Journal of Applied Sciences

ISSN 1812-5654

Journal of Applied Sciences 12 (10): 999-1005, 2012
ISSN 1812-5654 / DOI: 10.3923/jas.2012.999.1005

Performance of Silver Coated Copper Tool with Kerosene-servotherm Dielectric in EDM of Monel 400™

[1]R. Jothimurugan, [2]K.S. Amirthagadeswaran and [3]Joel Daniel
[1]Department of Mechanical Engineering, Erode Sengunthar Engineering College, Erode-638057, India
[2]Department of Mechanical Engineering, Government College of Technology, Coimbatore-641013, India
[3]Department of Mechanical Engineering, P.G. Scholar in Manufacturing Engineering, Erode Sengunthar Engineering College, India

Abstract: Technologies to improve the material removal rate and reduce the tool removal rate, achieve the good surface finish and dimensional accuracy are very demanding in electrical discharge machining (EDM). The work focused on comparing performance of optimum silver coated copper tool electrode with conventionally used copper tool electrode using optimum proportionate kerosene-servotherm and commercial grade EDM oil in electrical discharge machining of Monel 400™. The optimum thickness of silver coating over the copper tool electrode and optimum proportionate Kerosene-Servotherm dielectric were developed experimentally. The copper tool electrode with silver coating of five microns reported slightly more material removal rate, very low tool wear rate, better dimensional accuracy and good surface finish than copper tool electrode with Kerosene-Servotherm (75:25) dielectric.

Key words: Electrical discharge machining, material removal rate, tool wear rate, surface roughness, dielectric medium

INTRODUCTION

Electrical discharge machining is a well developed unconventional thermal machining process which is being employed for successful machining of both conductive and insulating materials of any hardness with good dimensional accuracy and surface finish (Choudhury and El-Baradie, 1998). In this process, the energy intense rapid and repetitive spark discharge is maintained between work piece and tool electrode causing melting and evaporation work piece (Singh *et al*., 2004). It is recognized as a standard process in industries for making cavities in hardened die and process tool (Chen *et al*., 1999). Many research works had been done by using different tool electrode materials and dielectric media for obtaining best machining output (Pradhan *et al*., 2009). The performance of Cu tool electrode is better than Al electrode with kerosene in EDM of En-31 tool steel (Sharma *et al*., 2002). The performance of cu-cr alloys is better than Cu and brass with both kerosene and distilled water in EDM of OHMS die steel (Haron *et al*., 2008). The performance of WC-Cu composite was inferior to Cu tool (Chow *et al*., 2000). The enhancement in wear resistance of machined surface by using WC-Cu composite was observed. The Cr-Cu composite shows higher MRR than Cu and also improved the corrosion resistance of work piece (Hascalik and Cayday, 2007). The performance of ZnBr-Cu composite is superior to Cu tool was observed (Jilani and Pandey, 1984).

MATERIALS AND METHODS

In these investigations, the servotherm is mixed with different amounts (0, 12.5, 25, 37.5, 50, 62.5, 75 and 100 wt.%) of kerosene. The dielectric media of six different combinations were obtained. The copper tool electrode of 10 mm diameter and 6 mm length has been prepared and performance of the same was investigated in EDM of Monel 400™ with different combinations of kerosene-servotherm at 10 A current. A depth of cut of 5 mm was done on work piece for each combination and the optimum combination was obtained.

The comparison of performance of Cu tool electrode was done with kerosene-servotherm (75:25) and commercial grade EDM oil at different current settings (6, 7, 8, 9, 10, 11 and 12 A).

The Cu tool electrodes of 6 cm length and 10 mm diameter are prepared and they are coated with the

Corresponding Author: R. Jothimurugan, Department of Mechanical Engineering, Erode Sengunthar Engineering College, Erode-638057, India

Table 1: Chemical composition (wt.%) of Monel 400™

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	2.50 max.

kerosene commonly used dielectric medium with cu. tool in EDM whereas, commercial grade EDM oil is being used instead of kerosene due to possessing of superior machining output (Klocke *et al*., 2004). In the present investigation, comparing the performance of optimum Ag coated Cu tool electrode with Cu tool electrode using optimum proportion of Kerosene-Servotherm and Commercial grade EDM oil in EDM of Monel 400™ (Schumacher, 2004). The optimum silver coating over copper tool and also optimum combination of kerosene-servotherm were obtained experimentally. The comparison performance has been observed at different current settings (6, 7, 8, 9, 10, 11 and 12 A). The phase changes in tool and work piece during the EDM are also observed. There is no published study on performance of silver coated Cu tool electrode with kerosene-servotherm dielectric (Singh *et al*., 1985). The chemical composition of this work material is given in Table 1.

Silver coating of different thickness (5, 10, 15, 20 and 25 μ) were done on over the Cu tool electrode using electrolysis process EDM was done using silver coated copper tool electrodes with optimum combination of kerosene-servotherm dielectric at optimum current setting. From the best machining output the optimum Ag coating thickness was obtained.

RESULTS AND DISCUSSION

The studies on Monel 400™ with kerosene-servotherm of different combinations and Cu tool electrode are shown in Fig. 1, 2. Figure 1 shows that the kerosene-servotherm of different combinations evolved in different Metal Removal Rate (MRR) and Tool Wear Ratio (TWR) under the given conditions among them the kerosene-servotherm of combination 75:25 yields the MRR as 14.82% more than and TWR as 56.6% less than kerosene. This may be due to less formation of energy consuming carbon layer over the surface of the work piece during machining process. The servotherm of 100% was being used and found that the MRR is 46.2% more than and TWR is 78.17% less than kerosene. Inspite of that servotherm could not be employed as dielectric because of it is denser fluid which requires more pumping energy causing excessive heat generation during machining process. It is clear that

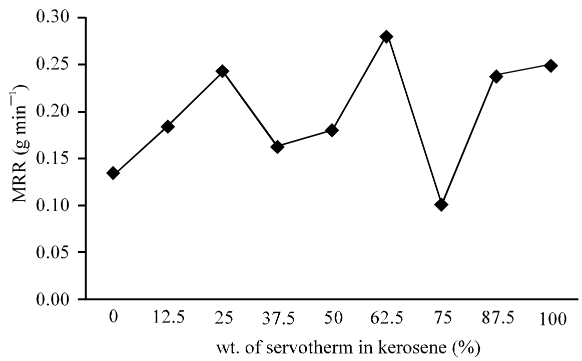

Fig. 1: Variation of MRR with different wt.% of servotherm in kerosene

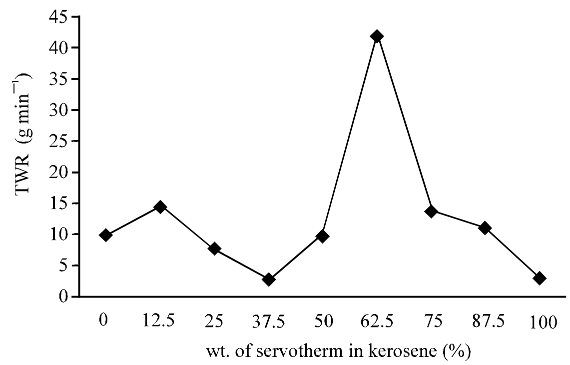

Fig. 2: Variation of TWR with different wt.% of servotherm in kerosene

kerosene-servotherm (75:25) could be considered as best performed combination. This may be due to optimum combination of thermal, electrical conductivity and viscosity.

The machined surface using 100% kerosene and kerosene-servotherm (75:25%) are analyzed by SEM and their images are shown in Fig. 3- 4, respectively. From the images it was observed that thickness of energy consuming carbon layer has been formed on machined surface when using 100% Kerosene is more than Kerosene-Servotherm.

Here, after the K-S (75:25) would be referred as P dielectric medium i.e., optimum proportion of K-S dielectric medium whose performance has been compared with commercial grade EDM oil at different current settings.

Figure 5 depicts that the P dielectric medium offers more MRR than commercial grade EDM oil in most of all current setting (i.e., 8, 12, 14 and 16 A). Figure 6 shows that the P dielectric provides less TWR than commercial grade EDM oil in most of all current setting (6, 10, 12, 16 and 18 A). In both dielectric media when the

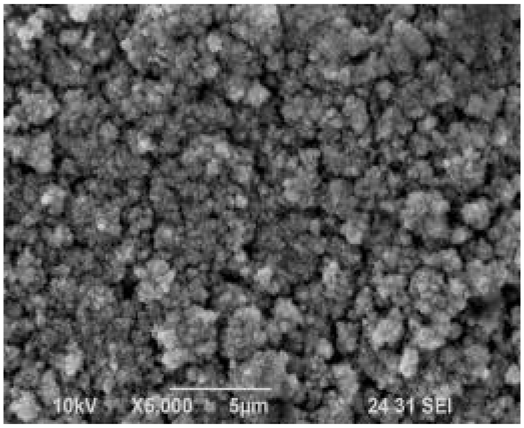

Fig. 3: SEM image of machined surface using 100% kerosene

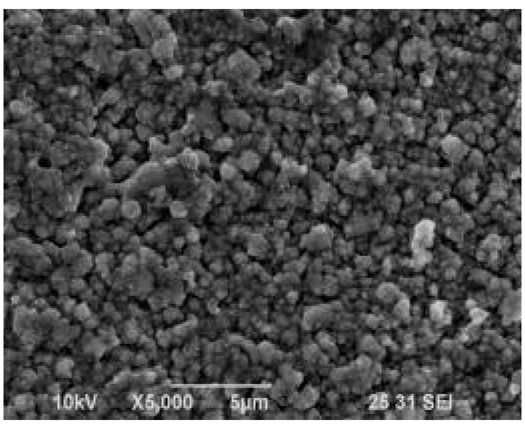

Fig. 4: SEM image of machined surface using 75% kerosene+25% servotherm

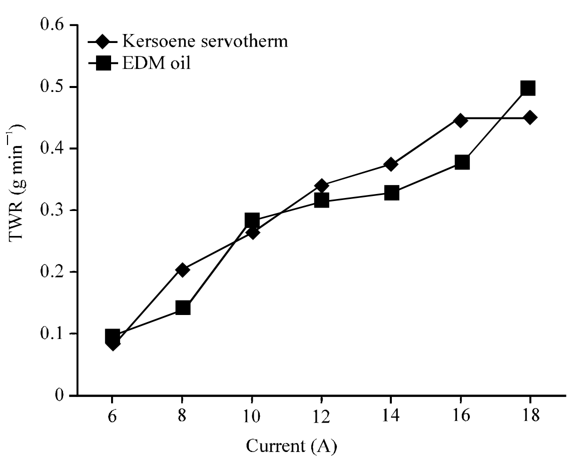

Fig. 5: Variation of MRR with current for P dielectric medium and commercial grade EDM oil

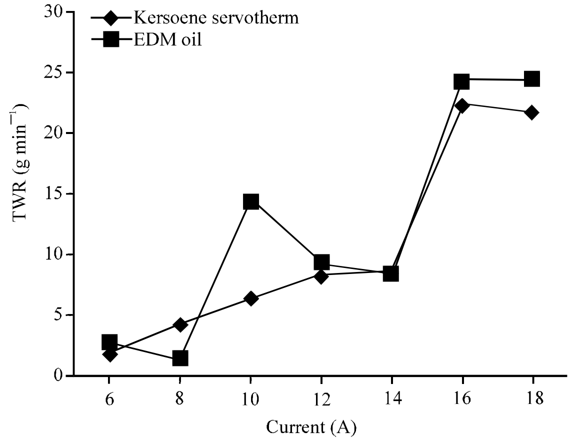

Fig. 6: Variation of TWR with current for P dielectric medium and commercial grade EDM oil

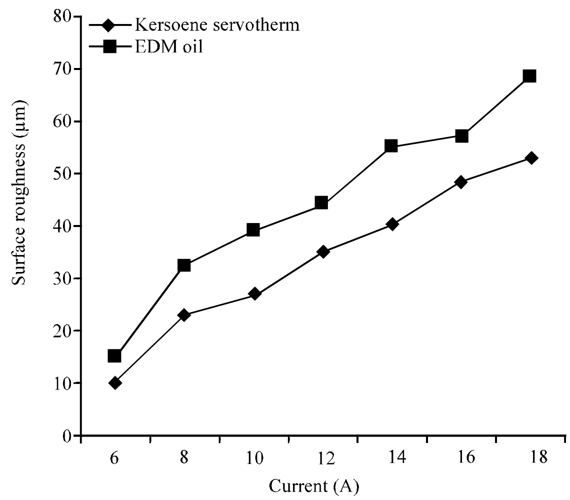

Fig. 7: Variation of surface roughness with current for P dielectric medium and commercial grade EDM oil

current is increased that the MRR found to be increased due to increase in input energy.

Considering the both machining outputs i.e., MRR and TWR the current setting at 10 A is found to be optimum, where the P dielectric offered MRR as 1.9% less than commercial grade EDM oil, inspite of that TWR is 55.24% less than the same. The higher current setting i.e., at 16 and 18 A the MRR and TWR are reported by the kerosene-servotherm (75:25) is much better than commercial grade EDM oil.

The Fig. 7-8 give the experimental results of surface roughness and diameteral overcut when using kerosene servotherm (75:25%) i.e., P dielectric medium and commercial grade EDM oil. It was found that kerosene-

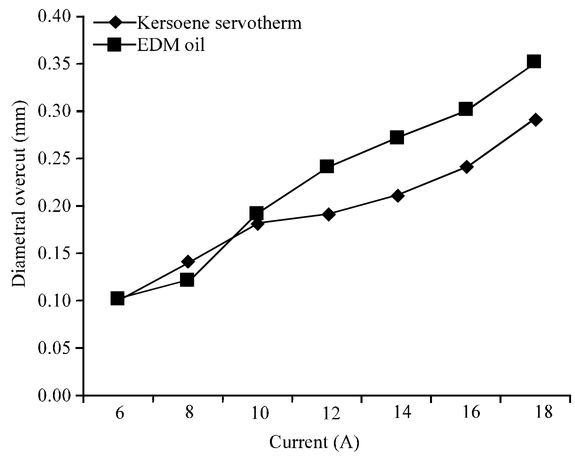

Fig. 8: Variation of current for P dielectric medium and commercial grade EDM oil

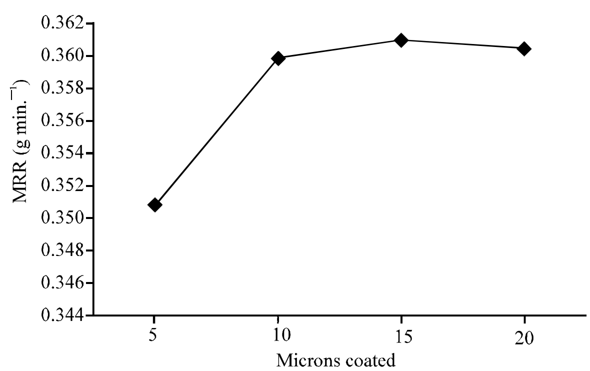

Fig. 9: MRR vs. different microns coated

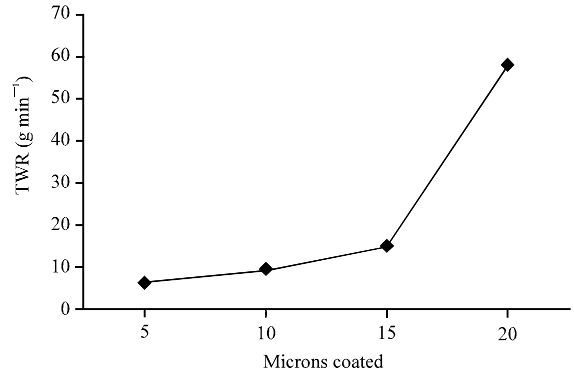

Fig. 10: TWR vs. different microns coated

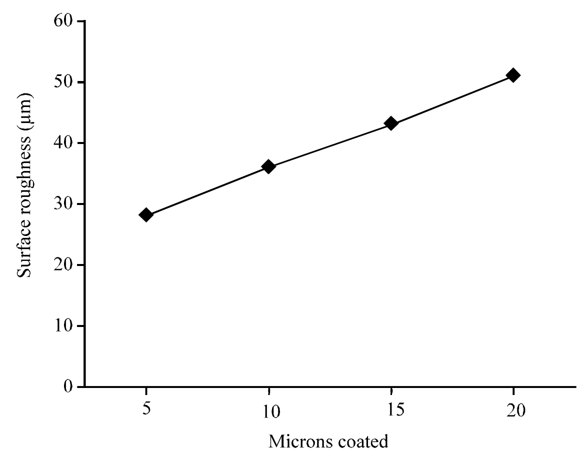

Fig. 11: Surface finish vs. different microns coated

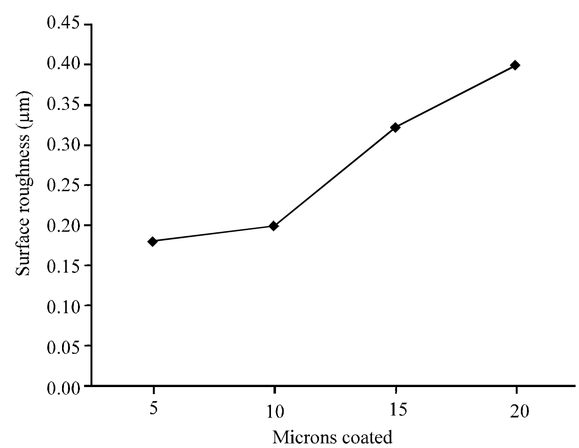

Fig. 12: Diameteral overcut vs. different microns coated

servotherm (75:25%) shows better surface finish and dimensional accuracy than commercial grade EDM oil.

From the arguments, that the 10A current is found to be more suitable so as to provides much lower T.W.R using optimum proportionate K-S than commercial grade EDM oil.

The performance of silver coated copper tool electrodes of different thickness (i.e., 5, 10, 15 and 20 μ) using P dielectric at different current settings are shown in Fig. 9 and 10 and it is observed that the M.R.R and T.W.R are found to be increased as the increase in coating thickness and it is due to increase in the mobility of electrons through Ag coating.

Figure 9 and 10 show, that the thickness of coating is increased by 5 μ, the corresponding increased in M.R.R and T.W.R are 6 and 46.01%, respectively, Further increasing 5 μ causing the increase in M.R.R and T.W.R are 16 and 62.9%. The thickness of coating increased beyond 15 μ, the machining output are found to be very unsatisfactory. Hence, Ag coating of 5 μ has considered as optimum.

Figure 11 and 12 give the experimental result of surface roughness and diameteral over cut using Cu tools

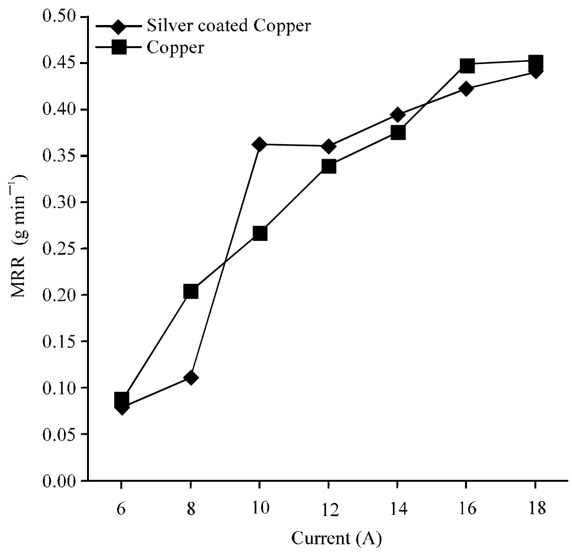

Fig. 13: MRR vs. different current setting

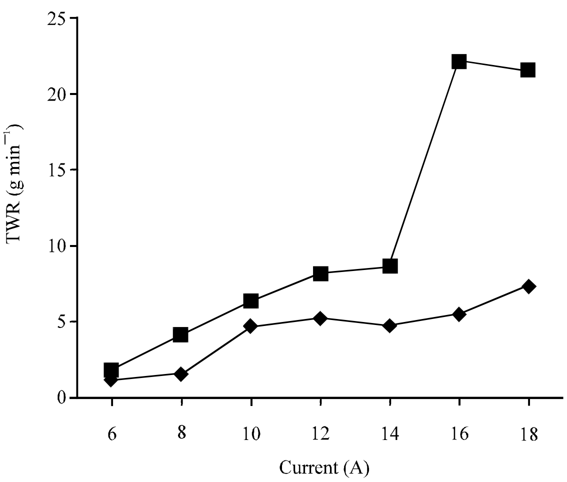

Fig. 14: TWR vs. different current setting

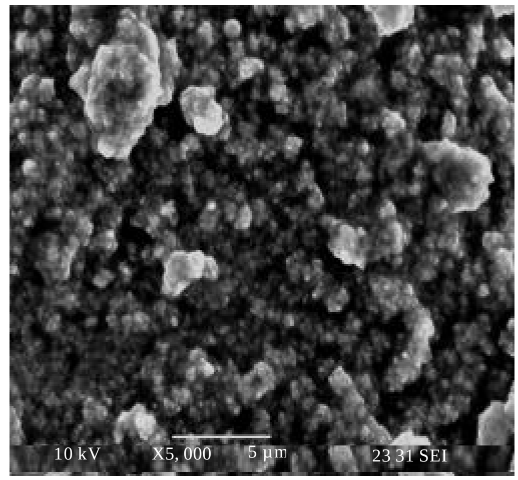

Fig. 15: SEM images of machined surface for copper tool electrode

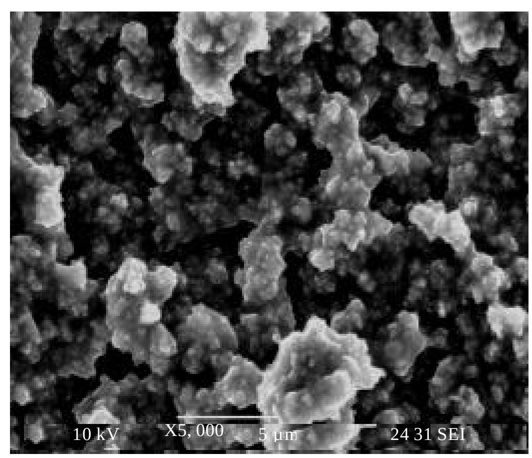

Fig. 16: SEM image of machined surface for silver coated Cu tool electrode

of different thickness of Ag coating with P dielectric medium. It was observed that both surface roughness and diameteral overcut are increasing in thickness of coating, it may be due to increasing input energy due to high mobility of electrons.

The performance of optimal silver coated Cu tool electrode is compared with Cu tool electrode at different current settings i.e., (6, 8, 10, 12, 14 and 18 A) are shown in Fig. 13 and 14.

The MRR reported by Ag coated Cu tool electrode is more than Cu tool at current settings of (10, 12, 14 A) and maximum of 0.3609 g min^{-1} is achieved at 10 A which is 26.8% more than Cu tool and corresponding reduced in TWR is 25%. The performance of Ag coated Cu tool electrode is much better than Cu tool electrode which is depicted in Fig. 13 and 14.

The Ag coated Cu tool electrode reports very low tool wear rate at all the current settings and very lowest tool wear had been achieved at 18 A which is 69.8% less than Cu tool. It is due to much reduced time of machining and less impingement of positive ions on surface of the tool.

The effect of silver coated Cu tool electrode and Cu tool electrode on surface roughness and diameteral overcut at different current settings using kerosene-servotherm dielectric are shown in Fig. 17 and 18,

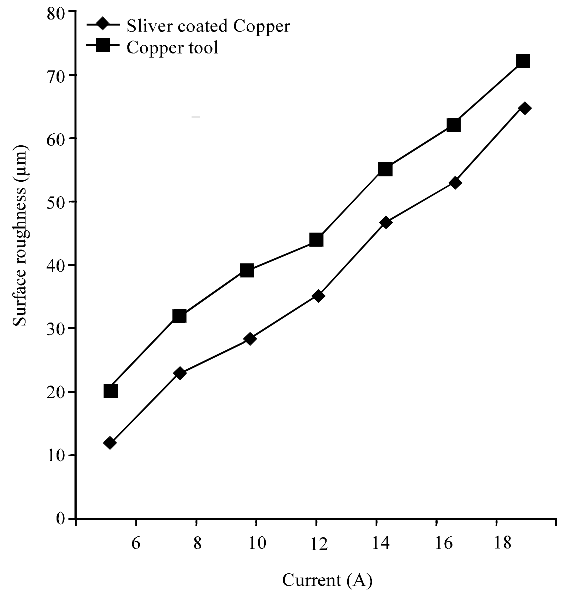

Fig. 17: SR vs. Different current setting

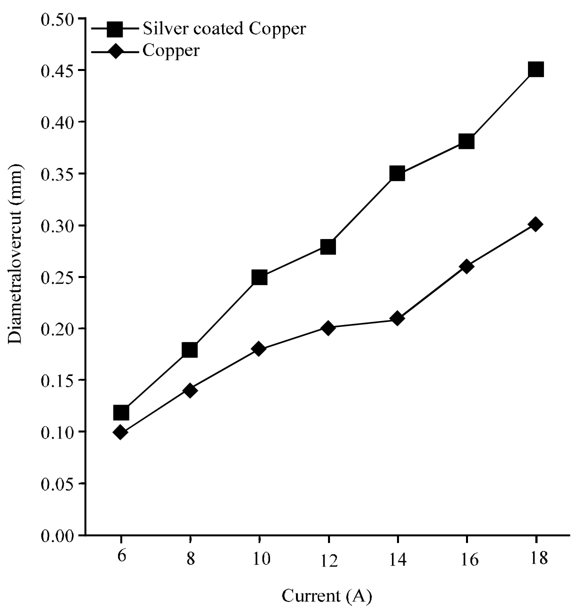

Fig. 18: Diameteral overcut vs. different current setting

respectively from these graphs it was observed that silver coated Cu tool electrode yield less surface roughness and high diameteral accuracy than Cu tool electrode.

The machined surface Monel 400^{TM} using silver coated Cu tool electrode and Cu tool electron with P dielectric were analyzed by SEM and their image have been shown in Fig. 15 and 16, respectively.

CONCLUSIONS

The EDM performance of silver coated Cu tool electrode and Cu tool electrode using optimum proportionate K-S dielectric was analyzed with Monel 400^{TM}. The important results are summarized as follows:

- The experimentally observed performance of kerosene-servotherm of different proportion and found that K-S [75:25] reported better machining output in EDM of Monel 400^{TM}
- The performance of K-S [75:25] was compared with EDM oil and observed that K-S yields 1.9% decrease in MRR inspite of that it shows 55.24% decrease in TWR
- The surface smoothness and diameteral accuracy reported by Kerosene-Servotherm are much better than commercial grade of EDM oil
- The performance of optimum Ag coated Cu tool had been compared with Cu tool with optimal proportion K-S at different current setting and results are summarized as follows:
- Ag coated Cu tool electrode reported 26.8% increase in MRR and 25% decrease in TWR than Cu tool
- Ag coated Cu tool electrode shows better surface finish and diameteral accuracy at all current settings

REFERENCES

Chen, S.L., B.H. Yan and F.Y. Huang, 1999. Influence of kerosene and distilled water as dielectric on electric discharge machining characteristics of Ti-6Al-4V. J. Mater. Process. Technol., 87: 107-111.

Choudhury, I.A. and M.A. El-Baradie, 1998. Machinability of nickel-base super alloys: A general review. J. Mater. Process. Technol., 77: 278-284.

Chow, H.M., B.H. Yan, F.Y. Huang and J.C. Hung, 2000. Study of added powder in kerosene for the micro-slit machining of titanium alloy using electro-discharge machining. J. Mater. Proces. Technol., 101: 95-103.

Haron, C.H.C., J.A. Ghani, Y. Burhanuddin, Y.K. Seong and C.Y. Swee, 2008. Copper and graphite electrodes performance in electrical-discharge machining of XW42 tool steel. J. Mater. Process. Technol., 201: 570-573.

Hascalik, A. and U. Cayday, 2007. Electrical discharge machining of titanium alloy (Ti-6Al-4V). Applied Surface Sci., 253: 9007-9016.

Jilani, S.T. and P.C. Pandey, 1984. Experimental investigations into the performance of water as dielectric in EDM. Int. J. Mach. Tools Manufact., 24: 31-43.

Klocke, F., D. Lung, G. Antonoglou and D. Thomaidis, 2004. The effects of powder suspended dielectrics on the thermal influenced zone by electrodischarge machining with small discharge energies. J. Mater. Process. Technol., 149: 191-197.

Pradhan, B.B., M. Masanta, B.R. Sarkar and B. Bhattacharyya, 2009. Investigation of electro-discharge micro-machining of titanium super alloy. Int. J. Adv. Manuf. Technol., 41: 1094-1106.

Schumacher, B.M., 2004. After 60 years of EDM the discharge process remains still disputed. J. Mater. Process. Technol., 149: 376-381.

Sharma, S., V.K. Jain and R. Shekhar, 2002. Electrochemical drilling of Inconel superalloy with acidified sodium chloride electrolyte. Int. J. Adv. Manuf. Technol., 19: 492-500.

Singh, S., S. Maheshwari and P.C. Pandey, 2004. Some investigations into the electric discharge machining of hardened tool steel using different electrode materials. J. Mater. Process. Technol., 49: 272-277.

Singh, U.P., P.P. Miller and W. Urquhart, 1985. The influence of electrical discharge machining. Proceedings of the 25th International Machine Tool Design and Research Conference, April 24-26, 1985, UK., pp: 337-345.