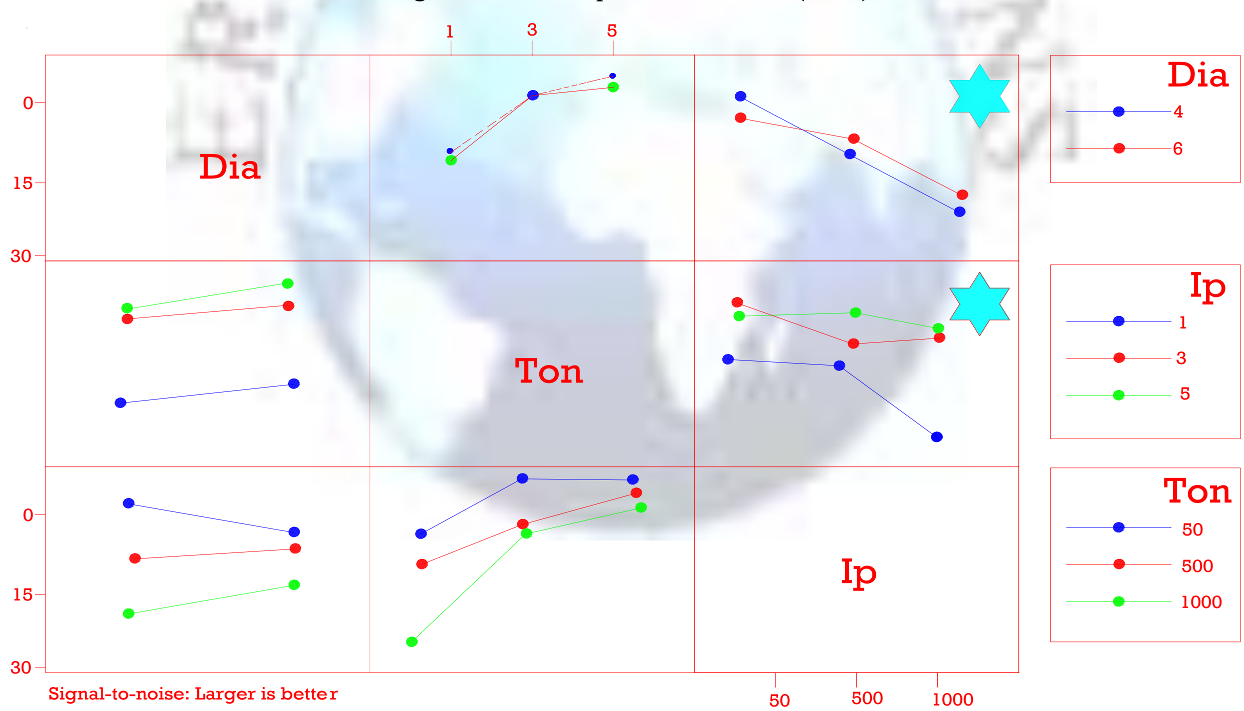

Fig. 3.2 Interaction plot for MRR

3.3.1 Model Analysis of MRR

The coefficients of model for S/N ratios for MRR are shown in Table 3.4. The parameter R^2 describe the amount of variation observed in MRR is explained by the input factor. R^2 = 99.7 % indicate that the model is able to predict the response with high accuracy. Adjusted R is a modified R^2 that has been adjusted for the number of terms in the model. If unnecessary terms are included in the model, R^2 Can be artificially high,but adjusted R^2 (=98.6 %.) may get smaller.

The standard deviation of errors in the modeling, S= 1.327. Comparing the p-value to a commonly used a-level = 0.05, it is found that if the p-value is less than or equal to a, it can be concluded that the effect is significant (shown in bold), otherwise it is not significant.

Table 3.4 Estimated Model Coefficients for SN ratios Term Coef

Term	Coef	Se coef	T	P
Constant	-1.5712	0.3127	-5.025	0.007
Dia 4	-0.5747	0.3127	-1.838	0.140
Ip 1	-11.5976	0.4422	-26.227	0.000
Ip 3	4.8052	0.4422	10.866	0.000
Ton 50	7.6805	0.4422	17.369	0.000
Ton 500	-0.2796	0.4422	-0.632	0.562
Dia x Ip 4 1	0.0519	0.4422	0.117	0.912
Dia x Ip 4 3	0.3973	0.4422	0.898	0.420
Dia x Ton 4 50	1.7636	0.4422	3.988	0.016
Dia x Ton 4 500	-0.3827	0.4422	-0.865	0.436
Ip x Ton 1 50	3.5404	0.6254	5.661	0.005
Ip x Ton 1 500	1.8758	0.6254	3.000	0.040
Ip x Ton 3 50	-0.1346	0.6254	-0.215	0.840
Ip x Ton 3 500	-2.9316	0.6254	-4.688	0.009
S = 1.327	**R – Sq = 99.7%R – Sq(adj) = 98.6%**			

The residual plot of MRR is shown in Fig 3.3. This layout is useful to determine whether the model meets the assumptions of the analysis. The residual plots in the graph and the interpretation of each residual plot indicate below:

a.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.

b. Residuals versus fitted values indicate the variance is constant and a nonlinear relationship exists as well as no outliers exist in the data.

c. Histogram proves the data are not skewed and not outliers exist.

d. Residuals versus order of the data indicate that there are systematic effects in the data due to time or data collection order.

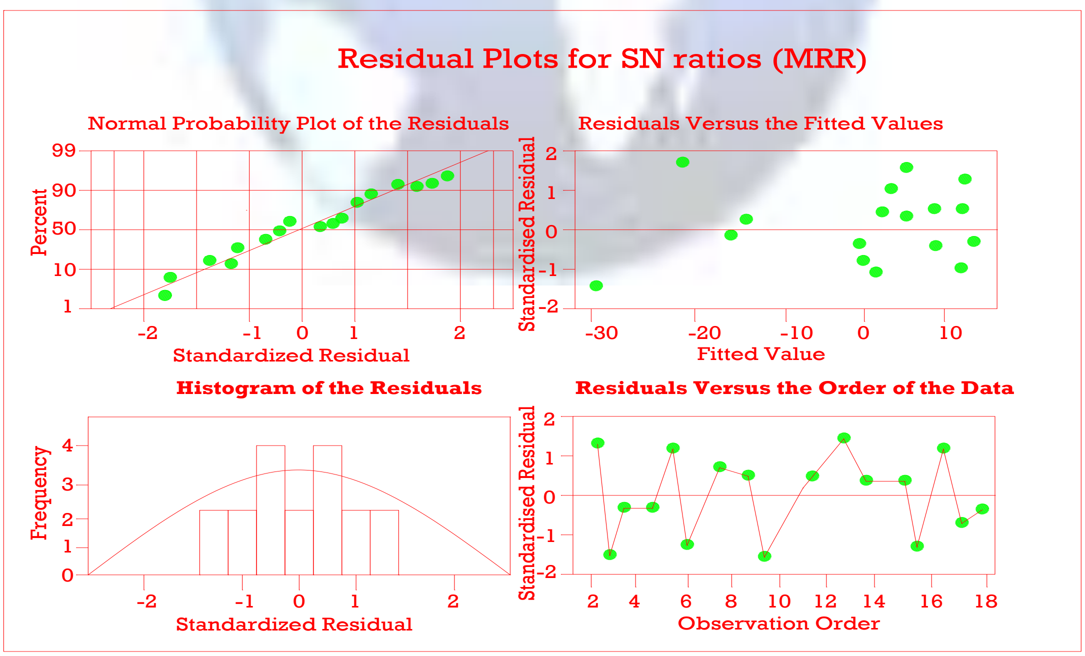

Fig. 3.3 Residual plot for MRR

3.4 INFLUENCES ON TWR

The S/N ratios for TWR are calculated as given in Equation 3.2. Taguchi method is used to analysis the result of response of machining parameter for smaller is better (SB) criteria.

Sb : $\eta = -10 \log[1/n\sum_{i=1}^{n} yi^{-2}]$ **. . . . . (3.2)**

The analysis of variances for the factors are Dia, Ip , Ton, and Ipx,Ton as shown in Table 3.5 is clearly indicate that the diameter of the tool is not important for influencing TWR and the value of Ip and Ton is most effected the TWR and as well as interaction Ip x Ton significant are shown in bold and otherwise not significant. The delta values are Dia. of tool, Ip and Ton are2.81, 18.36 and 17.04 respectively, in Table 3.6. The case of TWR Smaller is better, so from this table it is clearly definite that Ip is the most important factor then Ton and last is dia.of the tool.

Table 3.5: Analysis of Variance for 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 x Ip	2	12.42	12.42	6.209	2.98	0.161
Dia x Ton	2	71.66	71.66	35.828	17.19	0.011
Ip x 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 3.6: 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
Delta	2.81	18.36	17.04
Rank	3	1	2

During the process of EDM, the influence of various machining parameter like Ip, Ton and Diameter of tool has significant effect on TWR , as shown in main effect plot for S/N ratio of TWR in Fig 3.4. Increasing in the discharge current from 1 to 3 A the tool wear rate is decreasing, but discharge Current in the range of 3 to 5 A the tool wear rate is increasing. Because of Ip increases the pulse energy increases and thus more heat energy is produced in the tool work piece interface, leads to increase the melting and evaporation of the electrode. One can interpret that Ip has a significant direct impact on TWR . And pulse on time is directly proportional to the tool wear rate. And diameter of the tool has no significant effect on TWR. The interaction plot of TWR is shown in Fig 3.5, where each plot exhibits the interaction between three different machining parameters like Ip Ton and dia. of tool. This implies that the effect of one factor is dependent upon another factor. It is also confirmed by the ANOVA table (Table 3.5).

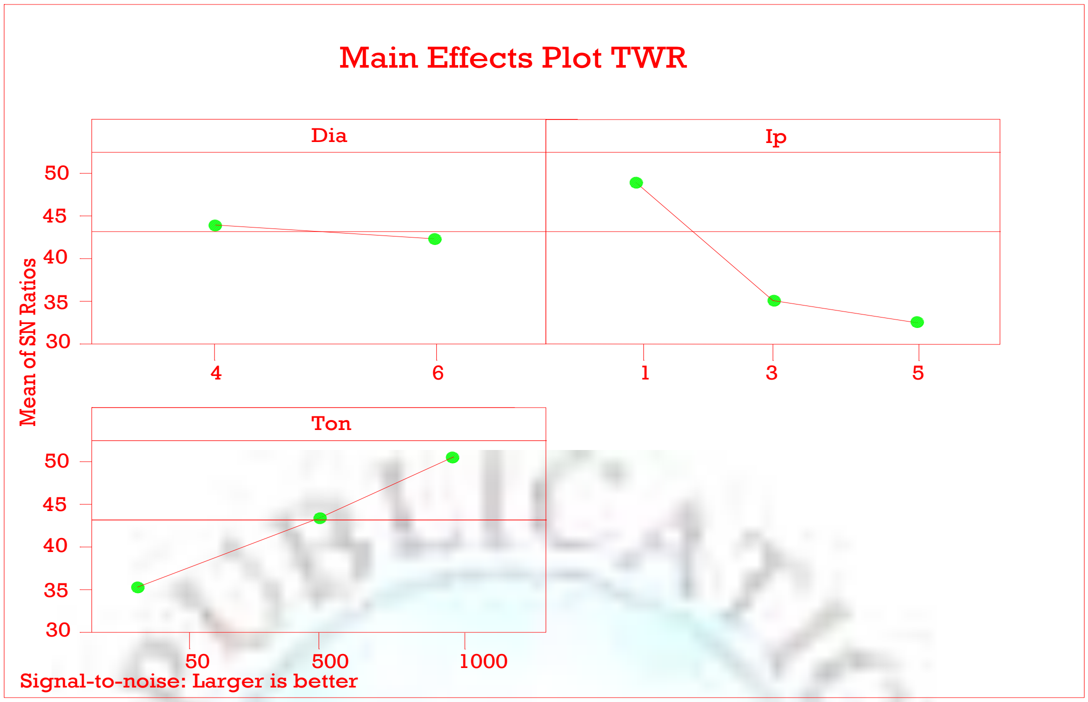

Fig. 3.4: Main effect plots for SN ratios (TWR)

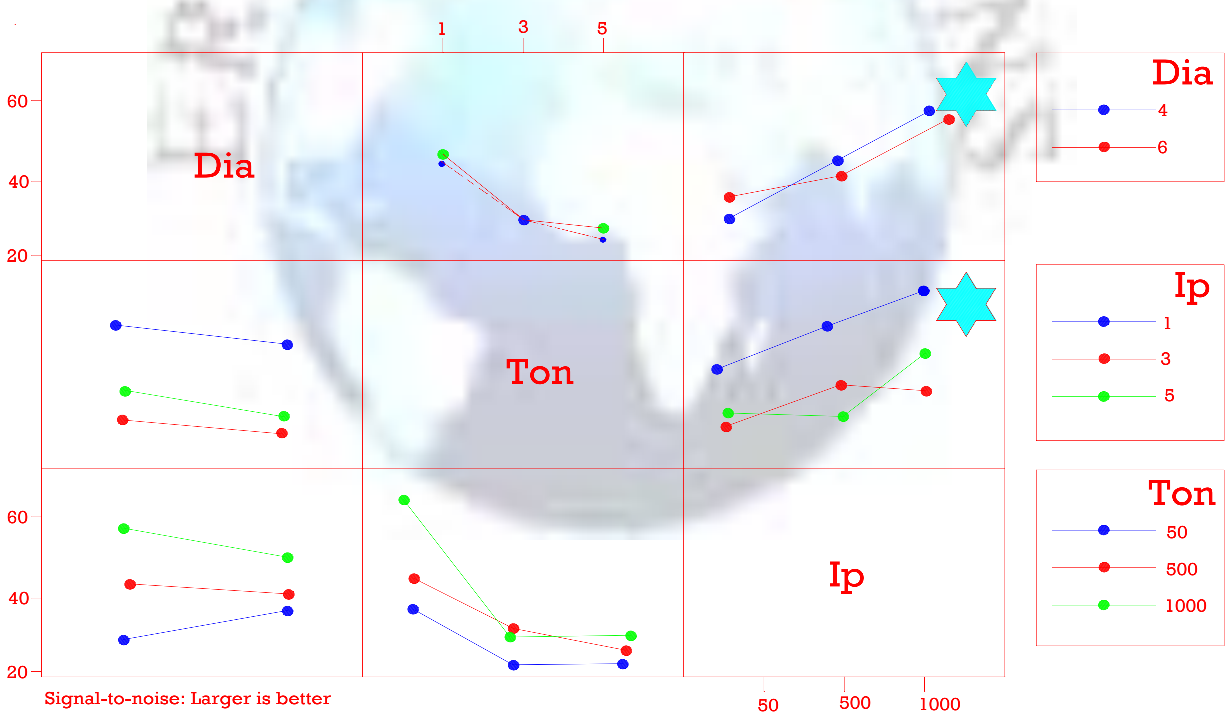

Fig. 3.5: Interaction plot for TWR

3.4.1 Model Analysis of TWR:

The coefficients of model for S/N ratios for TWR are shown in Table 3.7. The parameter R^2 (amount of variation)= 99.7% , Adj R2 = 98.5% , and standard deviation of error in the molding S= 1.444. And comparing the p value (less than 0.05) it can be concluded that the effect is significant (shown in bold), otherwise it is not significant.

Table 3.7: Estimated Model Coefficients for SN ratios (TWR)

Term	Coef	Se coef	T	P
Constant	38.2922	0.3403	112.537	0.000
Dia 4	1.4037	0.3403	4.125	0.015
Ip 1	11.3724	0.4812	23.633	0.000
Ip 3	-7.0097	0.4812	-14.567	0.000
Ton 50	8.4723	0.4812	-17.607	0.000
Ton 500	-0.0960	0.4812	-0.199	0.852
Dia x Ip 4 1	-0.9731	0.4812	-2.022	0.113
Dia x Ip 4 3	-0.0833	0.4812	-0.173	0.871
Dia x Ton 4 50	-2.2372	0.4812	-4.649	0.010
Dia x Ton 4 500	-0.3706	0.4812	-0.770	0.484
Ip x Ton 1 50	-3.6251	0.6805	-5.327	0.006
Ip x Ton 1 500	-0.3604	0.6805	-0.530	0.624
Ip x Ton 3 50	2.0048	0.6805	2.946	0.042
Ip x Ton 3 500	4.4999	0.6805	6.612	0.003
S = 1.444 R – Sq = 99.7%		**R – Sq(adj) = 98.5%**		

The residual plot of TWR is shown in Fig 3.6. This residual plot in the graph and the interpretation of each residual plot indicate below.

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

3.5 INFLUENCES ON OVER CUT

The S/N ratios for OC are calculated as given in Equation 3.2. Taguchi method is used to analysis the result of response of machining parameter for smaller is better (SB) criteria.The analysis of variances for the factors are Dia, Ip , Ton, and IpxTon as shown in Table 3.8 is clearly indicate that the interaction factors Ton x Dia. and Ton x Ip is not significant for OC and the value of Ip is most influencing of OC and also Dia. of tool is significant (shown in bold). The delta values are Dia. of tool, Ip and Ton are 7.900, 9.449 and 2.777 respectively, in Table 3.6. The case of OC Smaller is better, so from this table it is clearly definite that Ip is the most important factor then dia. of the tool and last is Ton.

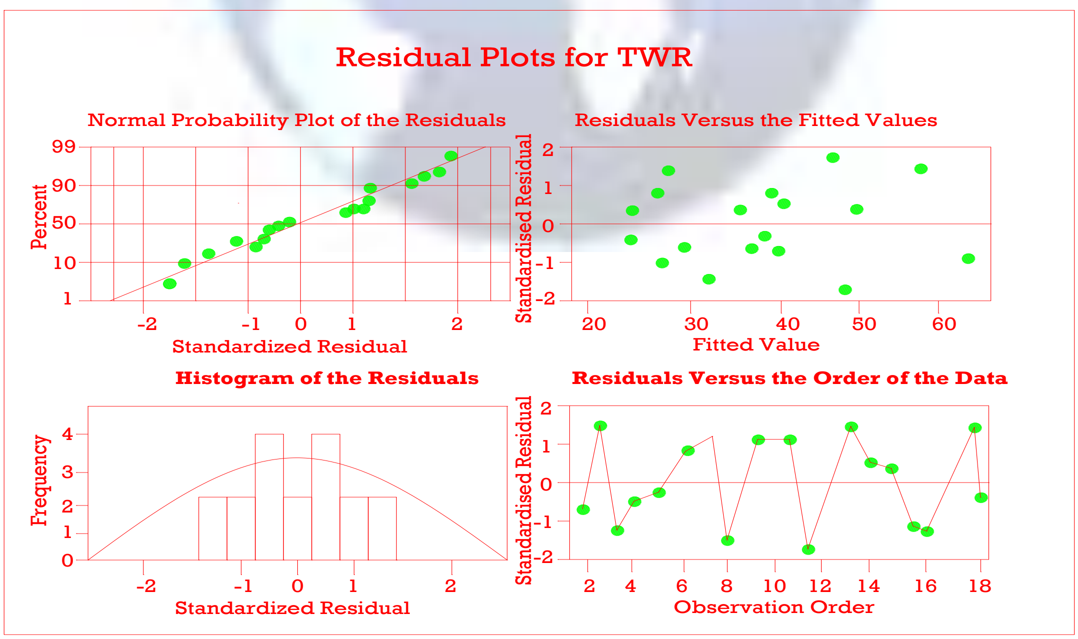

Fig. 3.6 Residual Plots for TWR

Table 3.8 Analysis of Variance for SN ratios (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	172.831	172.831	149.19	0.000
Ton	2	23.182	11.591	11.591	10.01	0.028
Dia x Ip	2	144.814	72.407	72.407	62.50	0.001
Dia x Ton	2	0.965	0.482	0.482	0.42	0.685
Ip x Ton	4	24.310	6.077	6.077	5.25	0.069
Residual error	4	4.634	1.158	1.158		
Total	17	824.379				

Table 3.9 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

The over cut between the dimension of the electrode and the size of the cavity it is inherent to the EDM process which is unavoidable though adequate compensation are provided at the tool design. To achieve the accuracy, minimization of over cut is essential. Therefore factors affecting of over cut is essential to recognize. The over cut are effect to each parameter such as diameter of tool, discharge current and pulse on time, the main effect plot for S/N ratios shown by Fig 3.7 for over cut . This graphs are represent the diameter of tool is directly proportional to the over cut.

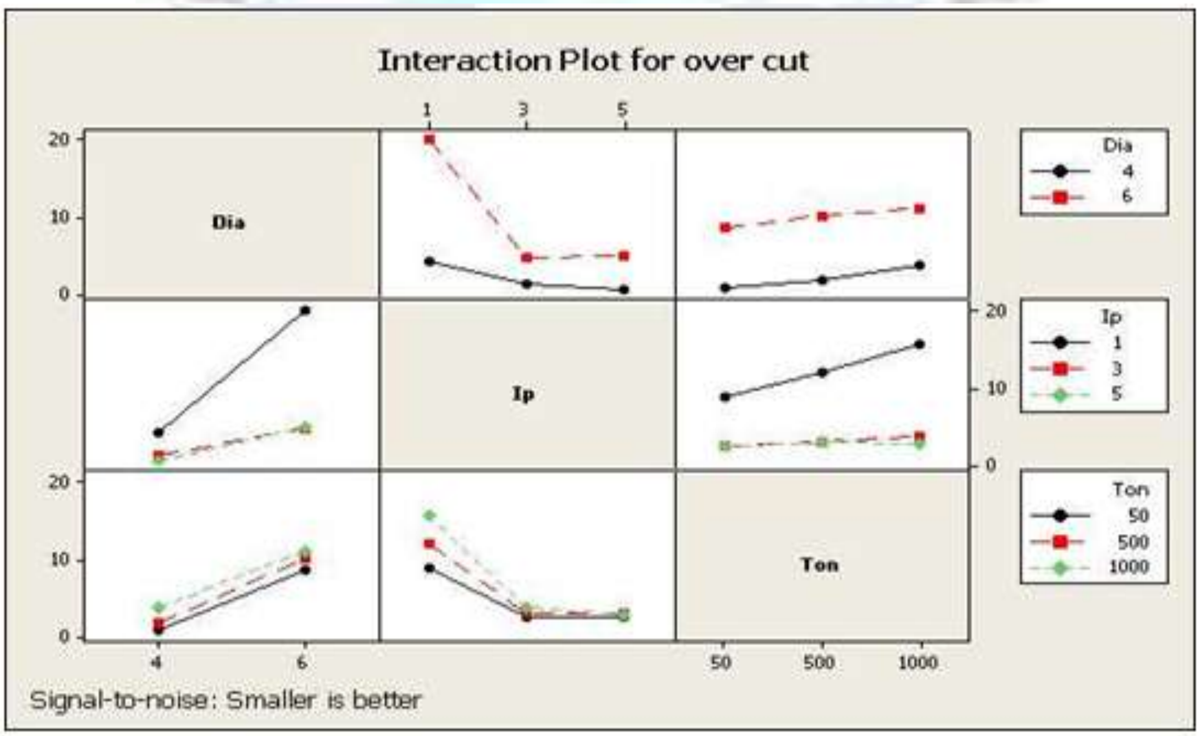

Fig. 3.7: Main effect plots for over cut

And the interaction plot of OC is shown in Fig 3.8, where each plot exhibits the interaction between three different machining parameters like Ip Ton and dia. of tool. This implies that the effect of one factor is dependent upon another factor. It is also confirmed by the ANOVA table (Table3.8).

International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463
Vol. 4 Issue 6, June-2015, pp: (538-551), Impact Factor: 1.252, Available online at: www.erpublications.com

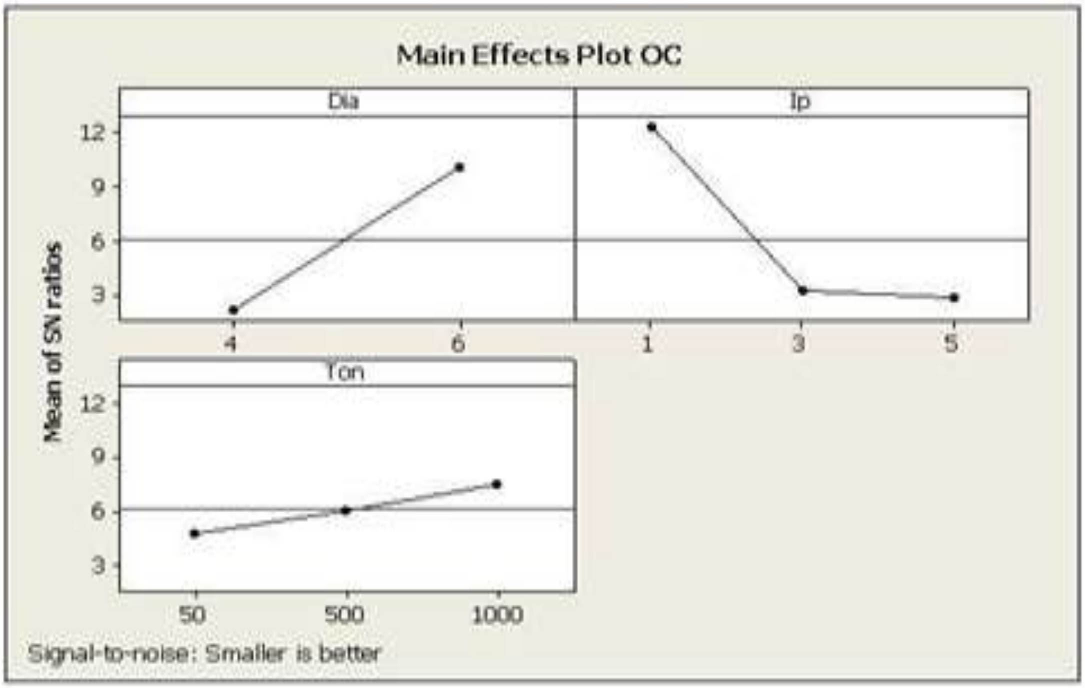

Fig. 3.8 Interaction plot for over cut

3.5.1 Model Analysis of OC

The coefficients of model S/N ratios for over cut shown in table 3.10 and parameter result are standard deviation of error S=1.076, amount of variation R = 99.4% and R2 (adj.) = 97.6%. And comparing the P value is less than or equal to 0.05 it can be concluded that the effect is significant (shown in bold), otherwise not significant.

Table 3.10 Estimated Model Coefficients for SN ratios (OC) Term

Term	Coef	Se coef	T	P
Constant	6.12461	1.022	5.993	0.000
Dia 4	-3.94977	1.022	-3.865	0.005
Ip 1	6.19469	1.445	4.286	0.003
Ip 3	-2.94067	1.445	-2.035	0.076
Ton 50	-1.35038	1.445	-0.934	0.377
Ton 500	-0.07594	1.445	-0.053	0.959
Dia x Ip 4 1	-3.99804	0.3588	-11.144	0.000
Dia x Ip 4 3	2.28120	0.3588	6.358	0.003
Dia x Ton 4 50	-0.00677	0.3588	-0.019	0.986
Ip x Ton 1 50	-1.89252	2.044	-0.926	0.382
Ip x Ton 1 500	-0.19081	2.044	-0.093	0.928
Ip x Ton 3 50	0.80375	2.044	-0.393	0.704
Ip x Ton 3 500	-0.03116	2.044	-0.015	0.988
S = 1.076	**R – Sq = 99.4%**		**R – Sq(adj) = 97.6%**	

The residual plot for over cut is shown in fig 3.3. This residual plot in the graph for normal probability plot indicates the data are normally distributed and variables are influencing the response.

And the Residuals versus fitted value indicate the variation is constant. And the Histogram proved the data are not skewed and not outline exist. And Residual versus order of the data indicates that there are systematic effects in the data due to time or data collection order.

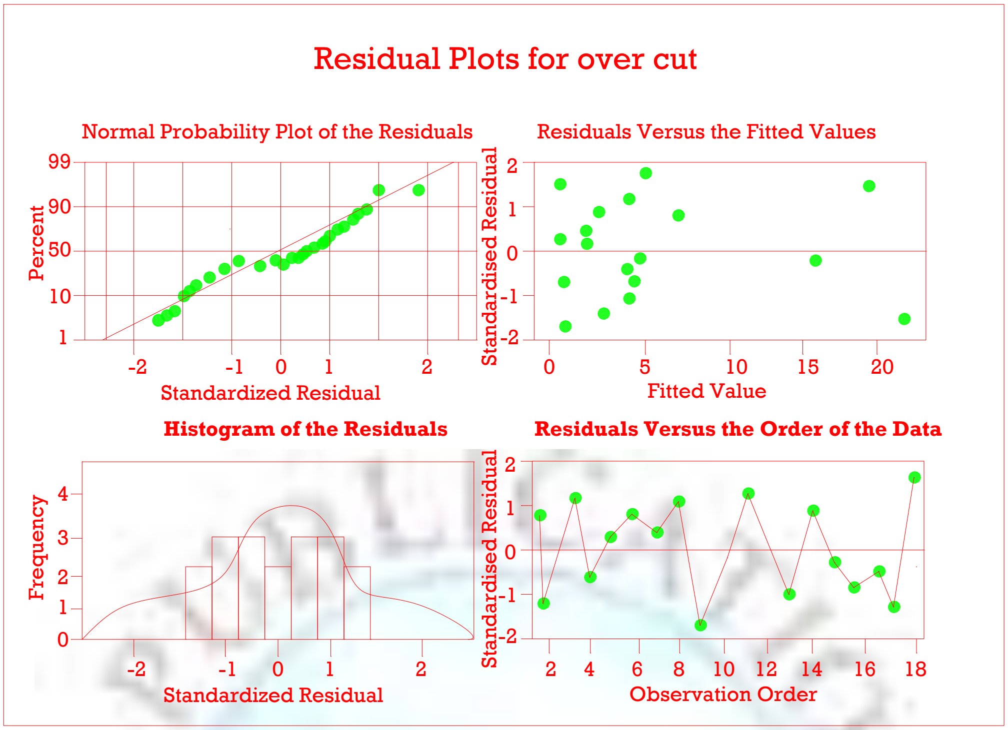

Fig. 3.9 Residual Plots for over cut

CONCLUSION

In the present study on the effect of machining responses are MRR, TWR and OC of the AISI P20 plastic mould steel component using the U-Shaped cu tool with internal flushing system tool have been investigated for EDM process. The experiments were conducted under various parameters setting of Discharge Current (Ip), Pulse On-Time (Ton), and diameter of the tool. L-18 OA based on Taguchi design was performed for Minitab software was used for analysis the result and theses responses were partially validated experimentally.

(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.

REFERENCES

.
[1]. Jeswani, M.L., 1981, “Effects of the addition of graphite powder to kerosene used as thedielectric fluid in electrical discharge machining”, Wear, 70, 133–139.
[2]. Erden, A., 1983, “Effect of materials on the mechanism of electric discharge machining (EDM)”, J. Eng. Mater. Technol., 105, 132–138.
[3]. S. Tariq Jilani, P.C. Pandey, (1984):Experimental investigations into the performance of water as dielectric in EDM, International Journal of Machine Tool Design and Research, 24, pp.31–43.
[4]. Sato, T., Mizutani, T., Yonemochi, K., Kawata, K., 1986, “The development of an electrodischarge machine for micro-hole boring”, Precision Engineering, 8 (3), 163–168.
[5]. Pandit, S.M., Mueller, T.M., 1987 “Verification of on-line computer control of EDM by data dependent systems”, J. Eng. Ind., 109, 109–121.
[6]. W. Koenig, L. Joerres (1987): A aqueous solutions of organic compounds as dielectric for EDM sinking, CIRP Annals—Manufacturing Technology, 36, pp. 105–109.
[7]. Phadke M.S. 1989, Quality Engineering Using Robust Design, Prentice-Hall, Englewood Cliffs, NJ.
[8]. Luis, C.J., Puertas, I., Villa, G., 2005 “Material removal rate and electrode wear study on the EDM of silicon carbide”, Journal of Materials Processing Technology, 164–165, 889–896.

[9]. Unal R, Dean E.B. 1991, Taguchi approach to design optimization for quality and cost: an overview, in: Proceedings of the International Society of Parametric Analyst 13th Annual, May 21–24
[10]. Bayramoglu, M., Duffill, A.W., 1992, "Production of three dimensional shapes using computational electrical discharge machining", In Proc. Int. M.T.D.R. conf., pp 107-112.
[11]. Glen Stuart Peace, "Taguchi Methods", Addison-Wesley Publishing, inc, 1993.
[12]. W. Konig, F.-J.Siebers, (1993): Influence of the working medium on the removal process inEDM sinking, American Society of Mechanical Engineers, Production Engineering Division (Publication) PED 64, pp. 649–658.
[13]. A.K.M. AsifIqbal and Ahsan Ali Khan (2010): Influence of Process Parameters on Electrical Discharge Machined Job Surface Integrity, American J. of Engineering and Applied Sciences 3, No.2, pp. 396-402.
[14]. Bayramoglu, M., Duffill, A.W. (1995): Manufacturing linear and circular contours using CNC EDM and frame type tools, Int. J. Mach. Tools Manuf., 35(8), pp.1125–1136.
[15]. Wong, Y.S., Lim, L.C., Lee, L.C., 1995, "Effect of flushing on electro-discharge machined surfaces", Journal of Materials Processing Technology, 48, 299–305
[16]. RanjitK.Roy, "A Premier On The Taguchi Method", Van Nostrand Reinhold, New York,1996.
[17]. Chen, S.L., Yan, B.H., Huang, F.Y. (1999): Influence of kerosene and distilled water asdielectric on the electric discharge machining characteristics of Ti-6Al-4V", Journal of Materials Processing Technology, 87, 107– 111.
[18]. Harpuneet Singh (2012):Investigating the Effect of Copper Chromium and Aluminum Electrodes on EN-31 Die Steel on Electric Discharge Machine Using Positive Polarity, Proceedings of the World Congress on Engineering ,Vol III WCE 2012, July 4 - 6, London, U.K.
[19]. B.H. Yan, C.C. Wang, W.D. Liu and F.Y. Huang, "Machining Characteristics of Al2O3/6061Al Composite using Rotary EDM with a Disklike Electrode", The International Journal of Advanced Manufacturing Technology, 16:322-333, 2000.
[20]. Lin, J.L., Wang, K.S., Yan, B.H., Tarng, Y.S., 2000, "Optimization of the electrical discharge machining process based on the Taguchi method with fuzzy logics", Journal of Materials Processing Technology, 102, 48–55.