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Enhancing performance measures in Electrical discharge Machining of Monel 400™ using Mixture of Dielectric fluids

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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, commercial grade EDM oils is conventional dielectric fluids in electrical discharge machining (EDM) which offer more tool wear rate and poor surface finish. The cited drawbacks could overcome by developing mixture of dielectric fluids. The mixture is developed by using EDM oil and servotherm. It is proposed experimentally obtain the best proportion of Commercial grade EDM oil–servotherm and observing its performance in EDM of monel 400TM. Sixteen samples of Commercial grade EDM oil–servotherm of different proportions were employed during the study. The best of EDM–servotherm observed was 85:15, which yielded in the highest material removal rate (MRR) as than other proportions and tool wear rate (TWR), and surface finish (SR) are found to be not satisfactory as comparing EDM oil alone. This study may be more beneficial to automotives components manufacturing sectors for making the components with less machining cost with good quality of the products.

Keywords: Copper tool; Monel metal; Material removal rate; performance measures

1. INTRODUCTION

EDM process is a unconventional electro-thermal process which is being widely employed Automotive and Air craft industries,Tool and Die Industries, Medical equipment industries and armament industries. The major drawback anticipated in EDM process is consume more time to machine the material and excessive tool wear rate, so that machining cost found to higher than

conventional machining processes . Performance measures in EDM process are poor causing poor surface finish and more surface defects in EDM product [1]. Jothimurugan et.al [2] developed kerosene-servother (75:25) which shows better performance than single dielectric fluid. The dielectric fluid employed in EDM process must possess high breakdown potential and less ignition delay which would lead to more MRR and less TWR [3]. Leao et al. [4] explored the dielectric fluid of carbon compound and the hydrocarbons fluids generally offer less MRR and more TWR coupled with formation of carbon layer on the machined surface. The type of dielectric fluid and additive concentration are much influencing in machining attributes of EDM process [5]. Singh et al. [6] mentioned that researchers achieved to improve the performance measures of the EDM process by introducing the additives in kerosene and hydrocarbon oil.

2. EXPERIMENTAL SETUP OF VCR ENGINE

In the focused study, sixteen different proportions of Commercial grade EDM oil-Servotherm are obtained by mixing the 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 servotherm in EDM oil. The copper rod used as tool electrode was 10 mm in diameter and 6 cm in length. The forty one test pieces made of Monel 400^{TM} were prepared to required size using cutting and grinding processes. A hole of 10 mm diameter and 5mm depth was machined in the workpiece using EDM oil – servotherm, with 10 A current. The performance measures like MRR and TWR were measured by electronic weight balance and a stopwatch (accuracy 0.02 s).

The surface roughness (SR) was measured using standard dial indicator (Mitutoyo) with a resolution of 0.001mm. Measurements were done in three time at three different places over a length of surface of 5 mm, with average values being taken as the SR of the hole. Observing the performance of different combinations it is arrived Commercial grade EDM oil-Servotherm (85:15) proportion which offered more MRR and less TWR than other proportion employed for present study. The experiments were conducted by employed a NC electrical discharge machine (Glory Engineering) attached with a stirrer, as shown in Figs. 1. Surface study on the machined surface of work piece samples were done by scanning electron microscope (SEM) and EDAX (kV 20.00; tilt 0.20; take-off 45.22; AmpT 35.6; detector type SUTW-Sapphire; resolution 233.20). The EDM process variables and chemical composition of the workpiece are given in Tables 1 and 2.

Table 1 Experimental Design

Working conditions	Description
Work-piece	Monel 400™
Electrode	Copper
Dielectric type	EDM oil–Servotherm (75:25)
Current	12 A
Power supply in voltage	40 V

Table 2 Monel 400™ chemical composition (wt. %)

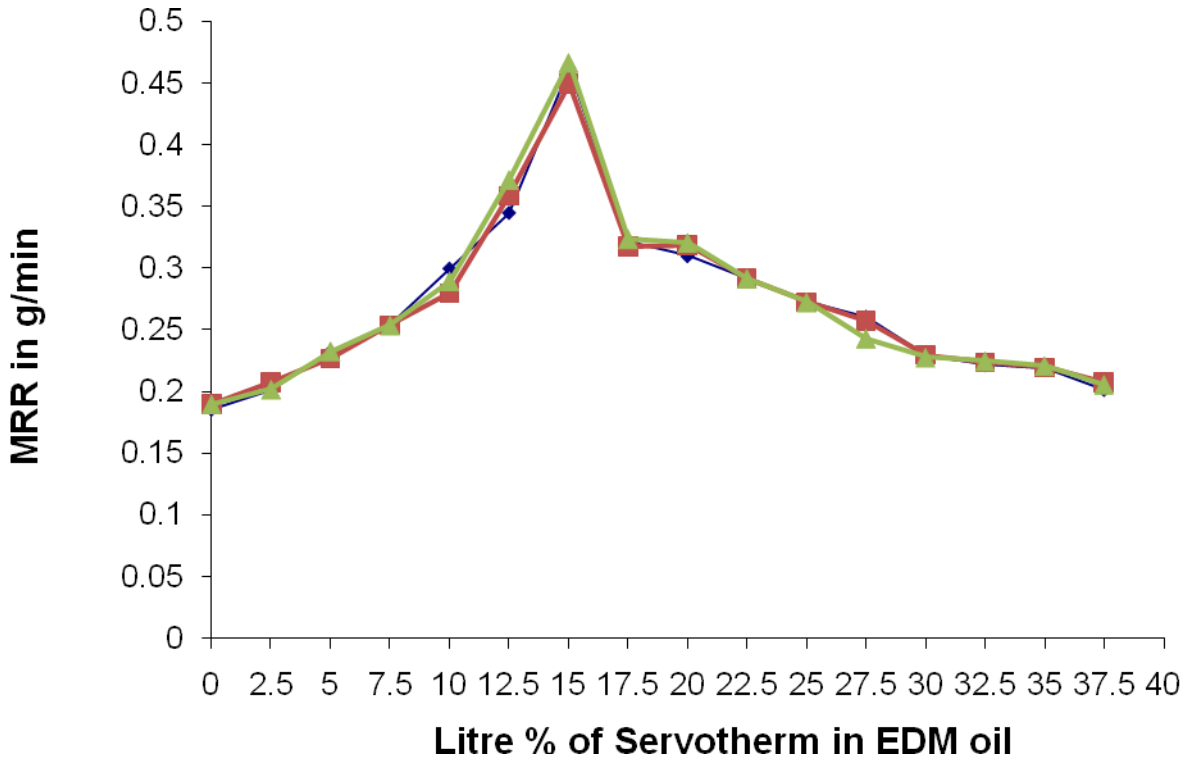
Elements	Composition (wt. %)
C	0.40 max
Mn	1.90 max
S	0.044 max
Si	0.46 max
Ni	62.0 min
Cu	27.0 – 32.0
Fe	2.8

Fig. 1 Picture of experimental setup

3. RESULTS AND DISCUSSION

It is observed that the machining performance of sixteen different proportion of Commercial grade EDM oil –Servotherm in EDM process are depicted in the figure 2 & 3 .

Commercial grade EDM oil –Servotherm in varying proportions offered different MRR and TWR values under the given experimental design. Material removal rate steeply increased with increasing l% of servotherm up to 85:15, latter it was declined. A Commercial grade EDM oil – servotherm ratio of 85:15 offered the enhanced MRR which was 1.9-fold more than kerosene alone, This is due to the more breakdown potential, less ignition delay of the mixture. It is observed that increasing the % of servotherm beyond 15% which would lead to significant increase in viscosity of the mixture causing poor flushing. Figure 3 revealed that TWR increased with increasing concentration of servotherm upto 12.5%, then it declined; at 15% servotherm, the reduced in TWR was observed to be 14% less than with Commercial grade EDM oil alone, this might be transfer nickel from work surface to tool [evident from EDAX analysis, Fig. 4(b)], where it is formed coating of heat resistance so that reduce the tool wear rate considerably. The experiment is not conducted beyond 37.5% of servothem, since it is costlier. The newly developed mixture offers more heating effect causing rougher surface is produced than Commercial grade EDM oil alone which is depicted in figure 4(a).



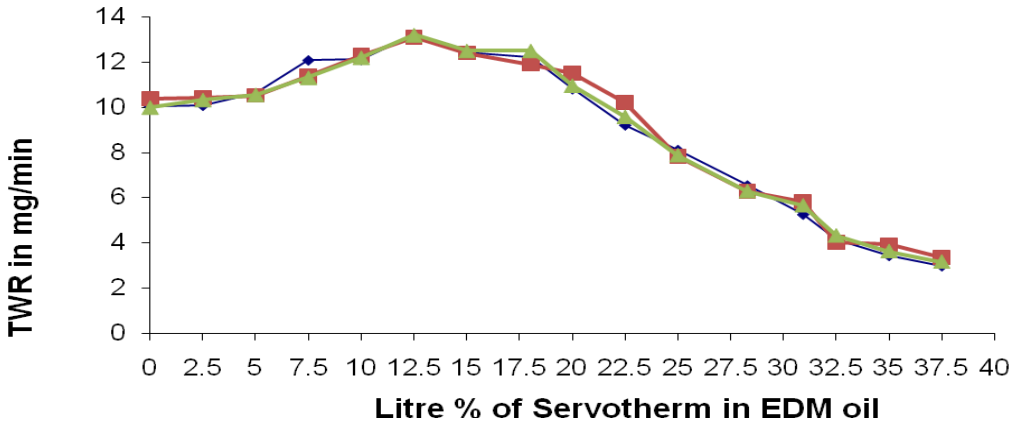


Figure 3 TWR vs. Lt % of Servotherm in EDM oil

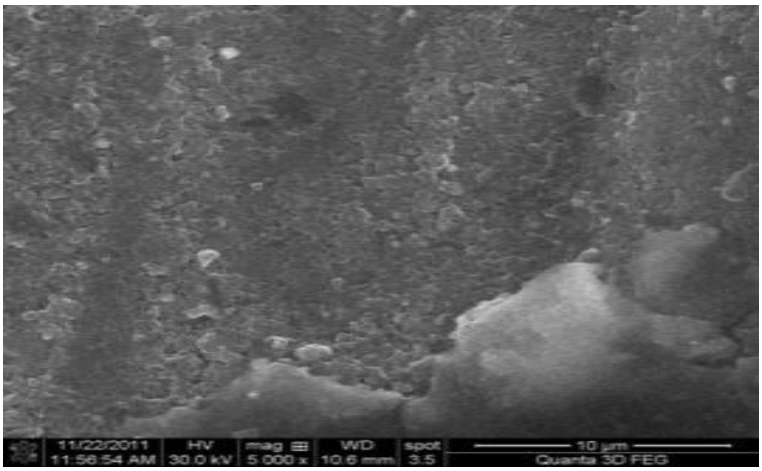


Figure 4(a)

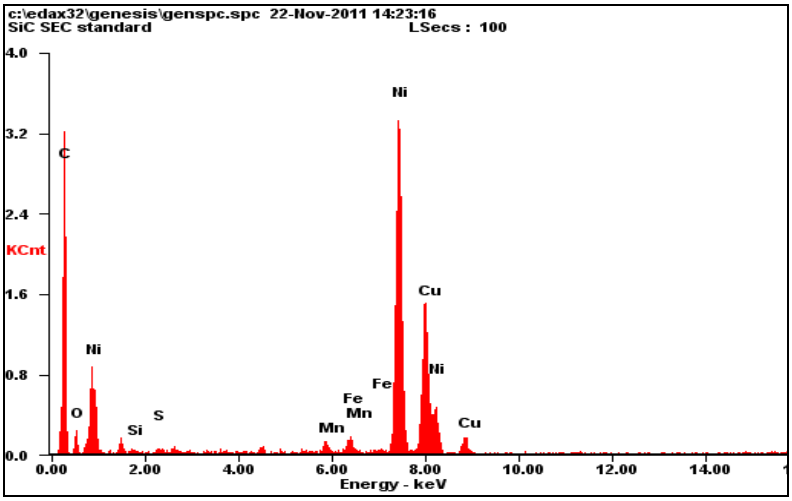


Figure 4(b)

Figure 4 (a) SEM (b) EDAX images of machined surface for commercial grade EDM oil

4. CONCLUSION

From the experimental study it was concluded that Commercial grade EDM oil – servotherm ratio of 85:15 offers MRR which 1.9 times more than Commercial grade EDM oil alone due to considerable reduction in ignition delay & more breakdown potential. The mixture yields less tool wear rate due to migrating more nickel from machined surface to tool face. The surface roughness developed somewhat more than Commercial grade EDM oil alone due to more heating effect. The mixture can be employed for EDM applications rather than EDM oil alone for achieving better performance measures. This study offers much more benefits to automotive components manufacturing sectors.

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