

Enhancing Performance Measures in Electrical Discharge Machining of Monel 400™ using Paraffin-Servotherm

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Abstract - Electrical discharge machining (EDM) process is a most reliable technology to machine wide varieties of materials to required complicated shapes, since it is widely used in aerospace, automotive, mould making, tool and die casting industries. Many researchers have strived to improve the performance of EDM process by introducing various tool materials, dielectric fluids and additives, despite the machining efficiency of this process being much less than conventional machining processes. In general, kerosene is used as a dielectric fluid in both die sinker and wire-cut EDM applications. In general, paraffin is conventional dielectric fluids in electrical discharge machining (EDM), despite their poor performance measures being major drawbacks. It was focussed to develop a dielectric fluid offering good performance measures in the EDM process, by determining the appropriate proportion of paraffin oil-servotherm and analyzing its performance with and without the additive concentration in EDM of Monel 400™. Sixteen samples of paraffin-servotherm of varying proportions were used in this study. The optimum proportion of paraffin-servotherm was found to be 70:30, which resulted in the highest material removal rate (MRR) as compared with other proportions and tool wear rate (TWR), and surface finish (SR) are found to be poorer than when using paraffin oil alone.

Key Words: Dielectric; Electrode; Graphite; paraffin; Material; Servotherm; Tool.

1. INTRODUCTION

EDM process is a unconventional electro-thermal process which is being widely employed Tool and Die Industries Automotive and Air craft industries, Medical equipment industries and armament industries. The major drawback found in EDM process is more time of machining and high tool wear rate, since total cost of machining is much more than conventional machining process. In addition, poor surface finish is imparted to the machined work piece coupled with showing some surface defects Singh et.al [1]. The dielectric fluid employed in the EDM process should possess high breakdown potential, instantaneous recovery of breakdown potential after ionization, high thermal steadiness, lower viscosity, the ability to keep the machining zone free from debris, lower cost, and ready availability [2]. Machining output is influenced by the type of dielectric and flushing method employed [3]. Leao et al. [4] indicated that kerosene and hydrocarbon oil are the dielectric fluids generally used in the EDM process. These contain more carbon and at high temperature they deposit an energy consuming carbon layer over the surface of the machined work piece. This carbon layer results in a low material removal rate (MRR) and poor surface finish. Singh et al. [5] mentioned that researchers have attempted to improve the performance measures of the EDM process by introducing the additives kerosene and hydrocarbon oil.

2. Experimental details

In this study, servotherm is mixed with different amounts (0, 2.5, 5, 7.5, 10, 12.5, 15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, and 37.5 l%) of Paraffin-servotherm in 16 different proportions, The copper rod used as tool electrode was 6 mm in diameter and 5 cm in length. A Monel 400™ plate was used as work piece, which was cut into 41 small pieces that were smoothed before initiating the EDM process. A hole of 6mm diameter and 3mm depth was machined in the workpiece using paraffin- servotherm, with 10 A current. MRR and TWR were measured by electronic weight balance and a stopwatch (accuracy 0.01 s). A standard dial indicator (Mitutoyo) with a resolution of 0.001mm was employed to measure surface roughness (SR). Measurements were done in triplicate at three different sites over a length of 3mm, with average values being taken as the SR of the hole. Comparing the performance of the 16 combinations was chosen as appropriate combination on the basis of machining output a 85:15 ratio of paraffin to servotherm. The experiments were done using a numerically controlled electrical discharge machine (Glory Engineering) incorporating a stirrer, as shown in Figs. 1(a) and 1(b). Phase changes in the machined surface of work piece samples were analyzed by scanning electron microscope (SEM) and EDAX (kV 30.00; tilt 0.20; take-off 35.22; AmpT 25.6; detector type SUTW-Sapphire; resolution 133.20). The chemical composition of the workpiece and EDM process variables are given in Tables 1 and 2,

Table 1 Monel 400™ chemical composition (wt. %)

Elements	Composition (wt. %)
C	0.30 max
Mn	2.00 max
S	0.024 max
Si	0.50 max
Ni	63.0 min
Cu	28.0 – 34.0
Fe	2.5

Table 2 Experimental Design

Working conditions	Description
Work-piece	Monel 400™ (Density 27.68 g/cm ³)
Electrode	Copper (Density 8.96 g/cm ³), Melting point 1083 C
Dielectric type	Paraffin–Servotherm (70:30)
Current	10 A
Power supply in voltage	30 V



Fig. 1 Picture of experimental setup

2.1 RESULTS AND DISCUSSION

The performance of 16 combinations of Commercial grade EDM oil and servotherm in regard to MRR and TWR during the three trials is shown in Figs 2. and 3. Commercial grade EDM oil –Servotherm indifferent proportions exhibited variation in MRR and TWR values under the given conditions. Material removal rate increased with increasing 1% of servotherm up to 85:15, beyond which it declined. A Commercial grade EDM oil –servotherm ratio of 85:15 showed the highest MRR which was 1.9-fold more than kerosene alone, which may be attributed due to the high breakdown potential its immediate resumption after ionization. By increasing the liter percentage of servotherm beyond 25% the viscosity of the mixture increased markedly, which would have affected flushing thereby reducing MRR. Figure 3 shows that TWR increased with increasing proportion of servotherm to 12.5%, after which it declined; at 15% servotherm, the decrease in TWR was found to be 14% less than with kerosene alone, possibly due to significant levels of nickel having moved from the work piece to the tool surface [evident from EDAX analysis, Fig. 5(b)], where it formed as a coating of spark erosion resistance thereby reducing TWR markedly. We did not investigate servotherm levels above 37.5% on account of prohibitive cost. It was observed from the SEM images as shown in Figs 3(a) and 3(b) that paraffin–servotherm at a ratio of 85:15 achieved a slightly greater heating effect than paraffin alone, resulting in marked roughness on the surface

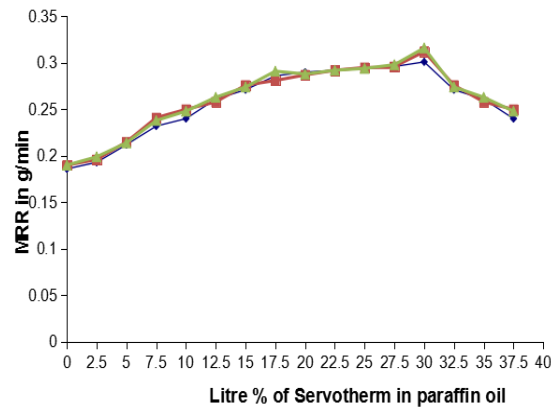


Figure 2 MRR vs. Lt % of Servotherm in paraffin oil

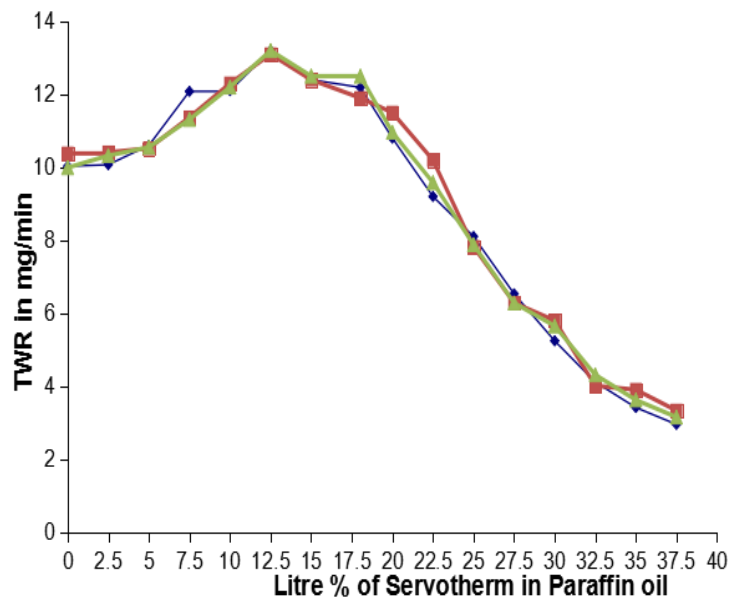


Figure 3 TWR vs. Lt % of Servotherm in Paraffin oil

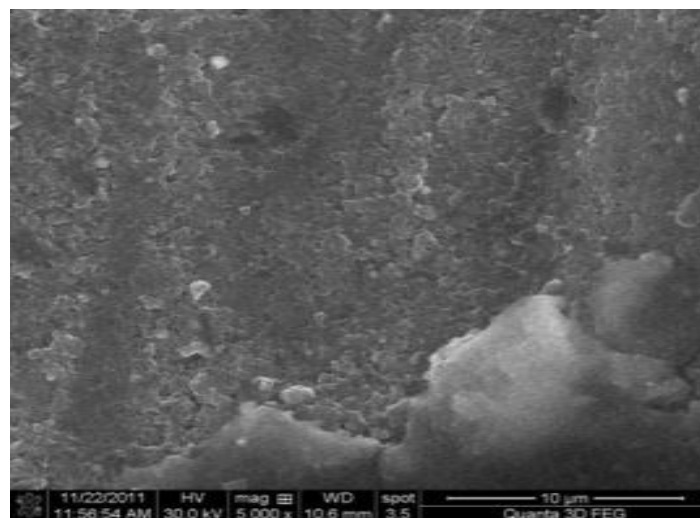


Figure 4(a)

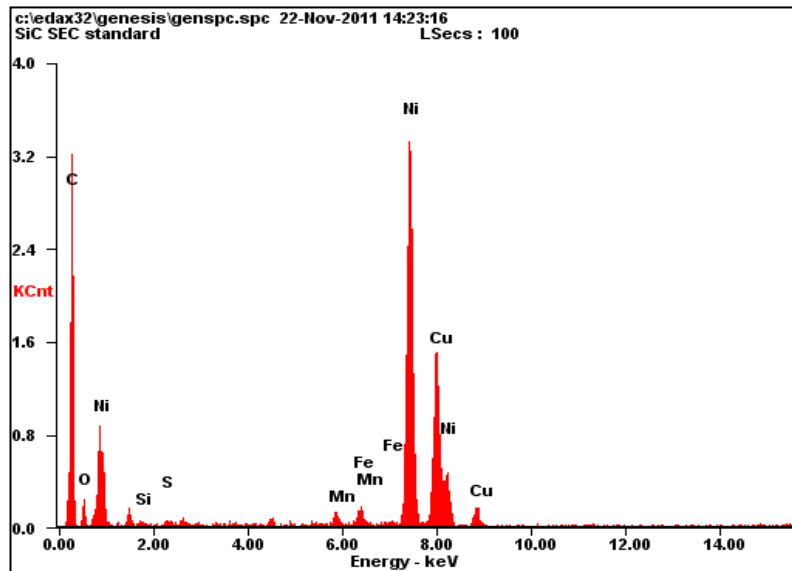


Figure 4(b)

Figure 4 (a) SEM and (b) EDAX images of machined surface for Paraffin

3. CONCLUSION

Electrical discharge machining of Monel 400TM was carried out using paraffin –servotherm in 16 different proportions. The results obtained from the study are summarized below. Servotherm significantly reduced ignition delay since the mixture of paraffinand servotherm (70:30) enhanced MRR 1.9-fold that of paraffinalone. The mixture of paraffin and servotherm (70:30) reduced TWR by 14 %that of paraffindue to the formation of nickel coating (spark erosion resistance) over the tool surface during machining. The mixture of paraffin and servotherm (85:15) has been considered for EDM applications instead of EDM oil alone since it offers more MRR and reduced TWR.

4. REFERENCES

1. Singh et al. (2006) conducted experimental investigation in AEDM of cast aluminium metal matrix composites (Al/Al₂O₃P-20%) using silicon carbide powder in dielectric and reported better machining rate as compared to simple die sinking. Further, they optimized the process parameters using Taguchi methodology and published “Electrical discharge machining (EDM) of aluminium metal matrix composites using powder-suspended dielectric fluid”, Journal of Mechanical Engineering 2006, vol. 57, no. 5, pp. 271-290.
2. Singh et al. (2006) conducted experimental investigation in AEDM of cast aluminium metal matrix composites (Al/Al₂O₃P-20%) using silicon carbide powder in dielectric and reported better machining rate as compared to simple die sinking. Further, they optimized the process parameters using Taguchi methodology.
3. Xue Bai et.al (2018) studied the EDM process using three-phase flow dielectric medium and arrived optimum combat ion so that achieve better machining measures and published Experimental study on the electrical discharge machining with three-phase flow dielectric medium in International journal of advanced manufacturing process
4. Canadian metal working (2017) found highly refined and synthetic fluids can have a much longer lifespan than petroleum based oils.

BIOGRAPHIES



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