A Study of the Influence of a Shield in Machining Region in Magnetic Assisted EDM

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***Abstract*—Electrical Discharge Machining, commonly known as EDM is a non-conventional machining method used to remove material by a number of repetitive electrical discharges of small duration and high current density between the workpiece and the tool. EDM is an important and cost-effective method of machining extremely tough and brittle electrically conductive materials. In EDM, since there's no direct contact between the workpiece and also the electrode, hence there are no mechanical forces existing between them. Any type of conductive material will be machined using EDM no matter of the hardness or toughness of the job or electrode. In EDM, electrical spark energy is used for continuous melting and evaporation of the workpiece material also machining operation is generally performed under dielectric medium. It is required to use a high proportion of the energy produced by spark for melting and evaporation of the workpiece. But only a small proportion of the energy produced in the spark is used for melting and evaporation of the workpiece material, remaining energy is dissipated in the dielectric fluid in the form of convection and radiation.**

In this present work, an attempt is made to restrict the energy dissipation in the dielectric fluid and for this purpose, an enclosure is provided around the electrode with the aim to create a back pressure thereby restricting the expansion of the plasma in the EDM process. This enclosure is also called as a shield and again to remove debris from the workpiece, the magnetic field generated by the magnets is used around the machining region.

***Keywords*—Shield, Magnets, Electrical Discharge Machining (EDM), Spark Energy, Material Removal Rate (MRR) and Electrode Wear Rate (EWR)**

I. INTRODUCTION

EDM could be a controlled metal-removal method that's accustomed take away metal by means that of electricalspark erosion. In this process an electric spark is used as the cutting tool to cut (erode) the workpiece to produce the finished part to the desired shape. The metal-removal process is performed by applying a pulsating (ON/OFF) electrical charge of high-frequency current through the electrode to the workpiece. This removes (erodes) tiny pieces of metal from the workpiece at a controlled rate. A small proportion of the energy produced in the spark is used for melting and evaporation of the workpiece material, remaining energy is dissipated in the dielectric fluid in the form of convection and radiation. Fig. 1 shows block diagram of energy losses in machining region.

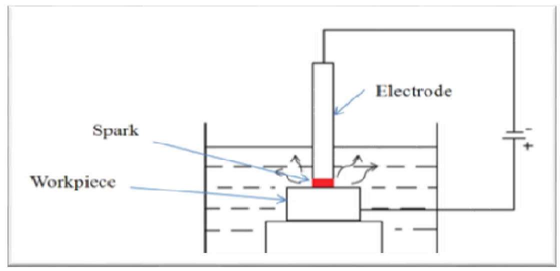

Fig. 1 Block diagram showing energy losses in machining region

It is necessary to restrict the energy dissipation into the dielectric fluid to avail maximum heat energy at the machining region so that melting rate of a workpiece is higher which further increases in MRR. To restrict this energy dissipation a shield which is mounted on the electrode is being used.

II. LITERATURE REVIEW

P. Govindan and S. Joshi [1] carried out an experimental evaluation of dry electrical discharge drilling. It has been shown that, dry EDM can be performed by providing an enclosure (shielding) to the sparking region. This study has revealed various characteristics of dry EDM process by measurement of oversize, examination of machined surface morphology in addition to MRR and EWR study. S. Joshi et al. [2] proposed a new hybrid approach using pulsating magnetic field assistance is introduced to confine dry EDM plasma and improve process performance. It is demonstrated that the magnetic field, due to higher ionization and plasma confinement, aids a higher transfer of thermal energy to the workpiece and helps to improvise material removal mechanism and melting in dry EDM. An improvement in the geometric accuracy of the workpiece and the machined surface quality were evident. M. Gangil and M. Pradhan [5] focused on the importance of the optimum gap condition of electrical discharge machining and its influence on the variables in terms of MRR, EWR and surface roughness. This study also concludes that the effect of magnetic field is useful to maintain the optimum machining gap. R. Teimouri and H. Baseri [6] conducted experiments to investigate the combined effect of tool rotation and various intensities of external magnetic field on EDM process by considering output response variables.

As per the above literature review [1] researcher had used shield attached to the workpiece. In this case, there is a problem of 'evacuation of the debris from the machining gap'. Generally it is recommended that during pulse off time dielectric fluid should remove debris from the machining zone, but in the above case due to shield is mounted on the workpiece, it is forming an obstacle to remove debris. Accumulation of debris in gap space causes inactive pulses such as short and open circuit and the abnormal electrical discharge, so the stability of EDM process will be disturbed and for that reason it adversely affects the material removal rate (MRR), surface roughness (SR) and electrode wear rate (EWR).

III. EXPERIMENTAL SETUP

L9 orthogonal array is selected for trial experiments for conventional EDM and shield assisted EDM. For both the experiments 3 levels and 3 factors are being used. The experiments are conducted on S50 CNC EDM machine.

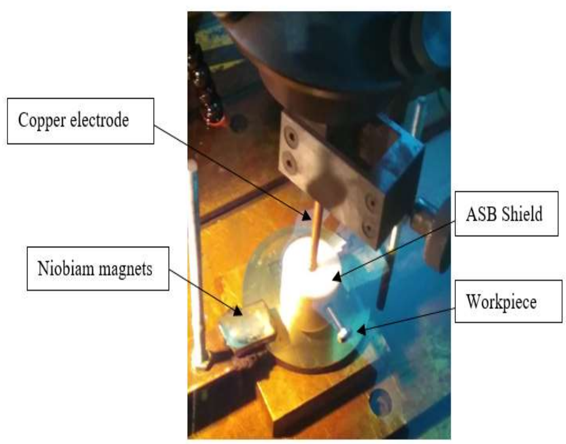

Fig. 2 Machining region set-up

For experimentation EN24 workpiece material, Copper electrode of 5mm diameter used. No. of experiments are designed by Taguchi design of experiments

A. Development of a Shield

For development of shield Acrylonitrile Butadiene Styrene (ASB) polymer is being used since the process itself requires a non-conductive material which is also good resistant to heat. Thermal conductivity of ASB polymer is 0.1 W/mK. The main purpose of developing the shield is that, to compare regular EDM process with shield attached EDM process, because in shield attachment we can reduce heat losses by convection and radiation. For development of shield cylindrical shaped raw material is brought, then it is cut into required dimension and shape on lathe machine according to electrode size it is drilled throughout then boring operation is done up-to quarterlength. A cross-nut is used for electrode to be fit inside the shield very tightly.

B. Magnetic Field Generation

Even though a shield attachment is being used but it is still required to use permanent magnets for proper burr removal during machining. That's why experiments are carried out by using magnetic field generated by Niobium magnets which are very strong in developing magnetic field.

It is shown in Fig. 2 Niobiam are very useful for burr removal. As a strong magnetic field generated by Niobiam, burr removal happens even through the dielectric oil. The process parameters and their levels are as shown in Table 1.

TABLE I

INPUTPARAMETERS and THEIRLEVELS

Sr. No.	Process Parameter	Levels		
		1	2	3
1	Current (I) [A]	10	15	20
2	Pulse on Time (POT)[μs]	100	150	200
3	Voltage (V)	50	60	70

L9 array of experiments are performed by using ASB shield and without using the shield for fixed duration of 3 hours of time for each of the experiments. Image of the specimen is shown in Fig. 3.

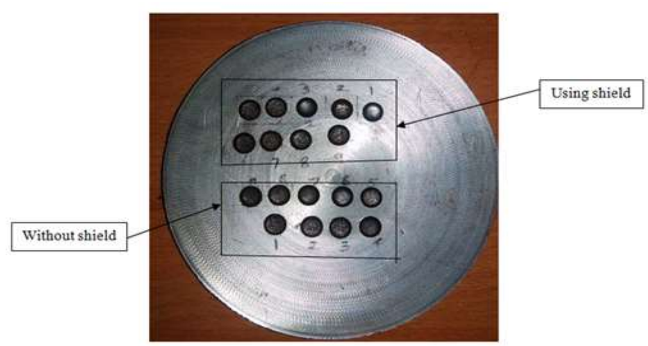

Fig. 3 Image of specimen after experimentation

IV. RESULTS AND DISCUSSION

By using same parameter combination with shield and without using shield MRR is calculated as shown in Table 2. Similarly EWR is calculated by using shield and without using shield as shown in Table 3. For calculation of MRR and EWR simple cylindrical volume formula being used. Approximate diameter produced on the EN 24 workpiece material is measured by using the digital microscope since there is difference between actual electrode and the diameter of the drill produced.

For calculation MRR and EWR following parameters are used. MRR and EWR calculated by approximate diameter of the hole produced (D), fixed duration of machining is 180 mindiameter of the copper electrode used (d) is 5mm, Depth of material removal (L) mm andlength of tool wear (l) mm these all parameters are used. Depth of the material removed is given by CNC EDM machine for fixed duration of time of 180min for each of the experiments, for the calculations of the MRR and EWR.

TABLE 2

EXPERIMENTAL RESULTSFOREDM (MRR)

Trial No.	Current (I) [A]	Pulse ON Time (POT) [µs]	Voltage (V) [V]	MRR (without shield) (mm^3/min)	MRR (with shield) (mm^3/min)	MRR Improvement (%)
1	10	100	50	0.1260	0.1260	0
2	10	150	60	0.1175	0.1360	15.74
3	10	200	70	0.1209	0.1415	17.03
4	15	100	60	0.1319	0.1582	19.93
5	15	150	70	0.1580	0.1759	11.32
6	15	200	50	0.1795	0.1796	0.055
7	20	100	70	0.1671	0.1759	5.26
8	20	150	50	0.1847	0.1921	4
9	20	200	60	0.2089	0.2104	0.718

TABLE 3

EXPERIMENTAL RESULTSFOR EDM (EWR)

Trial No.	Current (I) [A]	Pulse ON Time (POT) [µs]	Voltage (V) [V]	Length of tool wear (mm)	Length of tool wear (mm) with shield	EWR (without shield) (mm^3/min)	EWR(with shield) (mm^3/min)
1	10	100	50	0.2	0.2	0.0218	0.0218
2	10	150	60	0.2	0.2	0.0218	0.0218
3	10	200	70	0.2	0.2	0.0218	0.0218
4	15	100	60	0.3	0.3	0.0327	0.0327
5	15	150	70	0.4	0.3	0.0436	0.0327
6	15	200	50	0.4	0.4	0.0436	0.0436
7	20	100	70	0.3	0.3	0.0327	0.0327
8	20	150	50	0.4	0.4	0.0436	0.0436
9	20	200	60	0.5	0.4	0.0545	0.0436

$$MRR = \frac{\pi * D^2}{4 * 180} * L \quad (1)$$

$$EWR = \frac{\pi * d^2}{4 * 180} * l \quad (2)$$

Using equations (1) and equation (2), MRR and EWR calculated. It is shown in following Fig. 4 during each of the experimentation by using ASB shield MRR has been increased by 0%, 15.74%, 17.03% and so on. As there is restriction to heat dissipation away from the machining region by usage of the shield, heat energy remain available at machining region. MRR increases with increase in amount of heat energy available for machining. In case of EWR due to direct current straight polarity where electrode is being used as negative terminal there is very less wear takes place. It is shown in the Fig. 5 during each of the experimentation EWR remains same except during experimentation no. 5 and 9.

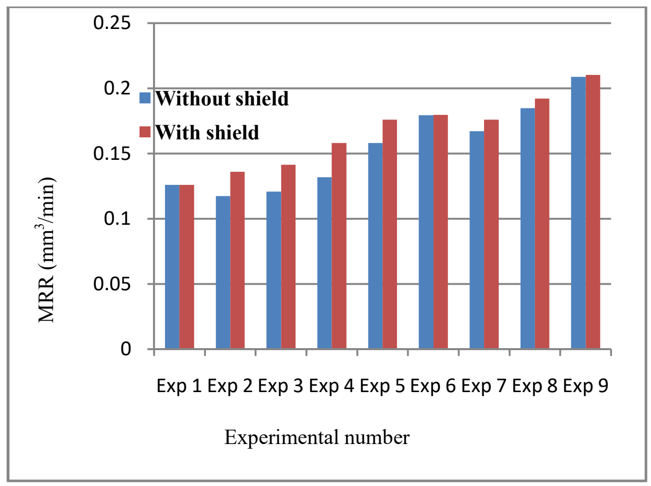

Fig. 4 Comparison between MRR

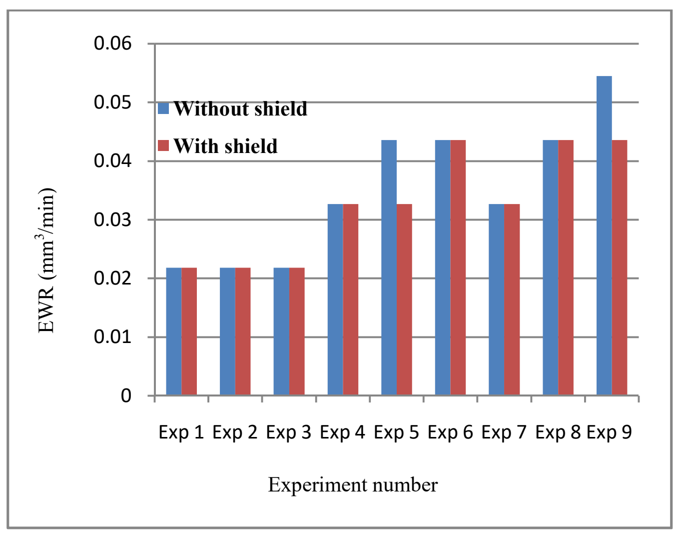

Fig. 5 Comparison between EWR

V. CONCLUSIONS

It is shown in table 2 during each of the experimentation by using ASB shield MRR has been increased by 0%, 15.74%, 17.03% and so on. It is concluded that by using ASB shield MRR can be increased.

EWR remains same for almost each of the experiment except for experiment no. 5 and no.9. Hence there is no significant changes in EWR by using shield and without using shield.

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