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Analysis of the Influence of EDM Parameters on Material Removal Rate of Low Alloy Steel and Electrode Wear of Copper Electrode

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ABSTRACT: The various process parameters affecting the quality characteristics of the EDM during the process were identified using the Ishikawa diagram. In this paper, the optimization of the parameters of the EDM machining has been carried out by using the taguchi's method for design of experiments (DOE). In recent years many ways has been found for improving the MRR of the WORK PIECE. Taguchi method has been used for design of experiments with three input parameters and their three levels using L-27 array. In the research twenty seven experiments had been done along with circular and square copper tool material as well as Low Alloy Steel material had been used as a work piece. The dielectric used is EDM oil. The main objective of the research is the analysis to optimize the process parameters of EDM with the help of taguchi method and using Minitab software in terms of MMR and EWR. The different parameters considered while carrying out the experiments on EDM would be the current, Ton, Toff. The research findings show that the circular copper electrode having high material removal rate with respect to square copper electrode.

KEYWORDS:EDM, , Taguchi Method, S/N Ratio, ANOVA.

I. INTRODUCTION

Electro Discharge Machining (EDM) is an electro-thermal non-traditional machining process, where electrical energy is used to generate electrical spark and material removal mainly occurs due to thermal energy of the spark. EDM is mainly used to machine difficult to machine materials and high strength temperature resistant alloys. EDM can be used to machine difficult geometries in small batches or even on job-shop basis. Work material to be machined by EDM has to be electrically conductive. Spark erosion Machining is a process based on the disintegration of the dielectric and current conduction between the Job and work piece by an electrical discharge occurring between them. This process is also called as Electro Discharge Machining/Electro Erosion Process/Electro Spark Machining. In this method the Job and the work piece (which act as electrodes) are separated by a certain gap filled with a dielectric medium. A pre-set pulse is applied across the Job and work piece. Depending upon the micro irregularities of Tool and Work piece surfaces, and presence of carbon and metal particles, the dielectric is broken down at several points producing, the dielectric is broken down at several points producing ionized columns which allow a focused stream of electrons to flow and produces compression shock waves and there is an intense increase in the local temperature. Due to the combined effect of these two particles of metal are thrown out, very much similar to the boiling out of water. As erosion progresses the gap changes and that gap is continuously maintained by the servomechanism.

II. LITERATURE REVIEW

S.H.Tomadi et al. [1] studied the effects of operating parameters of tungsten carbide on the machining characteristics such as surface quality, material removal rate and electrode wear rate. The study was carried out on the basis of the parameters such as pulse on time and pulse off time peak current, power supply voltage,. The investigated of surface quality was in this carried out by using perthometer machine. Material removal rate (MRR) and electrode wear (EW) in this experiment was calculated by using mathematical method.

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KuldeepOjha et al. [2] Studied that EDM researchers have find number of ways to optimize and improve the MRR depart from the traditional EDM sparking phenomenon. During investigation he concluded that, in EDM process Material removal rate (MRR) is an important performance measure.

BholaJha et al. [3] studied that the performance of the process, to a large extent, depends on the material, design and manufacturing method of the electrodes. Method of its manufacturing and Electrode design also affect on the cost of electrode. Design of electrode is explored by many researchers and devised various ways of manufacturing. for improving and optimizing performance measures and reducing time and cost of manufacturing.

MohammadrezaShabgard et al. [4] studied theInfluence of Input Parameters such as pulse on-time and pulse current on the EDM Process. The studied process characteristics included machining features, embracing material removal rate, tool wear ratio, and arithmetical mean roughness, as well surface integrity characteristics comprised of the thickness of white layer and the depth of heat affected zone of AISI H13 tool steel as workpiece.

Sharanjit Singh et al. [5] studied the Presence of metal partials in dielectric fluid changes its properties, which reduces the insulating strength of the dielectric fluid and increases the spark gap between the tool and work piece. In their study they found that, the process becomes more stable and metal removal rate (MRR) and surface finish increases.

Prof. N. G. Alvi et al. [6] studied the effects of process parameters i.e. discharge current, pulse on and off times, and capacitance on process outputs i.e. material removal rate and electrode wear rate which was determined on the bases of minimum number of experiments. For the prediction, mathematical modeling of process has been done using response surface methodology. In their results a developed model can achieve reliable prediction of experimental results within acceptable accuracy.

Nikhil Kumar et al. [7] optimize that a silver electrode give better performance in certain characteristics but the cost become high for machining so keeping in mind cost and other some characteristics a graphite electrode is more preferable than copper electrode in case of both MRR and TWR. The performance of the process, to a large extent, depends on the Electrode material, work piece material manufacturing method of the electrodes. Finally they conclude that a suitable selection of electrode can reduce the cost of machining.

Harpreet Singh et al. [8] studied the effects of pulse on and pulse of time machining of AISI D3 die steel using copper and brass electrode in EDM. They compared the material removal rate achieved using different tool materials. Workpiece used is AISI D3 and tool materials used copper and brass electrode with pulse on/pulse off as parameter. The electrolyte they used is kerosene oil.

Amandeep singh et al. [9] studied Electric discharge machining is an electro sparking method of metal working involving an electric erosion effect. The unwanted material from the parent metal is removed through melting and vaporizing by pulse discharge occurs in a small gap between the work piece and the electrode

Rajeev Kumar et al. [10] Reviewed the research is oriented on newer aspects of wire EDM in the field of analysis and optimization. The mathematical models have been developed to predict material removal rate and surface finish while machining AISID2 tool steel at different machining conditions. A neural network model and simulated annealing algorithm have been formulated in order to predict and optimize the surface roughness and cutting velocity of the WEDM process in machining of SUS 304 stainless steel materials. The cutting speed and surface roughness of EDM process have been modeled through the response surface methodology and artificial neural networks (ANNs**).**

III. METHODOLOGY

The selection of the material and work piece on the basis of reviewed research paper and the selected tool is copper and work piece material is AISI 304L stainless steel. According to the taguchi method of experimental design the experiment has been done with 9 experimental run. The input parameter is current, Ton and Toff and output parameter is MRR. The researcher has selected the three level of input parameter. The parameters are current, Ton and Toff and the level of parameters are (6, 10, 14),
(50, 100, 150), (8, 10, 12) respectively. Material removal rate (MRR), Electrode Wear Rate (EWR) and Signal to noise ratio is calculated as following

$$MRR = \frac{[(\text{weight before machining}) - (\text{weight after machining})]}{[(\text{time duration}) \times (\text{material density})]}$$

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$$EWR = \frac{\textit{(Weight of the tool before machining) – (Weight of the tool after machining)]}}{\textit{Machining time}}$$

For this experiment S/N ratio, is taken as the “Larger is Better” so the equation to find out signal to noise ratio is.

$$S/N = -10 * \log(\Sigma (1/Y2)/n)$$

Fig.1. Electrode setup

Fig. 2. Tool and work material

IV. RESULT AND DISCUSSION

A. Results for Material Removal Rate (MRR)

The finding of the research is obtained using mini-tab software. The S-N ratio for each and every experiment is taken as “Larger is Better” condition. Weight of the workpiece material is taken before and after the machining on EDM and with help of weight and density, material removal rate is obtained. The Effect of input parameters on the output parameter is recorded in the table.Twentyseven experiments done on the electro discharge machine based on the taguchi method and summarized in the following table.

Table.4.1: Experimental Result of MRR

S. No.	IP	T off	Ton	work before	Work after	Time	MRR
1	6	8	50	268.63	266.87	33	0.053333
2	6	8	100	266.87	265.03	32	0.0575
3	6	8	150	265.03	263.26	32	0.055312
4	6	10	50	263.26	261.43	28	0.065357
5	6	10	100	271.43	269.59	27	0.068148
6	6	10	150	259.59	257.73	26	0.071538
7	6	12	50	257.73	255.93	26	0.069231
8	6	12	100	255.93	254.12	26	0.069615
9	6	12	150	254.12	252.27	25	0.074
10	10	8	50	272.71	271.03	18	0.093333
11	10	8	100	271.03	269.21	17	0.107059
12	10	8	150	268.91	265.3	17	0.212353
13	10	10	50	267.3	265.56	15	0.116
14	10	10	100	265.56	263.69	14	0.133571
15	10	10	150	263.69	261.84	12	0.154167
16	10	12	50	261.84	260	14	0.131429

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17	10	12	100	260	258.14	14	0.132857
18	10	12	150	258.14	256.26	13	0.144615
19	14	8	50	261.01	259.33	9	0.186667
20	14	8	100	259.33	257.48	8	0.23125
21	14	8	150	257.48	255.67	7	0.258571
22	14	10	50	255.67	254	8	0.20875
23	14	10	100	254	252.19	8	0.22625
24	14	10	150	252.19	250.37	7	0.26
25	14	12	50	250.37	248.7	8	0.20875
26	14	12	100	248.7	246.98	7	0.245714
27	14	12	150	245.54	243.05	6	0.415

Table 4.2 Analysis of Variance for MRR, using Adjusted SS for Tests

Source	**DF**	**Seq SS**	**Adj SS**	**Adj MS**	**F**	**P**
IP	2	0.155114	0.155114	0.077557	56.09	0.000
T off	2	0.003448	0.003448	0.003448	1.25	0.338
T on	2	0.015622	0.015622	0.007811	5.65	0.030
IP*T off	4	0.004541	0.004541	0.001135	0.82	0.547
IP*Ton	4	0.008898	0.008898	0.002224	1.61	0.263
T off*Ton	4	4 0.001954	0.001954	0.000489	0.35	0.835
Error	8	0.011062	0.011062	0.001383		
Total	26	0.200639				
S = 0.0371856 R-Sq = 94.49% R-Sq(adj) = 82.08%						

In addition to the above tables, Mini-Tab software has been utilized for finding the signal to noise ratio and also meansfor most affecting parameters. The all solution of signal to noise ratio and means value are shown below.

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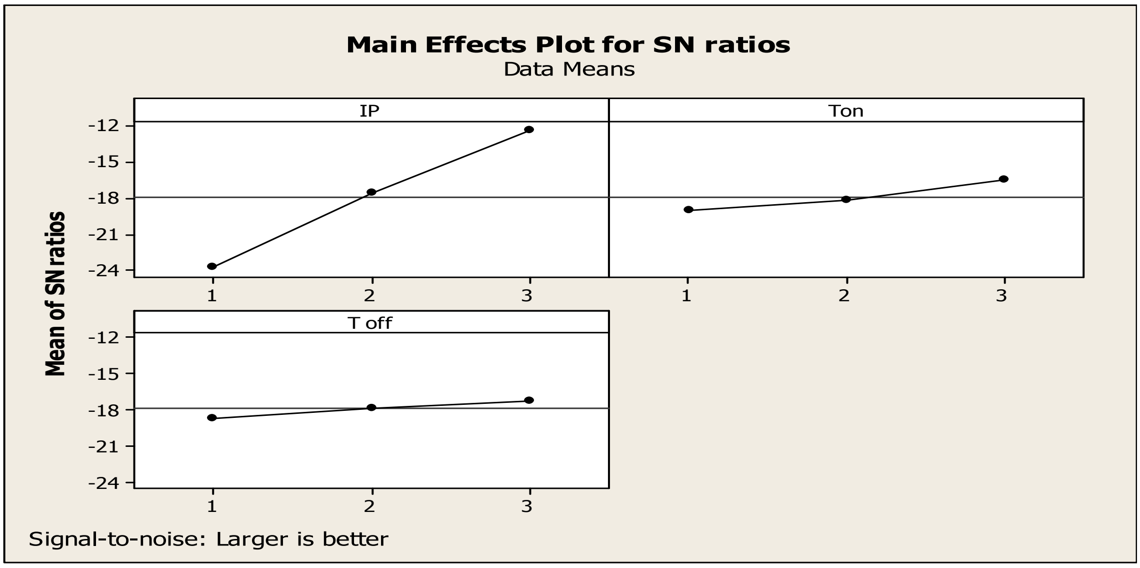

Graph.1. Main effect plot for Means

Table 4.3 Response Table for Mean of MRR

Level	Ip	Ton	Toff
1	23.85	18.87	18.51
2	17.91	18.12	17.89
3	12.26	16.23	17.23
Delta	11.59	2.64	1.28
Rank	1	2	3

From the above response table for means of MRR it has been claimed that the Ip (Peak current) has the greatest effect on the MRR and the same has been proved from the graph of main effect plot for means. It has also been observed from the following table that the optimum parameter set for the MRR is Current-14, Ton-150, Toff-12.

B. Results for Electrode Wear Rate (EWR)

The S-N ratio for each and every experiment is taken as “Smaller is Better” condition. Weight of the electrode is taken before and after the machining on EDM and Electrode Wear Rate (EWR) is obtained. The Effect of input parameters on the output parameter is recorded in the table. Twenty seven experiments done on the electro discharge machine based on the taguchi method and summarized in the following table.

Table.4.4: Experimental Result of EWR

S. No.	IP	T off	Ton	electrode before	electrode after	Time	EWR
1	6	8	50	69.13	69.11	33	0.000606
2	6	8	100	68.35	68.34	32	0.000312
3	6	8	150	69.58	69.56	32	0.000625

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4	6	10	50	71.54	71.5	28	0.001429
5	6	10	100	68.48	68.46	27	0.000741
6	6	10	150	68.01	68	26	0.000385
7	6	12	50	68.82	68.8	26	0.000769
8	6	12	100	66.38	66.36	26	0.000769
9	6	12	150	70.59	70.57	25	0.0008
10	10	8	50	71.82	71.78	18	0.002222
11	10	8	100	68.92	68.89	17	0.001765
12	10	8	150	68.29	68.27	17	0.001176
13	10	10	50	70.94	70.86	15	0.005333
14	10	10	100	74.35	74.33	14	0.001429
15	10	10	150	69.11	69.09	12	0.001667
16	10	12	50	68.34	68.29	14	0.003571
17	10	12	100	69.56	69.55	14	0.000714
18	10	12	150	71.5	71.47	13	0.002308
19	14	8	50	68.46	68.22	9	0.026667
20	14	8	100	68	67.88	8	0.015
21	14	8	150	68.8	68.72	7	0.011429
22	14	10	50	66.36	66.16	8	0.025
23	14	10	100	70.57	70.5	8	0.00875
24	14	10	150	71.78	71.72	7	0.008571
25	14	12	50	68.89	68.74	8	0.01875
26	14	12	100	68.27	68.2	7	0.01
27	14	12	150	70.86	70.84	6	0.003333

Table 4.5.Analysis of Variance for TWR, using Adjusted SS for Tests

Source	**DF**	**Seq SS**	**Adj SS**	**Adj MS**	**F**	**P**
IP	2	0.0009764	0.0009764	0.0004882	306.64	0.000
T off	2	0.0000202	0.0000202	0.0000101	6.35	0.022
Ton	2	0.0001859	0.0001859	0.0000929	58.38	0.000
IP*T off	4	0.0000553	0.0000553	0.0000138	8.69	0.005
IP*Ton	4	0.0002320	0.0002320	0.0000580	36.43	0.000

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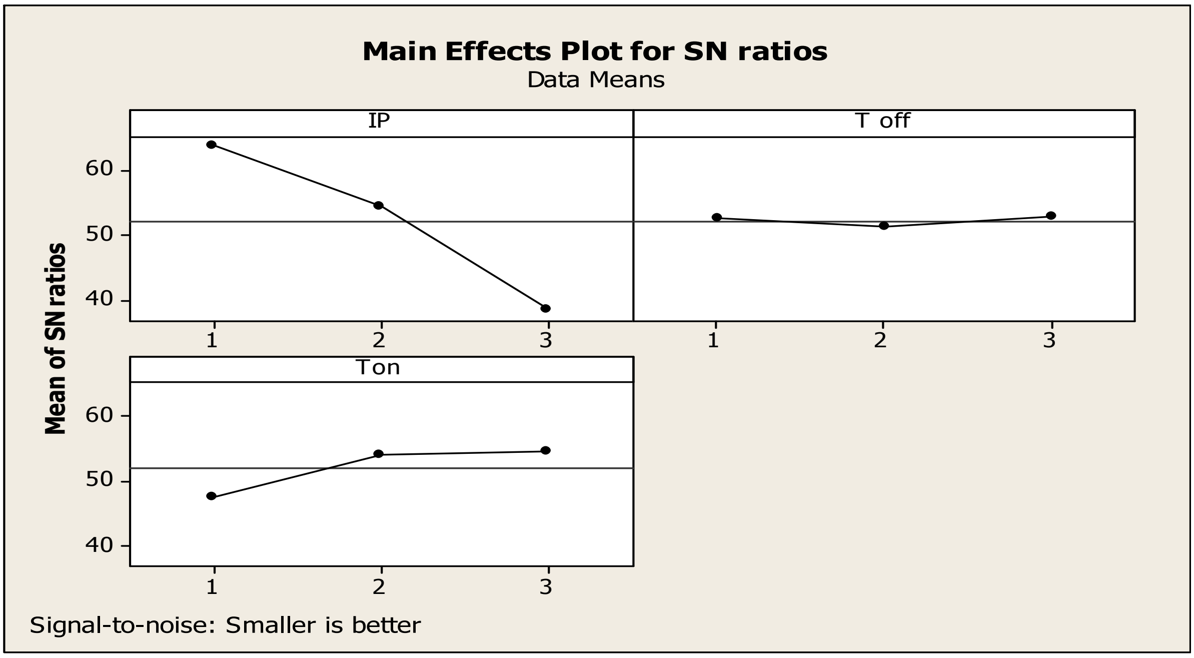
T off*Ton	4	0.0000088	0.0000088	0.0000022	1.38	0.322
Error	8	0.0000127	0.0000127	0.0000016		
Total	26	0.0014914				
S = 0.00126176 R-Sq = 99.15% R-Sq(adj) = 97.22%						



Graph.2. Main effect plot for Means

Table 4.6 Response Table for Mean of TWR

Level	Ip	Toff	Ton
1	64.53	51.12	48.22
2	52.23	50.83	53.19
3	38.91	51.95	54.71
Delta	26.62	1.12	6.49
Rank	3	1	2

From the above response table for means of EWR it has been claimed that the Ip (Peak current) has the greatest effect on the EWR and the same has been proved from the graph of main effect plot for means. It has also been observed from the following table that the optimum parameter set for the maximum and minimum EWR is Current-14, Ton-50, T off-8 and Current-6, Ton-100, T off-8 respectively.

V. CONCLUSION

In this research the influence of electrode shape and discharge current on MRR and TWR was investigated. Electrodes of two different shapes of constant cross sectional area were used for experiment with different discharge current. The MRR and EWR were measured and analyzed. The following conclusions can be made from this experimental research.

1. For round shaped electrodes MRR was the maximum followed by the square shaped electrodes.
2. A round shaped electrode undergoes less wear then the square shaped electrode. It is because of no vulnerable sharp corner at the sparking tip.
3. Cavities made by EDM die sinking may have intricate shapes and it is difficult to achieve high accuracy at the sharp corner of the cavities.

VI. FUTURE SCOPE

Various theoretical models describing material removal mechanism have been proposed by the researchers from timeto time. Still a lot of in-depth study is required to better understanding and development of the EDM process. Futurescope which would express this research is some non-electrical parameters like electrode rotation and work piecerotation while machining improve the flushing conditions and thus may improve MRR. Performance of water baseddielectric is yet to be investigated for machining materials like composites and carbides. Selection of different types ofelectrode would also change in MRR, TWR, and Surface roughness. It may also be used the hybrid Electric DischargeMachine such as Abrasive and Dielectric mixture EDM, Magnetic EDM, etc.

REFERENCES

[1] S.H.Tomadi, M.A.Hassan, 2009, “Analysis of the Influence of EDM Parameters on Surface Quality, Material Removal Rate and Electrode Wear of Tungsten Carbide”, Proceedings of the International Multi Conference of Engineers and Computer Scientists Vol. II, March, 18 – 20.
[2] KuldeepOjha, R. K. Garg, K. K. Singh, 2010, “MRR Improvement in Sinking Electrical Discharge Machining: A Review”, Journal of Minerals & Materials Characterization & Engineering, Vol. 9, No.8, pp.709-739.
[3] BholaJha, K.Ram and Mohan Rao, 2011 “An overview of technology and research in electrode design and manufacturing in sinking electrical discharge machining”, Journal of Engineering Science and Technology Review 4 (2) (2011) 118-130.
[4] MohammadrezaShabgard, MirsadeghSeyedzavvar, 2011, “Influence of Input Parameters on the Characteristics of the EDM Process”, Journal of Mechanical Engineering 57(2011)9, 689-696
[5] Sharanjit Singh and Arvind Bhardwaj, 2011 “Review to EDM by Using Water and Powder-Mixed Dielectric Fluid”, Journal of Minerals & Materials Characterization & Engineering, Vol. 10, No.2, pp.199-230.
[6] Dr. S. V. Deshmukh, Ram.R.Wayzode and Prof. N. G. Alvi, 2012 “Mathematical modeling of EDM hole drilling using response surface methodology”, Review of Research (May).
[7] Nikhil Kumar, Lalit Kumar, HarichandTewatia , 2012, “Comparative study for mrr on die-sinking edm using electrode of copper & graphite”, International Journal of Advanced Technology & Engineering Research (IJATER)
[8] Harpreet Singh and Amandeep Singh, 2012, “ Effect of Pulse On/Pulse Off Time On Machining Of AISI D3 Die Steel Using Copper And Brass Electrode In EDM”, International Journal of Engineering and Science ISSN: 2278-4721, Vol. 1, Issue 9 , PP 19-22.
[9] Amandeep singh, Neel kanthgrover and Rakesh sharma, 2012, “ Recent Advancement In Electric Discharge Machining, A Review”, International Journal of Modern Engineering Research (IJMER), Vol.2, Issue.5, Sep-Oct. pp-3815-3821.
[10] Rajeev Kumar and Shankar Singh, 2012, “Current Research Trends in Wire Electrical DischargeMachining: An Overview”, International Journal on Emerging Technologies 3(1): 33-40.
[11] Prof. S.R.Nipanikar, 2012,“Parameter optimization of electro discharge machining of AISI D3 steel material by using taguchi method”, Journal of Engineering Research and Studies.
[12] M. M. Pawade and S. S. Banwait, 2013, “An Exhaustive Review of Die Sinking Electrical Discharge Machining Process and Scope for Future Research”, International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering Vol:7, No:6.
[13] S. B. Prajapati and N. S. Patel, 2013, “Effect of Process Parameters on Performance Measures of Wire EDM for AISI A2 Tool Steel”, International Journal of Computational Engineering Research||Vol, 03||Issue, 4||
[14] AjeetBergaley and Narendra Sharma, 2013, “ Optimization of Electrical and Non Electrical Factors in EDM for Machining Die Steel Using Copper Electrode by Adopting Taguchi Technique”, International Journal of Innovative Technology and Exploring Engineering (IJITEE).
[15] Saeed Daneshmand1, Ehsan Farahmand Kahrizi,2013, “ Influence of Machining Parameters on Electro Discharge Machining of NiTi Shape Memory Alloys” Int. J. Electrochem. Sci., 8 (2013) 3095 – 3104
[16] Sanjay Kumar Majhi, M. K. Pradhan, HargovindSoni, 2013, “ Experimental Investigations of EDM Parameters”, International Journal of Engineering Research and Development , Volume 7, Issue 5 (June), PP. 31-34.
[17] Sandeep Kumar, 2013, “Status of recent developments and research issues of electrical discharge machining (EDM)” International Journal of Latest Trends in Engineering and Technology (IJLTET), Vol. 2 Issue 3 May.
[18] Kumar Sandeep, 2013, “Current Research Trends in Electrical Discharge Machining: A Review” Research Journal of Engineering Sciences, Vol. 2(2), 56-60, February.

[19]Manpreet Singh, Harvinder Lal and Ramandeep Singh, 2013, "Recent Developments in Wire EDM: A Review" International Journal of Research in Mechanical Engineering & Technology (IJRME) Vol. 3, Issue 2, May – Oct.

[20] Sanjay kumar majhi, m. k. pradhan, hargovindsoni, 2013, "optimization of edm parameters using integrated approach of rsm, gra and entropy method", International Journal of Applied Research in Mechanical Engineering (IJARME) ISSN: 2231 –5950, Volume-3, Issue-1.

[21]Dhirendranathmishra , Aarti Bhatia and Vaibhav rana, 2014, "Study on Electro Discharge Machining (Edm)", The International Journal Of Engineering And Science (IJES), Volume 3, Issue-2,Pages, 24-35.

[22] Pratik N.Chhaniyara, Neeraj P. Badola, 2014 " A Review Paper on EDM and ECM of Stainless Steel", International Journal of Engineering Development and Research, Volume 2, Issue 4.

[23] V.Vikram Reddy, P.Madarvalli, 2014 "Mathematical Modeling of Process Parameters on Material Removal Rate in EDM of EN31 Steel Using RSM Approach", International Journal of Research and Innovations in Science and Technology, Volume 1 : Issue 1.