EFFECT OF TOOL GEOMETRY ON THE PERFORMANCE OF EDM

Paridhi Malhotra[1], Himank Ambashta[2],Charanjeev Mehndiratta[3], Lakshay Sachdeva[4]

[1] Asst Prof, Dept. of Mechanical Engineering, Manav Rachna International University, Haryana, India
[2,3,4] Student, Dept. of Mechanical Engineering, Manav Rachna International University, Haryana, India

---***---

Abstract — *EDM is the modern machining method which encounters the problem of high TWR and Low MRR therefore our vision is to increase the efficiency of machining process which can be achieved by modifying the tool geometry and introducing the Air Compressor unit, thereafter enhancing the performance of EDM. In this paper, we explained the work in the development of die-sinking EDM for the improvement of machining characteristics. We investigated the optimum process parameters of EDM on EN19 steel alloy material with EDM oil as a dielectric fluid for solid and air assisted rotary electrode having three holes. We studied the effect of process parameters such as pulse current, rpm, duty cycle on Tool wear rate and Material removal rate for air assisted rotary electrode having three-hole processes as well as on conventional EDM process Three different levels of discharge current, rpm, duty cycle levels of pulse on time have been selected for investigation.*

Key Words: *Three* Holed electrode tool, Solid electrode tool, Air compressing Unit, MRR, TWR

1.INTRODUCTION

Electrical Discharge Machine (EDM) is especially used for the manufacturing of 3-D complex geometry and hard material parts that are extremely difficult-to- machine by conventional machining processes. Its ability to control the process parameters to achieve the required dimensional accuracy and finish has placed this machining operation in a prominent position in industrial applications.[1] In a conventional Die-Sinking EDM machine the manufacturing process the desired shape is obtained by using electrical discharges (sparks). Material is removed from the work piece by a series of rapidly recurring current discharges between two electrodes, separated by a dielectric liquid and subject to an electric voltage. One of the electrodes is called the tool-electrode, or simply the "tool" or the other is called the work piece-electrode, or "work piece. "This conventional. method shows the disadvantages of having high tool wear rate and lower material removal rate due to which it increases machining time and offers less efficiency. [2]
In EDM, since there is no direct contact between the work piece and the electrode, hence there are no mechanical forces existing between them. Any type of conductive material can be machined using EDM irrespective of the hardness or toughness of the material.

2. MATERIAL SELECTION AND FABRICATION

2.1 Tool

The selection of the most appropriate electrode material is a key decision in the process plan for any sinking EDM job. [3] The important variables to be considered for selection of electrode material are material removal rate, tool wear rate, surface roughness, machinability and material cost therefore we choose electrolytic copper rod[4] with three holes drilled in it.

2.1.1   Manufacturing of Tool

The manufacturing of the tool involved a series of steps on the Copper rod:[5]

- The rod was first subjected to turning operation to obtain the rough dimensions.
- The body of the tool is drilled using 2 mm drill and a blind hole drilled which will serve as the passage for the compressed air.
- Then, on the side wall three holes are drilled of 2 mm diameter.
- Wall of the tool is externally turned to 12 mm. This is done in stages and with a wooden support inside the electrode because copper used to get extremely hot and there were chances of the bending of the tool.
- Finally, the finishing operation is done to obtain the finish required with the tolerances.

Figure 1: EDM electrodes with no hole and 3-holes
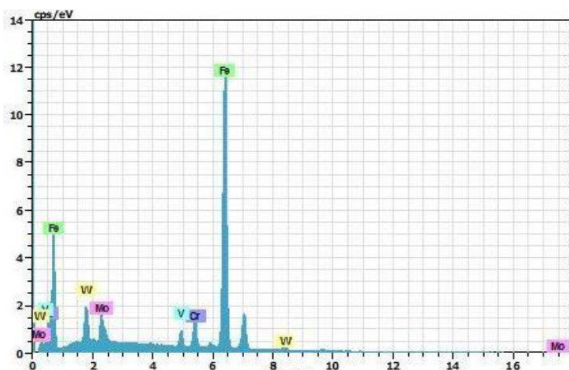
2.2 Work pieces

We chose work pieces made up of EN19 steel which are suitable for applications such as gears, bolts, and plethora of applications where a good quality high tensile steel grade is essential.

Table 1:Chemical composition analysis in % of Work piece

C	V	Cr	Mo	W	Fe
0.99	2.06	4.21	5.03	6.10	Rest

2.2.1   Characterization of Work Piece

Work piece is characterized by performing EDX. This is done in order to have the data collected as a reference to measure the performance of process. [6]

Figure 2:EDX of EN19

Figure 3:Identical Workpieces

3. SELECT RESPONSE VARIABLE

Based on the basic characteristics of EDM, machining parameters are selected which are varied as per the orthogonal array. We have selected four machining parametersfor the experiment which results in a L_9 orthogonal array. [7]

- Discharge Current(A)
- Pulse on time (μs) (Ton)
- Duty cycle (dc)
- Rotation (rpm)

Table is given below showing levels of each parameters.

Table 2:L_9 Array of Experiments

SNo.	Current	TON	D.C	RPM
1	3	100	0.56	200
2	3	300	0.64	500
3	3	500	0.72	800
4	5	100	0.64	800
5	5	300	0.72	200
6	5	500	0.56	500
7	7	100	0.72	500
8	7	300	0.56	800
9	7	500	0.64	200

4.RESULTS AND DISCUSSION

The results are calculated for each experiment set as mention in Table 2. Solid and 3-hole electrode are the types tool electrode have been used. Hence, two types of flushing methods have been applied i.e. jet and through flushing for solid and 3- hole electrode respectively. The MRR, TWR and %electrode wear are calculated for each case.

4.1 Material Removal Rate

Table 3:MRR of Work pieces machined with solid tool

S No	initial wt.	final wt.	MRR
1	74.7255	74.6069	0.1186
2	59.7612	59.6804	0.0808
3	71.061	71.0103	0.507
4	63.1816	62.9101	0.2715
5	71.9841	71.8112	0.1729
6	59.7211	59.1481	0.573
7	84.9552	84.763	0.1922
8	67.5381	67.3402	0.1979
9	73.9744	73.8866	0.878

Table 4: MRR of Work pieces machined with 3- holed tool

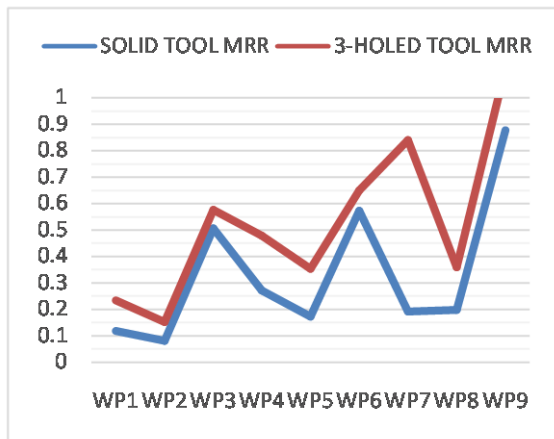| S No	initial wt.	final wt.	MRR
1	62.7165	62.6011	0.1154
2	62.6569	62.5955	0.0614
3	69.7315	69.6925	0.039
4	59.6183	59.4114	0.2069
5	64.5881	64.4079	0.1802
6	65.0377	64.9607	0.077
7	66.2305	65.5826	0.6479
8	74.7604	74.5982	0.1622
9	75.4655	75.2315	0.234

Figure 4: Comparison between MRR produced with solid tool and 3-holed tool
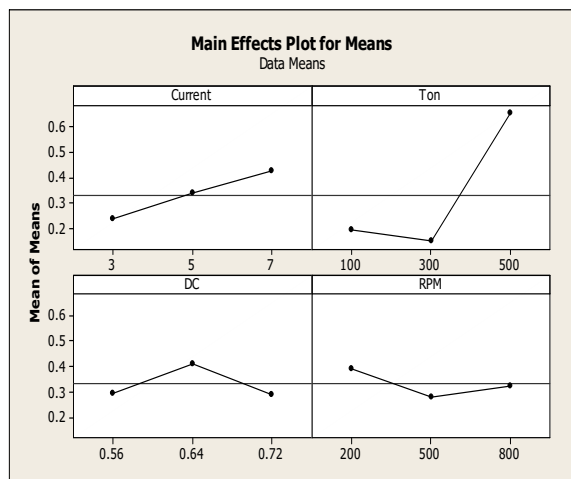

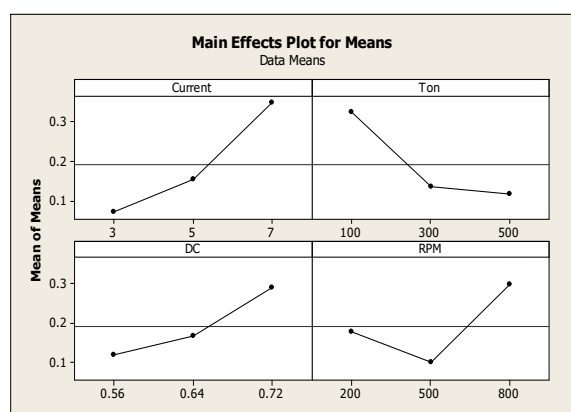**Figure 5**:MRR Graph plotted for mean for EDM process with solid electrode

Figure 6: MRRGraph plotted for mean for EDM process with 3-holed electrode

It can be clearly perceived from the graph that as the current increases mean, the value of MRR also increases because of

an increase in the discharge energy in machining zone resulted in more melting and evaporation of materials. An air assisted three-holed tool with rotation surges the hydrostatic pressure variation in discharge gap and hence an immense drop in pressure excites additional molten metal to be dispatched from the crater. [8] The crater size is larger in air compressor assisted EDM, because there is an additional heat other than the heat input by the spark. Also, increase of plasma channel is observed due to prolonged pulse on time, hence the energy density decreases resulting in the occurrence of marginal melting and vaporization of work piece. This reduces the MRR at prolonged pulse-on time. MRR improves with a rise in duty cycle because at higher value of duty cycle, high spark energy generated which causes more molten and evaporation of material from the work piece and thus MRR in air assisted three-holed tool EDM process is more than solid tool EDM process. [9] Also, the injection of compressed air contributes in faster removal of melted and vaporize material, hence resulting in more efficient flushing of eroded particles from the machining gap.Therefore, we can have concluded that MRR in air assisted EDM process is more than the three-holed tool EDM and solid tool EDM process.

A.   Tool Wear Rate

Table 5: TWR of work pieces machined with solid tool

S No	initial wt.	final wt.	TWR
1	51.3577	53.5572	-0.0133
2	50.2665	50.3655	-0.0066
3	49.6716	49.85005	-0.01123
4	51.2267	51.23105	-0.00029
5	50.6661	50.69505	-0.00227
6	48.5041	48.51325	-0.00061
7	52.2517	52.3282	-0.0051
8	51.2642	51.3017	-0.0025
9	49.6752	49.78485	-0.00731

Table 6: TWR of work pieces machined with 3-holed tool

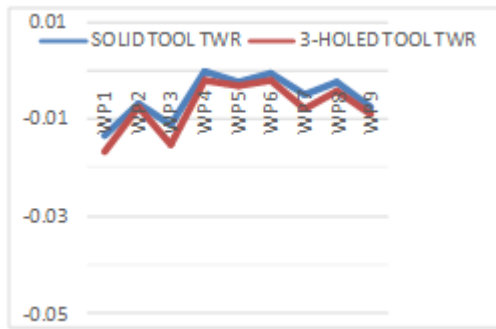| S No.	initial wt.	final wt.	TWR
1	27.4492	27.6997	-0.0167
2	29.0000	29.11205	-0.00747
3	28.6521	28.8780	-0.01506
4	28.1131	28.14295	-0.00199
5	29.0465	29.0942	-0.00318
6	29.0266	29.0563	-0.00198
7	28.9111	29.03211	-0.008013
8	28.8821	28.9448	-0.00418
9	28.8676	29.0047	-0.00914

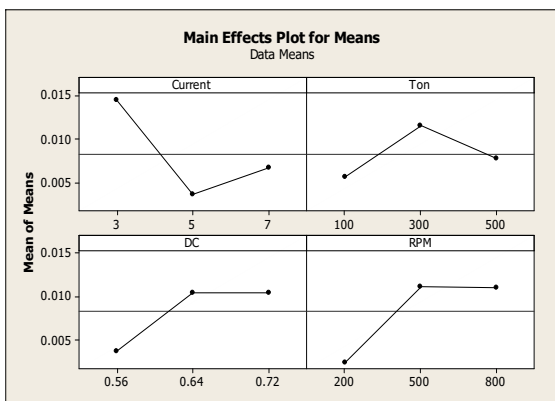**Figure 7:** Comparison between TWR produced with solid tool and 3-holed tool

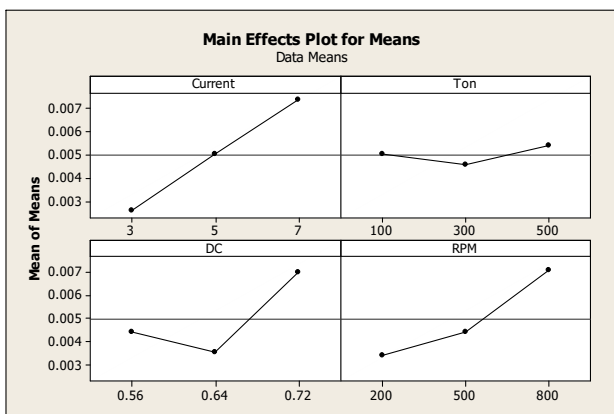**Figure 7**:TWR Graph plotted for mean for EDM process with Solid electrode

Figure 98:TWR Graph plotted for mean for EDM process with 3-holed electrode

Increase in current increases accumulation of eroded particles at the discharge gap, which causes a more wear on the tool electrode. TWR has been found to have an inverse relation with pulse duration probably because the temperature of the electrode surface reduces significantly as athe plasma channel expands at higher values of pulse duration. [10] The black carbon layer emitted due to decomposition of dielectric is deposited on the electrode

surface for longer pulse duration which produces resistance against the wear of the electrode. Further, it can be depicted that TWR is lower in the Three-holed tool EDM process than the conventional solid tool EDM process. It can be possibly explained as due to long pulse duration, compressed air in multi holed EDM process facilitates faster removal of heat which reduces the temperature around the surface of tool electrode, resulting in lower TWR. [11]

5.CONCLUSION

An investigation is made to compare MRR and TWR of Solid tool with Air Assisted three-holed EDM witnessing the parameters; Discharge Current(A), Pulse on time (μs) (Ton), Duty cycle (dc), Rotation(rpm). The following conclusions have been drawn through this investigation:

1. Clearly 3-holed electrode tool assisted with air compressor unit possess higher MRR and lower TWR when compared to solid tool as it can flush the eroded particles from the surface of the work piece and as well the gap.
2. Increase in Pulse-on results in decreasing of MRR consistently. Consequently, with increase the MRR, reduction in Pulse-onbecomes imperative. Also as the pulse on increases, TWR increases.
3. In three-holed electrode the crater size is larger in comparison to solid electrode tool because of existence of an additional heat in addition to the heat input by the spark.

6. REFERENCES

1. Mohan Khire and Amar Bhandare "Electro Discharge Machining Studies", LAP Lambert Academic Publishing, March 8, 2012, ISBN-10: 3848423820 ISBN-13: 978-3848423828

2. AzharEqubal, Anoop Kumar Sood, "Electrical Discharge Machining: An Overview on Various Areas of Research", Journal of manufacturing and industrial engineering, ISSN 1339-2972 (On-line)

3. Fred L. Amorim[l]; Walter L. Weingaertne, "The behavior of graphite and copper electrodes on the finish die-sinking electrical discharge machining (EDM) of AISI P20 tool steel", J. Braz. Soc. Mech. Sci. & Eng. vol.29 no.4 Rio di Janeiro Oct./Dec. 2007,http://dx.doi.org/10.1590/S1678-58782007000400004, ISSN 1678-5878*On-line version* ISSN 1806-3691

4. E. Bud Guitrau. "The EDM Handbook", Carl Hanser Verlag GmbH & Co, 1 December 1997, ISBN-10**:** 1569902429 ISBN-13: 978-1569902424

5. P Pandey and H Shan, "Modern Machining Processes", McGraw Hill Education; New edition

edition, 1 July 2017, ISBN-10: 0070965536 ISBN-13: 978-0070965539

6. P.N. Rao, "Manufacturing Technology - Vol. 2", McGraw Hill Education; Third edition (1 July 2017), ISBN-10: 1259029565 ISBN-13: 978-1259029561

7. Elman C. Jameson, "Electrical Discharge Machining", Society of Manufacturing Engineers, 2001, ISBN-087263521X, 9780872635210

8. Sushil Kumar Choudhary, Dr. R.S Jadoun, "Current Advanced Research Development of Electric Discharge Machining (EDM): A Review", International Journal of Research in Advent Technology, Vol.2, No.3, March 2014 E-ISSN: 2321-9637

9. Prof. S.R. Nipanikar, "parameter optimization of electro discharge machining of AISI d3 steel material by using taguchi method", Journal of Engineering Research and Studies, E-ISSN0976-7916

10. Harshit K. Dave1, Sudhanshu Kumar, Nipul C. Rana, Harit K. Raval, "electro discharge machining of AISI 304 using solid and bundled electrodes", 5th International & 26th All India Manufacturing Technology, Design and Research Conference (AIMTDR 2014) December 12th–14th, 2014, IIT-Guwahati, Assam, India

11. Teepu Sultan, Anish Kumar, and Rahul Dev Gupta, "Material Removal Rate, Electrode Wear Rate, and Surface Roughness Evaluation in Die Sinking EDM with Hollow Tool through Response Surface Methodology", International Journal of Manufacturing Engineering Volume 2014 (2014), Article ID 259129, 16 pages, "http://dx.doi.org/10.1155/2014/259129", Copyright © 2014 Teepu Sultan et al.