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Enhancing performance measures in Electrical discharge Machining of Monel 400^{TM} using Pennzoil Platinum Oil - servotherm

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Abstract - Electrical discharge machining (EDM) process is an unconventional machining process to machine wide varieties of materials to required complex shapes with good dimensional accuracy, since it is employed in aerospace, automotive, mould making, tool and die casting industries. The scientist have tried to improve the performance measures of EDM process by using various tool materials, dielectric medium and additives, though the machining efficiency of this process being much less than traditional machining processes. In general, kerosene is a conventional dielectric fluid in both die sinker and wire-cut EDM applications, but it offers poor offers surface quality in machined products. In general, Pennzoil Platinum Oil is conventional dielectric fluids in electrical discharge machining (EDM), despite their poor performance measures being major drawbacks. It was focussed to develop a mixture of dielectric fluid offering good performance measures in the EDM process, by determining the appropriate proportion of Pennzoil Platinum Oil –servotherm and analyzing its performance in EDM of monel 400^{TM}. Sixteen samples of Pennzoil Platinum Oil –Servotherm of varying proportions were used in this study. The optimum proportion of Pennzoil Platinum Oil –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 less and more respectively than when using Pennzoil Platinum Oil alone.

***Key Words*:** Dielectric; Electrode; Graphite; Pennzoil Platinum Oil; Material; Servotherm.

1. INTRODUCTION *(Size 11, Times New roman)*

EDM process is a unconventional electro-thermal process which is being widely employed in tool and die industries, automotive and air craft industries, medical equipment industries and armament industries. The major drawback found in EDM process is less machining efficiency coupled with more tool wear rate due to using conventional dielectric. 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 workpiece. This carbon layer results in a low material

2.1 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 Pennzoil Platinum Oil–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^{TM} 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 work piece using Pennzoil Platinum oil – 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 70:30 ratio of Pennzoil Platinum Oil - 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^{TM} 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

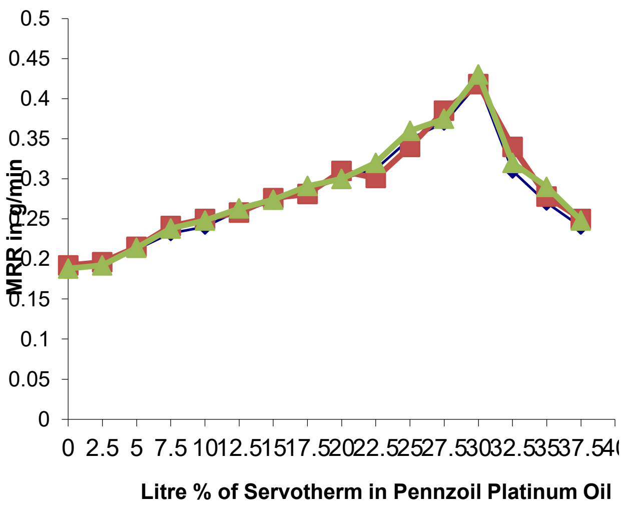
Working conditions	**Description**
Work-piece	Monel 400^{TM} (Density 27.68 g/cm^3)
Electrode	Copper (Density 8.96 g/cm^3), Melting point 1083 C
Dielectric type	Pennzoil Platinum Oil –Servotherm (70:30)
Current	10 A

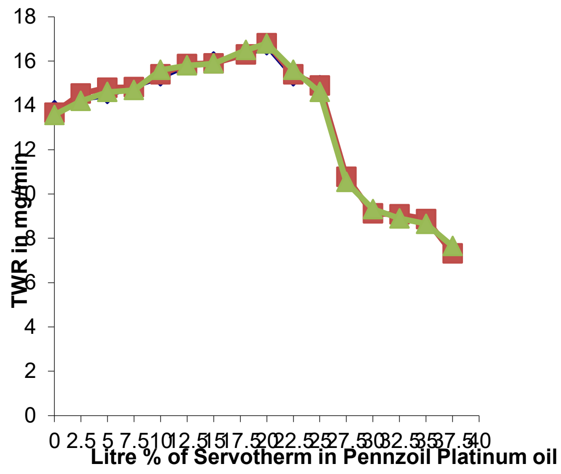
Power supply in voltage	30 V

Fig. 1 Picture of experimental setup

RESULTS AND DISCUSSION

The performance of 16 combinations of Pennzoil Platinum Oil and servotherm in regard to MRR and TWR during the three trials is shown in Figs 2. and 3. Pennzoil Platinum Oil –Servotherm indifferent proportions exhibited variation in MRR and TWR values under the given conditions. Material removal rate increased with increasing l% of servotherm upto 70:30, beyond which it declined. A Pennzoil Platinum Oil –servotherm ratio of 70 :30 showed the highest MRR which was 2.25 fold more than platinum oil alone and it is 5.6 times more than kerosene, which may be attributed due to the high breakdown potential its immediate resumption after ionization. By increasing the liter percentage of servotherm beyond 30% 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 22.5%, after which it declined; at 30% servotherm, the TWR was found to be 9.21 mg/min which is 1.55 times less than EDM oil, 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 Pennzoil Platinum Oil –servotherm at a ratio of 70:30 achieved a slightly greater heating effect than Pennzoil Platinum Oil alone, resulting in marked roughness on the surface





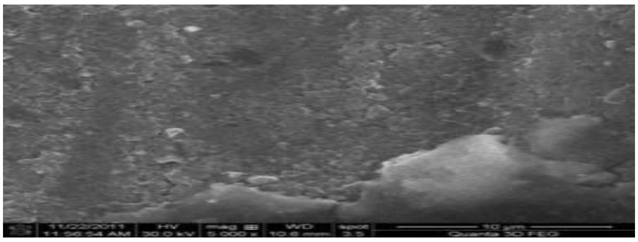


Figure . 4(a)

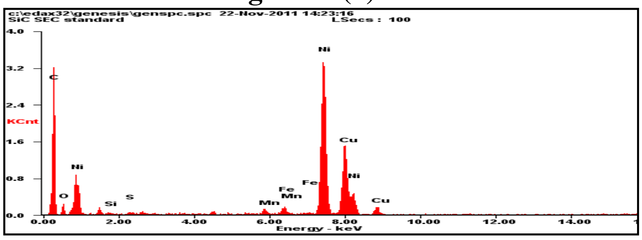


Figure 4(b)

Figure 4 (a) SEM and (b) EDAX images of machined surface using Pennzoil Platinum Oil

3. CONCLUSIONS

Electrical discharge machining of Monel 400™ was carried out using Pennzoil Platinum Oil –servotherm in 16 different proportions The results obtained from the study are summarized below. Servotherm significantly reduced ignition delay since the mixture of Pennzoil platinum oil and servotherm (70:30) enhanced MRR 2.25 fold that of Pennzoil platinum oil alone. The mixture of Pennzoil Platinum Oil and servotherm (70:30) reduced TWR by 34 % that of Pennzoil Platinum Oil due to the formation of nickel coating (spark erosion resistance) over the tool surface during machining. The mixture of Pennzoil Platinum Oil and servotherm (70:20) has been considered for EDM applications instead of conventional dielectric media since it offers more MRR and reduced TWR.

REFERENCES

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BIOGRAPHIES (Optional not mandatory)

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