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EXPERIMENTAL INVESTIGATIONS 0N ELECTRIC DISCHARGE MACHINE USING DIFFERENT MATERIALS BY GREY THAGUCHI METHOD AND OPTIMISING BY MINITAB TOOL

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Abstract-Going with the improvement of mechanical industry, the requests for combination materials having high hardness, sturdiness and effect opposition are increasing all things considered , such materials are hard to be machined by customary machining strategies. Consequently , non-conventional machining techniques including electrochemical machining ,ultrasonic machining ,electrical release machining (EDM) and so forth are connected to machine such hard to machine materials. Electric discharge machining is non traditional machining process utilized for machining hard and hard to machine materials.In this process a pulse discharge occurs in a small gap between the Working parts and electrodes and removing unnecessary material from the metal by melting and evaporating. In EDM, electronics and decorations are not connected to the process of removing electrical equipment and mechanism. which is converted into thermal energy through a series of subdued electrical discharge energy prevail between the cathode(work piece)and the anode (electrode) sinking in an insulating dielectric fluid. It is commonly used in mould, die making industry and in manufacturing of automotive, aerospace surgical components. The objective of the present work is to optimize the machining parameters for die sinking operation of EDM so as to achieve high material removal rate (MRR) and best surface roughness (SR). Three materials high carbon steel, mild steel and alluminium-6061 as work pieces and copper electrode of 10mm square shaped tool were used to carry out experiments by varying the input process parameters like discharge current (Ip) pulse on time (T_{ON}) and duty cycle. The output process parameters like MRR and SR will be determined for every experimental runs. By implementing the Taguchi L9 orthogonal array (OA) using commercial tool Minitab17 response to the variation of input parameters as an output was investigated with minimum no of experimental runs. Taguchi single objective optimization method was used to study the effect of individual input and output parameters for optimization both input and output parameters. The results this obtained from the above are given as inputs to Grey Taguchi multi objective optimization technique so to determine the optimized cumulative parameters.

Key words-EDM, high carbon steel ,mild steel, L9 OA, Grey Taguchi,minitab, MRR and SR.

INTRODUCTION OF EDM

Manufacturing process can be divided into two manufacturing process one is primary manufacturing process and second one is secondary manufacturing process. The primary manufacturing process involves providing the basic size and shape of the machining part. The secondary manufacturing process offers final size and shape with better tolerance of the dimensions and surface characteristics. The process of material removal can be divided into two types, these are:

- conventional machining process
- non traditional or non conventional machining process

Working Principle of Electrical Discharge Machining

The machining procedure is completed inside the dielectric liquid which makes way for release. At the point when potential contrast is connected between the two surfaces of work piece and device, the dielectric gets ionized and electric sparkles/releases are produced over the two terminals. An outside direct current power supply is associated over the two terminals to make the potential contrast. The extremity between the apparatus and work piece can be traded yet that will influence the different execution parameters of EDM process. For additional material expulsion rate work piece is associated with positive terminal as two third of the aggregate warmth produced is created over the positive terminal. The entomb anode hole between the instrument and work piece has a huge part to the advancement of release. As the work piece stay settled to the base by the apparatus plan, the instrument helps in centering the force of produced warm at the place of shape impartment. The use of centered warmth of the instrument raises the temperature of work piece in that locale, which thus

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dissolves and dissipates the metal. Thusly little volumes of work piece material are evacuated by the component of softening and vaporization amid a release. In a solitary start volume of material evacuated is little in the scope of 10-6 to 10-4 mm3, yet this fundamental procedure is constant around 10,000 times each second [5]. The disintegration procedure comprises of five stages, to be specific pre breakdown, breakdown, release, end of release and post release which are appeared in figure 1.2. Plasma channel is made between the terminal and work piece with the assistance of electro warm vitality and temperature ranges are 8000˚c to 12000˚c. With this high temperature of plasma state dissolving happens. This happens as (a) Pre-breakdown phase (b) Breakdown phase (c) Discharge phase (d) End of the discharge and (e) Post-discharge phase.

SELECTION OF WORKPIECES, ELECTRODES and PROCESS PARAMETERS

Material selection

Three different types of work pieces are used to do this experiment materials are high carbon steel, Mild Steel and alluminiu,-6061. The tool material used is copper for machining process in this work.

High carbon steel: high carbon steel remains popular for a wide variety of uses. This type of steel is applied in the manufacturing tools such as drill bits, knives, masonry nails, saws, metal cutting tools and wood cutting tools.

Mild steel: the Mild steel material is mainly used in making of pipes, transporting the water & natural gas, machine parts manufacture, building of frames and making gates.

Al-6061: The aluminium-6061 is mainly used at aircraft, aerospace components, and make for bicycle frames, drive shafts, electrical fitting and connectors.

Copper: Copper and copper alloys have better EDM wear resistance than brass, but are more difficult to machine than either brass or graphite. It is also more expensive than graphite. Copper is, however, a common base material because it is highly conductive and strong. It is useful in the EDM machining of tungsten carbide, or in applications requiring a fine finish. Copper can produce very fine surface finishes, even without special polishing circuits. With development of the transistorized, pulse-type power supplies, Electrolytic (or pure) Copper became the metallic electrode material of choice. This is because the combination of Copper and certain power supply settings enables low wear burning. Also, Copper is compatible with the polishing circuits of certain advanced power supplies.

Chemical composition:

ELEMENTS	**HIGH CARBON STEEL**	**MILD STEEL**	**ALUMINUM-6061**
Si	0.06	0.171	0.52
Mg	-	-	1.15
Mn	0.35	0.608	-
Zn	-	-	0.08
Cr	-	-	0.25
Ti	-	-	-
Cu	-	-	0.35
Fe	BALANCED	98.69	0.12
Al	-	-	BALANCED
C	0.85	0.223	-
S		0.036	-

Table 1: chemical composition for each material

Process Parameters : The input parameters are Discharge current, Pulse on time, Duty cycle the output parameters are MRR and SR.

EXPERIMENTAL SETUP:

Experimentation is done on Electronica SE-35die sinking EDM machine is shown in fig1. In EDM at first an ignition voltage around 200V is applied between the electrodes. The electrode is moved near the work piece which causes break down of the dielectric fluid (EDM oil of grade SAE450)Without contact with each other .

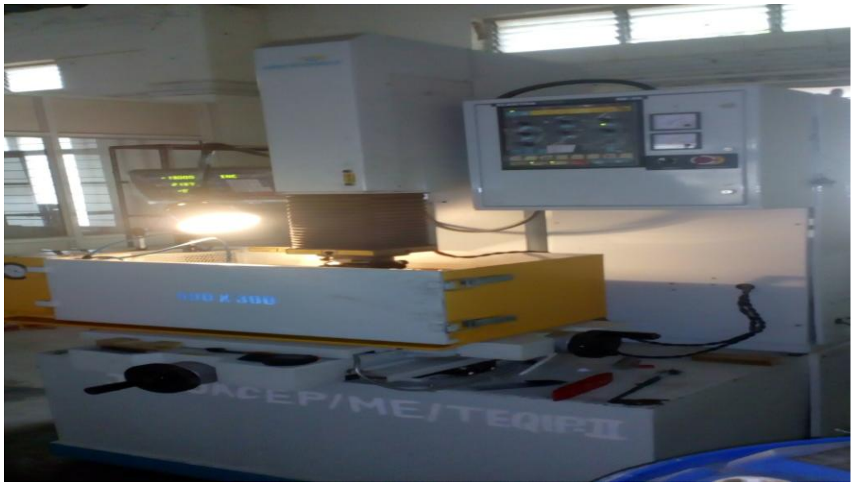

Figure 3: ELECTRIC DISCHARGE MACHINE

MACHINE SPECIFICATIONS

Description	**Electrical discharge machine**
Model	Electronica plus
Die electric medium	EDM oil
Types of Materials Cutting	MS, SS, Al, Brass, Titanium and EN Steels.
Supply Voltage	115/230V – 50Hz
Maximum power consumption	20 VA
Supply voltage fluctuation	Not to exceed $\pm$ 10% of the operating voltage
Type of flushing	Side jet flushing
Flushing pressure	0.25 kg/cm^2
Tolerance (+/-)	Depends on the thickness of material
Accuracy (+ / -)	0.6 – 1 mm
Discharge current	1-20 amp
Pulse on time	0.5-2000 μsec

Table 2: Machine specifications

Design of experiments*:* They are four types. (1) One factor (2) Factorial design (3) Response surface method designs (4) Reliability DOE.

ORTHOGONAL ARRAY -L9

Taguchi has tabulated 18 basic standards OA's. Depending upon the number of factors and their levels, it is generally possible to select one of these for a specific requirement. However the standard OA's can also be modified to suit complicated designs. The first step in selecting the appropriate OA involves the total degree of freedom. In this study L9 orthogonal array is selected having 8 degree of freedom with three input factors with three levels. The degree of freedom for three levels test is 3(3-1) = 6. And the degrees of freedom for experiments are 9. So as per Taguchi technique, the DOF for DOE is less than the DOF freedom for number of experiments. Hence L9 OA is selected. The control log for the experiment is then prepared by assigning the levels of each parameter to various rows of the OA. Such designed experiments are called matrix experiments and individual experiment constituting one row of the OA is called run (or) treatment. Experiments are performed at random by setting the value of each process parameter according to a single row of the OA. Three repetitions of each setting are desirable

Evaluation of MRR
MRR is defined as the ratio of the weight loss of the work piece before and after machining to the machining time.

$$\text{MRR} = \frac{\text{weight loss}}{\text{machining time}} = \left(\frac{W_i - W_f}{t}\right) \text{gm/min}$$

Where W_i = initial weight before machining W_f = final weight after machining t = machining time

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Measurement of Surface Roughness

Roughness of surface is a measure of texture of surface. It is counted by the vertical non conformities of the real surface from its perfect surface. It is more important inaccuracy by tolerance. If the tolerance is high, the surface roughness of a work piece is not in a good condition. Die sinking EDM produces a variety shapes in terms of length, width and thickness. While producing the product, the most important parameter to continuous the process is surface finish for any type of shape. In moulding or stamping industry, surface roughness values are more important considerations to increase the quality of the product.

EXPERIMENAL RESULTS

Experimental results for machined work pieces:

Run No.	Weight Before Machining (gm)	Weight after machining (gm)	Weight loss(gm)	Time taken for machining (min)	MRR (gm/sec)	SR (microns)
1	171.7	170.5	1.2	15.01	0.0799	1.856
2	170.5	169.0	1.5	13.83	0.1084	2.1
3	169.0	167.4	1.6	53.35	0.0299	0.74
4	167.4	166.0	1.4	6.22	0.2250	1.73
5	166.0	164.8	1.2	21.43	0.0559	1.983
6	164.8	163.4	1.4	23.0	0.0608	0.696
7	163.4	162.0	1.4	4.31	0..3248	1.676
8	162.0	160.4	1.6	5.32	0.3007	2.156
9	160.4	159.0	1.4	12.27	0.1140	0.836

Table 3: HIGH CARBON STEEL Calculation sheet for Measuring MRR and SR

Run No.	Weight Before Machining (gm)	Weight after machining (gm)	Weight loss (gm)	Time taken for machining (min)	MRR (gm/sec)	SR (microns)
1	151.0	149.7	1.3	13.11	0.99	1.55
2	149.7	148.2	1.5	19.25	0.077	1.63
3	148.2	146.7	1.5	50.14	0.029	1.43
4	146.7	145.2	1.5	6.42	0.233	2.51
5	145.2	143.6	1.6	7.05	0.226	3.61
6	143.6	142.3	1.3	15.20	0.085	2.11
7	142.3	141.0	1.3	5.30	0.245	2.01

8	141.0	138.7	1.3	6.17	0.210	2.71
9	138.7	137.2	1.5	9.18	0.163	2.74

Table 4: MILD STEEL Calculation sheet for Measuring MRR and SR

Run No.	Weight Before Machining (gm)	Weight after machining (gm)	Weight loss (gm)	Time taken for machining(min)	MRR (gm/sec)	SR (microns)
1	284.3	283.9	0.4	3.35	0.119	2.88
2	283.9	283.4	0.5	20.15	0.024	2.48
3	283.4	282.8	0.6	11.33	0.052	2.13
4	282.8	282.3	0.5	1.53	0.326	2.62
5	282.3	281.7	0.6	2.14	0.280	1.88
6	281.7	281.1	0.6	2.24	0.267	2.21
7	281.1	280.6	0.5	6.11	0.081	2.44
8	280.6	280.1	0.5	1.31	0.381	2.65
9	280.1	279.5	0.6	1.45	0.413	2.74

Table 5: AL-6061 Calculation sheet for Measuring MRR and SR

GREY THAGUCHI METHOD

Signal to Noise (S/N) Ratio

In Taguchi method, S/N Ratio is the Statistical measuring process for predict the optimum factors to respected Responses. Analysis in this content has tended to identify the components, which are influencing the normal reaction. A few signal to noise degrees available depending upon the category of characteristics. The Smaller the better, Higher the better and Nominal the better are three sorts for the S/N Ratio, for examine the factor's enactment.

S. No.	**Sort**	**Formulae**
01	Smaller the Better	$S/N = -10\log_{10} \sum_{i=1}^{n} (1/n)\,(Y^2{}_i)$ **or** $S/N = -10\log_{10} Y^2$
02	Nominal the Better	$S/N = -10\log_{10}(\bar{Y}^2/S^2)$, $S/N = -10\log_{10}(S^2)$
03	Bigger the Better	$S/N = -10\log_{10} \sum_{i=1}^{n} (1/n)\,(1/Y^2{}_i)$ **or** $S/N = -10\log_{10} \frac{1}{Y^2}$

Table6: Formulae of S/N Ratio

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GREY THAGUCHI METHOD FOR HIGH CARBON STEEL:

Exp No.	Grade	S/N ratio
1	0.3801	-8.4009
2	0.3736	-8.5518
3	0.6381	-3.9022
4	0.5050	-5.9333
5	0.3628	-8.8054
6	0.3924	-8.1243
7	1	0
8	0.7833	-2.1208
9	0.6163	-4.2041

Table 7 :Grey relational grade for (S/N ratio)

GREY THAGUCHI METHOD FOR MILD STEEL

Exp No.	Grade	S/N RATIOS
1	0.662	-3.582
2	0.617	-4.194
3	0.666	-3.530
4	0.705	-3.091
5	0.591	-4.560
6	0.508	-5.874
7	0.825	-1.665
8	0.606	-4.343
9	0.511	-5.831

Table 8: grey relational grades for S/N RATIOS

GREY THAGUCHI METHOD FOR AL-6061

Exp No.	Grade	S/N ratios
1	0.699	-3.110
2	0.3935	-8.112
3	0.508	-5.882
4	0.546	-5.256
5	0.463	-6.688
6	0.586	-4.642
7	0.420	-7.535
8	0.625	-4.082
9	0.685	-3286

Tabel 9: grey relational grades for S/N RATIOS

OPTIMISED VALUES OBTAINED FROM MINITAB TOOL

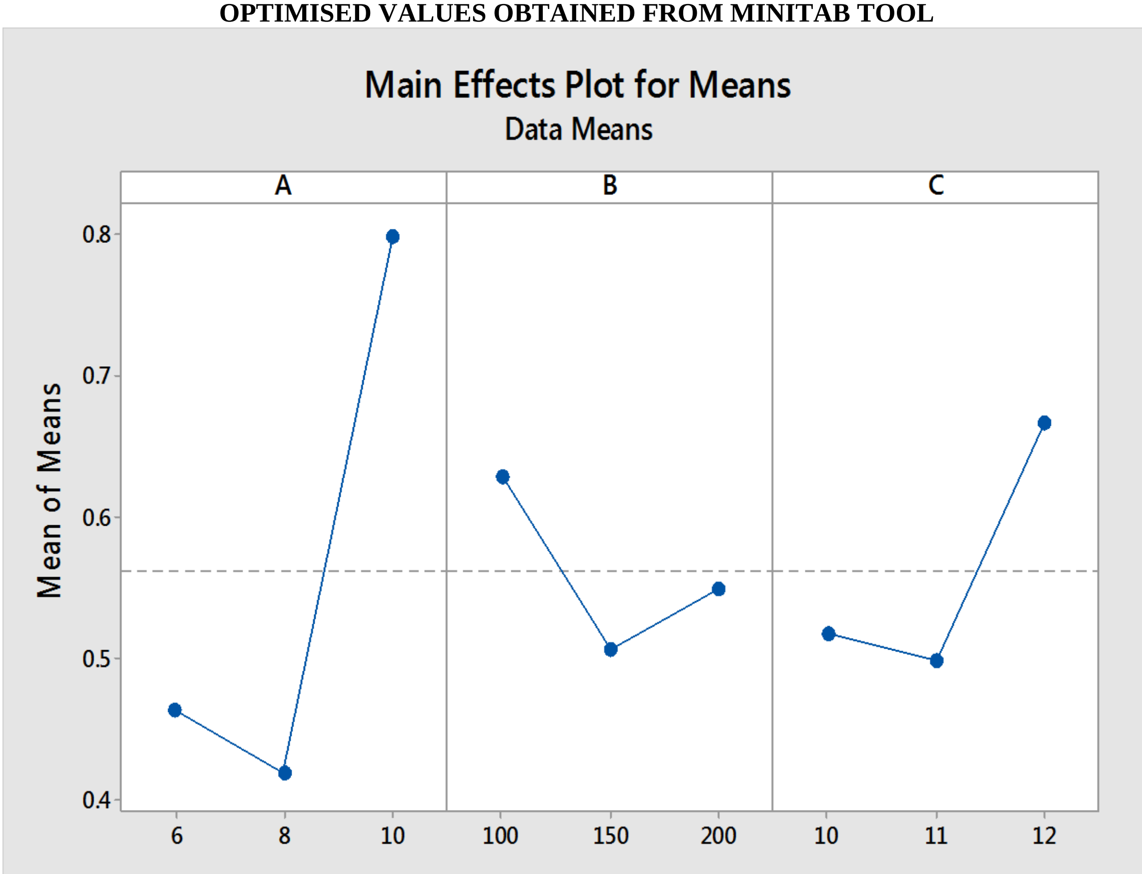

Figure 10 : Main effect plot for Grey relational grade(means) for HCS

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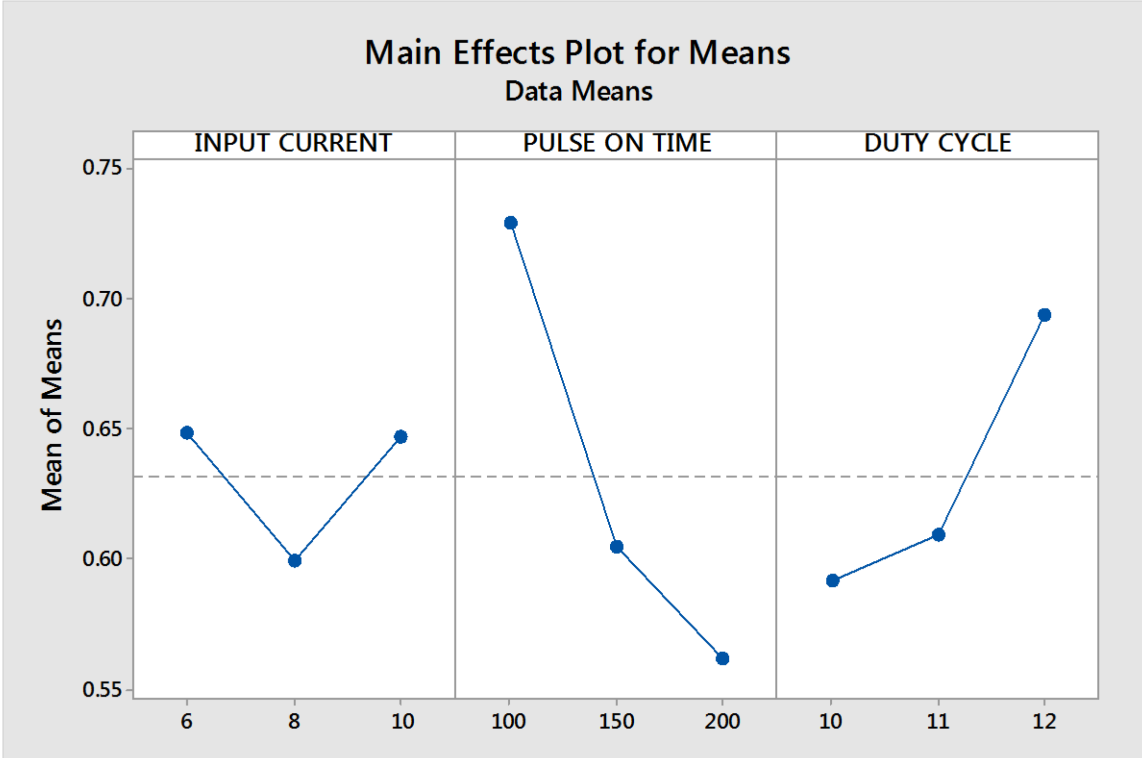

Figure 11: Main effect plot for Grey relational grade(means) for MILD STEEL

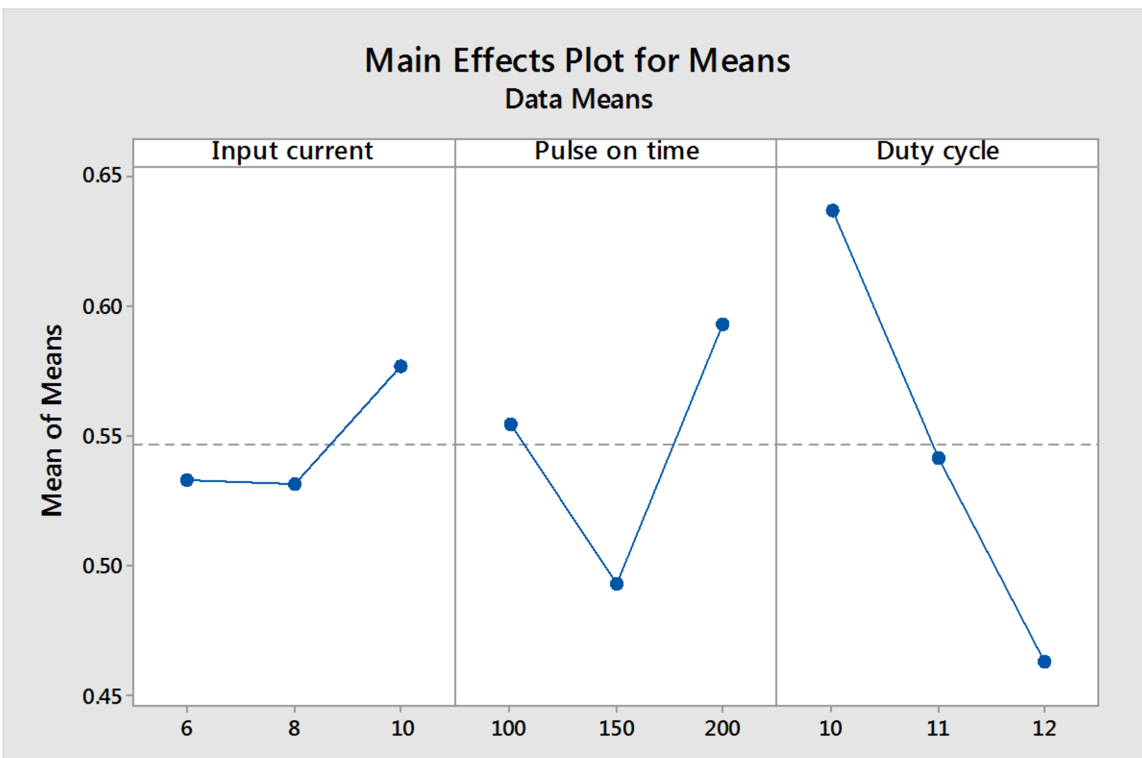

Figure 12: Main effect plot for Grey relational grade(means)for AL-6061

RESULT

The Experimental investigational data is normalized and grey relational grade is obtained. It is kept the maximum value i.e. higher the better. Then the values are subjected to ANOVA test which provided the percentage contribution of the input parameters. The optimized value is obtained from the main effect plots for means. From response table the input parameters are ranked to determine which input variable affects more on the output response. So the following results are obtained after the tests were completed.

OPTIMAL MATERIAL REMOVAL RATE AND SURFACE ROUGHNESS FOR HIGH CARBON STEEL

discharge current (Amp	pulse on time (μ sec)	duty cycle (%)	MRR **(mg/min)**	SR **(μm)**
10	100	12	0.3248	0.696

OPTIMAL MATERIAL REMOVAL RATE AND SURFACE ROUGHNESS FOR MILD STEEL

discharge current (Amp	pulse on time (μ sec)	duty cycle (%)	MRR**(mg/min)**	SR**(μm)**
6	100	12	0.245	1.33

OPTIMAL MATERIAL REMOVAL RATE AND SURFACE ROUGHNESS FOR ALUMINIUM-6061

discharge current (Amp	pulse on time (μ sec)	duty cycle (%)	MRR**(mg/min)**	SR**(μm)**
10	200	10	0.413	1.88

CONCLUSION

The effect of process parameters on output of the Electrical discharge machining process have been discussed and the optimal setting of process parameters has been obtained for maximum material removal rate (MRR) and best surface roughness (R_a) by using Taguchi technique for three different materials.

- The optimal setting parameters individually for achieving maximum MRR and best R_a at discharge current of 10 Amp, pulse on time of 100 μ sec and duty cycle of 12 %,by grey thaguchi method and Discharge current of 10 Amp, pulse on time of 100 μ sec and duty cycle of 12 % by experimental run respectively for the material of HIGH CARBON STEEL.
- The optimal setting parameters individually for achieving maximum MRR and best R_a at discharge current of 6 Amp, pulse on time of 100 μ sec and duty cycle of 12 %, by grey thaguchi method and Discharge current of 10 Amp, pulse on time of 100 μ sec and duty cycle of 12 % by experimental run respectively for the material of MILD STEEL.
- The optimal setting parameters individually for achieving maximum MRR and best R_a by grey thaguchi method at discharge current of 10 Amp, pulse on time of 200 μ sec and duty cycle of 10 %,and Discharge current of 10 Amp, pulse on time of 200 μ sec and duty cycle of 11 % by experimental run respectively for the material of ALUMIUNIUM-6061.
- This work is also shown that optimal value is obtained for each experimental work through the ANOVA and RESPONSE METHOD by its ranking .
- Also, that using the tool material or electrode as COPPER electrode with work materials as HIGH CARBON STEEL,MILD STEEL,ALUMINIUM-6061, the higher material removal is obtained for aluminium-6061 and the lower surface roughness is obtained for high carbon steel.

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