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Research Paper

EXPERIMENTAL INVESTIGATIONS INTO THE ELECTRICAL DISCHARGE MACHINING OF MONEL 400 USING DIFFERENT ELECTRODES AND DIELECTRIC MEDIUMS

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Electrical Discharge Machining (EDM),a nontraditional machining process has been replacing drilling milling grinding and other traditional machining operations and is now a well-established machining operation in many manufacturing industries throughout the world. Modern ED machinery is capable of machining geometrically complex or hard material component. The experimental investigations were carried out to study the effect s of dielectric mediums and pulsed current on MRR, Diametrical over cut, Electrode wear and surface roughness when machining MONEL 400(tm).In this investigation were need different dielectric mediums like kerosene, paraffin, EDM commercial grad oil and also kerosene+servotherm oil.

Keywords: EDM, Diameteral overcut, Electrode wear, Surface roughness, Electrode materials, Dielectric mediums

INTRODUCTION

The continuous introduction of new materials and the endless demands for engineers to produce complicated shapes with in tighter tolerances in many industrial applications is gradually increasing. From this point of view, machining special materials such as titanium is present great importance.

The usage of titanium and its alloys is increasing in many industrial and commercial applications because of these materials' excellent properties such as a high strength-weight ratio, high temperature strength and exceptional corrosion resistance. The alloys are extensively used in aerospace, biomedical applications and in many corrosive environments. The most common titanium is the +b type two phase MONEL 400 among several alloying types of titanium. However, titanium and its alloys are difficult to machine materials owing to several inherent properties

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of the material (Lin *et al*., 2000). Titanium is very chemically reactive with almost all cutting tool materials and its low thermal conductivity and low modules of elasticity also impairs machine ability. The traditional machining techniques are often unable to machine the alloy economically.

The spark erosion process or Electrical Discharge Machining (EDM) is a relatively modern machining process having distinct advantages over other machining processes and so its use is getting more and more widespread. EDM does not make direct contact between the electrode and the work piece where it can eliminate mechanical Stresses chatter and vibration problems during machining. Materials of any hardness can be cut as long as the material can conduct electricity. Hence, MONEL 400 which is difficult-to-cut material can be machined effectively by EDM.

The EDM process machines materials using electrical current which generates spark erosion between the electrode and work piece (Debabrata Mandal *et al.*, 2007). The electrode is positioned at the fixed small distance (spark gap) above the work piece, both submerged in a dielectric fluid. A pulsating dc power supply or EDM generator applies voltage pulses between the electrode and work piece generating sparks or current condition through the gap. The gap is stabilized by the servo control unit mechanism. When the current starts to flow the work piece, extreme high heat is generated in the cutting zone, sparks or current conduction are generated through the gap. Each spark result in localized heating and particles of metal become to molten having a very small area and at the end of the pulse duration the molten metal particles are flashed away by the dielectric fluid and remaining liquid material resolidifies. This resolidified/recast layer has been called white layer. The process repeats itself every few milliseconds. The material removal rate and the surface finish depend on the magnitude and duration of the discharge.

The aim of this study is fulfilling a detailed investigation of electrical discharge machining characteristic of MONEL 400 in relation to process parameters and different electrode materials.

Experimental Procedure

The base material used for this study was a commercial MONEL 400. The chemical composition of MONEL 400 is given in Table 1, while Table 2 lists the mechanical properties of studied material. The specimens were prepared with 75 dia and thickness of the material is 5 mm. Four kinds of tool electrode materials were used namely brass, and aluminum. The properties of tool electrodes were illustrated in Table 3. Tool electrodes were prepared with 25 mm length and 9.25 diameter of the rod (ø-diameter) in dimensions. The experiments were conducted with an electric discharge machine.

Table 1: Chemical Composition of Monel 400%

Ni	66.50
Fe	2.50
Si	0.50
Mn	2.00
C	0.300
Cu	31.00
S	0.024

Table 2: Work Piece Material Properties	
Density	8.8 g/cm3
Melting point	1350°C
Co-Efficient of Expansion	13.9µm/m.°C (20-100°C)
Modulus of rigidit	65.3 kN/mm2
Modulus of elasticity	105-120 kN/mm2

Table 3: Electrode Material Properties	
Poisson's Ratio	0.36
Specific heat	384.56 J/kg/K
Yield strength	398 W/m/K
Yield strength	100 MPa
Density	8960 kg/m^3

A study by Lee and Yur, have shown that the most efficient parameters are pulse current and pulse duration on the surface integrity of the material among the other EDM parameters. Hence, these two principle EDM parameters were selected for this study also and the experiments were established upon full factorial design of these parameters. The settings of EDM parameters were illustrated in Table 4. At the end of the experiments, the near surface of machined surfaces were grinded with 80-1200 mesh sandpaper; the grinded surfaces were cleaned and polished with 3 mm diamond paste and solvent. The polished specimens were etched with Keller reagent (2 ml HF, 10 ml HNO_3, and 88 ml pure water). The metallographic inspections of the samples were observed by Scanning Electron

Table 4: EDM Machining Parameters and Readings

S. No.	D.M	Ele	I (Amps)	T (sec)	M.R.R (g/min)	TWR (g/min)
1.	EDM Oil	Cu Ø 9.27mm	8	13.02	0.1397	0.0015
			10	10.5	0.1895	0.0019
			12	8.24	0.2196	0.0012
2.		Al Ø 9.27mm	8	21	0.0638	0.0085
			10	19.58	0.062	0.0097
			12	18.56	0.0554	0.0091
3.		Br Ø 9.27mm	8	16.13	0.0595	0.0564
			10	11.24	0.0676	0.0702
			12	9.11	0.0614	0.0801
4.		C Ø 9.00mm	8	9.11	0.1613	0.001
			10	7.19	0.2127	0.0013
			12	5.31	0.258	0.0018

Figure 1: EDM Machining

Figure 2: MRR in EDM Oil

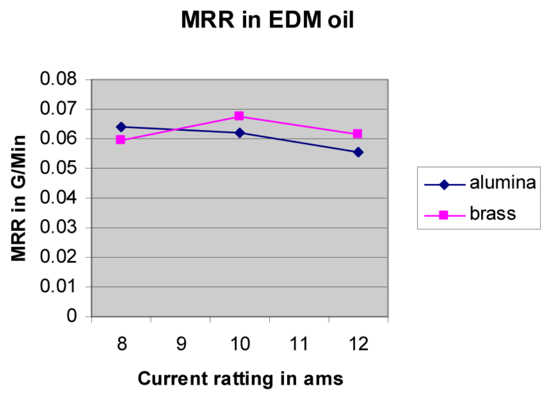
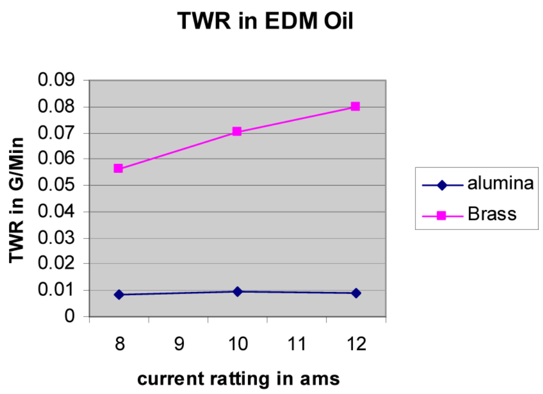


Figure 3: TWR in EDM Oil



Microscope (SEM), Energy Dispersive Spectrograph (EDS) and X-ray Diffraction (XRD)

EXPERIMENTAL RESULTS AND DISCUSSION

From the examination of the surface characteristics, it was observed that EDM process produces much damage on the surface such as globules of debris, pockmarks, melted drops, varying size craters and cracks. Thus, the surface texture is responsible for uneven surface profile (Demuth and Beale, 2006). The similar surface textures were obtained with all the experiments studied. As the pulse current and pulse duration increased, the deeper craters and global appendages were most evident and rougher surfaces were more pronounced This is due to the fact that when pulse current is increased, more intensely discharges strike the surfaces, a great quantity of molten and floating metal suspended in the electrical discharge gap during EDM and resulting in deterioration of the surface roughness. As similar to current effect, when the pulse duration is increased, the amount of heat energy is transferred to the sample surface and more material melted (Demuth and Beale, 2006; and Kalpakjian, 2003)

In addition to that, caused by the locally prevailing thermal affection, residual stresses are created at the surface during the machining process and when the stress in the surface exceeds the material's ultimate tensile strength, cracks are formed (Kalpakjian, 2003). The micro cracks in the white layer are penetrating into the bulk material perpendicularly. The heating and cooling process of the surface result in a rapidly increase of yield stress. The areas that have been plastically transformed during the heating cannot flow back, so that plane tensile stresses build-up parallel to surface, resulting in cracks normal to the surface.

[5]The material removal rate of graphite electrode is highest but, the surface finish of machined MONEL 400 is rough and therefore the graphite electrode is good for rough machining only (Kesheng Wang *et al.,* 2003). Due to the lower melting temperature of aluminium electrode, its wear rate is highest, thus, the material removal rate is lowest, but the surface finish of the machined part is the best among the three electrodes. As such, it is suitable for machining MONEL 400 for finish operations.

CONCLUSION

In the present work, the MONEL 400 alloy was machined by electrical discharge machining process with different machining conditions and electrode materials. Summarizing the mean features of the results, the following conclusions may be drawn. (1) The surface integrity of EDM in MONEL 400 includes roughening because of, surface micro cracks, debris and melted drops.

The material removal rate, surface roughness and electrode wear are increasing with process parameters for each electrode material except the prolonged pulse duration of 200 m. Graphite electrode gives the highest material removal rate, followed by electrolytic and brass exhibits the lowest wear rate due to higher melting point at all the applied condition. Brass electrode exhibits the best performance with regard to surface finish

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