

SHORT COMMUNICATION

Comparison of material removal rate of ductile cast iron using hollow and solid cylindrical electrical discharge machining electrodes

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Abstract

Comparison of performance of a hollow electrode with a solid electrode in blind hole drilling of ductile iron using Electrical Discharge Machining (EDM) has been experimented. After which material removal rate is compared by using the Taguchi design. All the parameters are kept constant for both the electrode. The experimental results showed that that material removal rate for the hollow copper electrode is higher than that of the solid copper electrode. By Increasing the Pulse ON from 6 μ s to 8 μ s and 8 μ s to 10 μ s, the Material Removal Rate (MRR) is decreased. By Increasing the Pulse OFF from 5 μ s to 7 μ s and 7 μ s to 9 μ s, the MRR is increased. The MRR is increased by increasing the current and also by increasing the flushing pressure above 15 Kg/cm². From this experimental work, it has been concluded that MRR is high for hollow electrode when compared with the solid electrode at the same machining parameters.

Keywords: Copper electrode, jet flushing pressure, solid electrode, hollow electrode, ductile cast iron.

Introduction

Cast iron contains 2 to 6.67% of carbon content. Since, high carbon content tends to make the cast iron very brittle, so therefore most commercially manufactured types iron are in the range of 2.5 to 4% of carbon. Cast iron cannot be rolled, drawn or worked at room temperature due to very low ductility. However, cast iron has property of good castability, due to its lower melting point (Metal Handbook, 1989; Source book on ductile iron, 1997). Since, casting is the only suitable process applied to these alloys, they are known as cast irons. The best method to classify cast iron is according to metallographic structure. The types of cast iron are as: (i) White cast iron (ii) Malleable cast iron (iii) Gray cast iron (iv) Chilled cast iron (v) Alloy cast iron (vi) Nodular cast iron or Ductile iron (Lin and Huang, 1996).

Murugesan *et al.* (2012) compared the performance of a multi-hole electrode with a solid electrode in blind hole drilling of Al-15% SiC Metal Matrix Composite (MMC) using Electrical Discharge Machining (EDM). It showed that multihole electrode performed better machining performance. Jet flushing is the most popular type of flushing for EDM. Takahisa *et al.* (1992) studied a dynamic jet flushing method with moving nozzles that sweep along the outline of the EDM gap. Experimental results clarified the effectiveness of this method on the precision of machining. Considering the lack of studies regarding machining of ductile cast iron by EDM as well as those of the modified the EDM process by using hollow electrode for improving MRR, were explored in this experimental study.

Materials and methods

All the experiments have been conducted using the Electrical Discharge Machine model S-35, Sparkonix. Figure 1 shows the final drilled work-piece in which holes are made with the help of the solid and hollow electrode by using EDM on the ductile cast iron work-piece by taking the following parameters as mentioned in Table 1. An experimental optimization is done in calculating the MRR using these levels and parameters for both solid and hollow electrode.

Fig. 1. Final drilled hole by using solid and hollow copper electrode.

Final drilled holes by using the solid copper electrode



Final drilled holes by using the hollow copper electrode

Table 1. Parameters for experimentations.

Parameters	Level		
	1	2	3
Peak current (A)	5	10	15
Pulse ON (µsec)	6	8	10
Pulse OFF (µsec)	5	7	9
Flushing pressure(Kg/cm ²)	10	15	20

Results and discussion

Material removal rate of each sample was calculated from weight difference of work piece before and after the performance trial:

$$MRR = \frac{\text{Diff. of weight of workpiece before and after machining}}{\text{Time of machining}}$$

Where, W_1 = Initial weight of work piece material (g);
 W_2 = Final weight of work piece material (g);
 T = Time period of trails in min.

Table 2. Results by solid electrode.

Pulse ON time (µs)	Pulse OFF time (µs)	Peak current (A)	Flushing pressure	Mean of MRR
6	5	5	10	0.237
6	7	10	15	0.33
6	9	15	20	0.877
8	5	10	20	0.399
8	7	15	10	0.296
8	9	5	15	0.116
10	5	15	15	0.246
10	7	5	20	0.112
10	9	10	10	0.243

Table 3. Results by hollow electrode.

Pulse ON time (µs)	Pulse OFF time (µs)	Peak current (A)	Flushing pressure	Mean of MRR
6	5	5	10	0.331
6	7	10	15	0.446
6	9	15	20	0.949
8	5	10	20	0.476
8	7	15	10	0.895
8	9	5	15	0.239
10	5	15	15	0.442
10	7	5	20	0.132
10	9	10	10	0.325

The results for the machining of the ductile cast iron on EDM by using solid copper electrode are shown in Table 2. The results for the machining of the ductile cast iron on EDM by using hollow copper electrode are shown in Table 3. By Increasing the Pulse ON, during the machining of ductile cast iron by both the solid and hollow electrode there is a decrease in the mean of MRR (Fig. 2). Keeping the pulse ON 6,8,10 µs constant, the MRR is high for hollow electrode when compared with the solid electrode. By Increasing the Pulse OFF, during the machining of ductile cast iron by both the solid and hollow electrode there is increase in the mean of MRR.

Fig. 2. Interaction of Pulse ON by solid electrode and hollow electrode on mean of MRR.

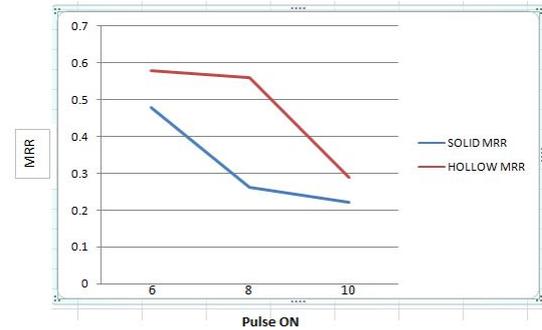


Fig. 3. Interaction of Pulse OFF by solid electrode and hollow electrode on mean of MRR.

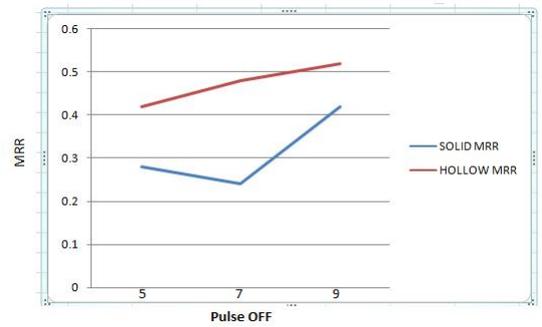


Fig. 4. Interaction of current by solid electrode and hollow electrode on mean of MRR.

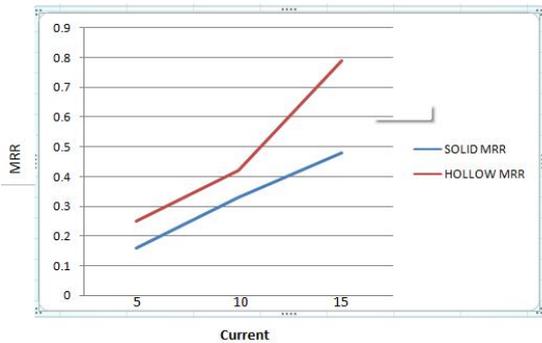
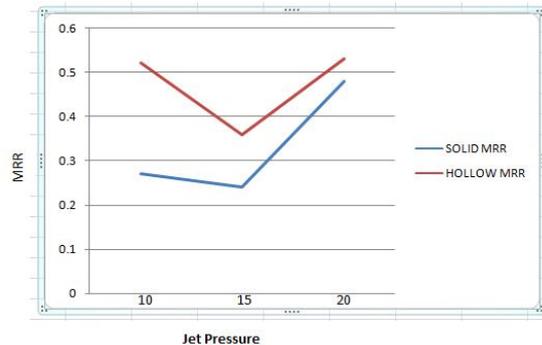


Fig. 5. Interaction of flushing pressure by solid electrode and hollow electrode on mean of MRR.



Keeping the pulse OFF 5, 7, 9 μs constant, the MRR is high for hollow electrode when compared with the solid electrode (Fig. 3). By increasing the current, during the machining of ductile cast iron by both the solid and hollow electrode there is increase in the mean of MRR (Fig. 4). Keeping the current 5, 10, 15 A constant, the MRR is high for hollow electrode when compared with the solid electrode. By Increasing the flushing pressure from 10 to 15 Kg/cm^2 , during the machining of ductile cast iron by both the solid and hollow electrode firstly there is a decrease in the mean of MRR (Fig. 5). But further on increasing the flushing pressure from 15 to 20 Kg/cm^2 , during the machining there is increase in the mean of MRR. Keeping the flushing pressure 10, 15, 20 Kg/cm^2 constant, the MRR is high for hollow electrode when compared with the solid electrode.

Conclusion

1. By Increasing the current, during the machining of ductile cast iron by both the solid and hollow electrode there is increase in the mean of MRR.
2. By Increasing the flushing pressure from 10 to 15 Kg/cm^2 , during the machining of ductile cast iron by both the solid and hollow electrode firstly there is decrease in the mean of MRR. But further on increasing the flushing pressure from 15 to 20 Kg/cm^2 , during the machining there is increase in the mean of MRR.
3. By Increasing the Pulse OFF, during the machining of ductile cast iron by both the solid and hollow electrode there is increase in the mean of MRR.
4. By Increasing the Pulse ON, during the machining of ductile cast iron by both the solid and hollow electrode there is decrease in the mean of MRR.
5. Keeping the constant machining parameters combinations, the MRR is high for hollow electrode when compared with the solid electrode.

References

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