Effect of Sink EDM Process Parameters on Aluminium and Die Steel

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Abstract- Copper electrodes with diameter of 12mm used as tool material and Die Steel & Aluminum with diameter of 50mm work materials at three current settings of 10, 15 & 20amps with an objective of determining the correlation obtains between the EDM parameters (current) and the machinability factors (material removal rate and electrode wear rate) on Sink EDM. Ruslic oil (trade name) used as dielectric fluid. The material removal rate of the work piece and the wear rate of the electrode material are based on the calculation of percentage of weight loss per machining time (wt. %/s) and the parameters depends on diameter of the electrode and supply of current.

Key words – Dielectric fluid, EDM, machining, MRR, tool material, TWR, work material.

I. INTRODUCTUION

Among non-traditional machining processes Electrical Discharge Machining (EDM) is one of the important and widely accepted as a standard machining process in manufacturing industries. The method is based on removing material from a work piece in a series of repeated electrical discharges produced by electric pulse generating at short intervals between an electrode (tool) and the work part will be machined by the use of the dielectric fluid medium.

II. EXPERIMENTAL DETAILS

The present experimental work carried out on CREATOR CR-6C (SYCNC PC-60) Electrode discharge machine and ruslic fluid used as a dielectric fluid. The selected work pieces materials were aluminum and die steel in the shape of cylindrical shapes of diameters 50mm. The properties of work piece materials also are presented in below.

2.1Properties of Tool Materials

Copper electrode tool has the following properties Electrical resistivity 1.96(μΩ/cm), Thermal conductivity 268.389(W/ m K), Melting point 1083(° C), Specific gravity at 20° C 8.9(g/cm³), Co efficient of thermal expansion 6.6(* 10^{-6} °C^{-1}), Density 8.9 (g/cm³).

2.2Properties of Work Materials

(i) Die Steel (AISI -1100)**:** Chemical composition of die steel: C-0.25, cr-13, Mn-0-25, si 0-6.,Hardness = 390 HV, Thermal conductivity = 29 w/m °K,

(ii) Aluminum :Chemical composition of **AL** Cu-0.1,Mg-0.2, Si-0.5, Fe-0.6, Mn-0.1, Zn-0.1.HARDNESS = 75HV, Thermal conductivity =250 w/m °K

A cylindrical copper tool having a diameter of 12 mm used as an electrode, has ground before experimental study and it mounted axially in line with work piece. Three work pieces of each Aluminum and Die steel were used. The work pieces were machined on EDM using copper electrodes giving 1mm depth at three different currents (i.e. 10 Amps, 15 Amps & 20 Amps).

2.3 MACHINING SET UP

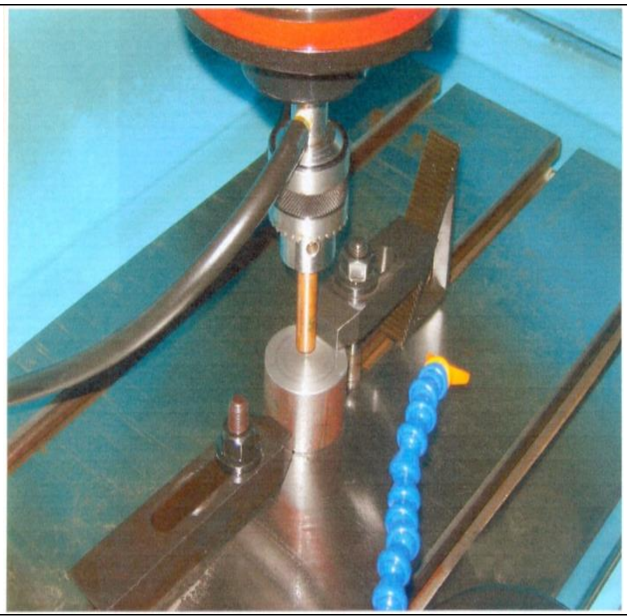

Photo-1—Al (work) being set with Cu-(tool) in EDM tank

Photo-2—Tool: Copper, work piece; Die steel

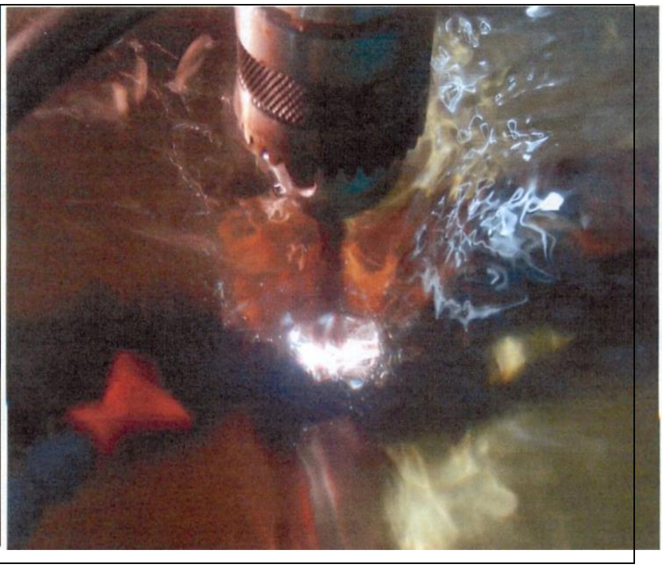

Photo-3 – Spark evolution during machining of Al STEEL

Photo-4 – Spark evolution during machining of DIE

2.4 Tools and work pieces after machining

Photo5-Copper tool, Die steel work piece (above)

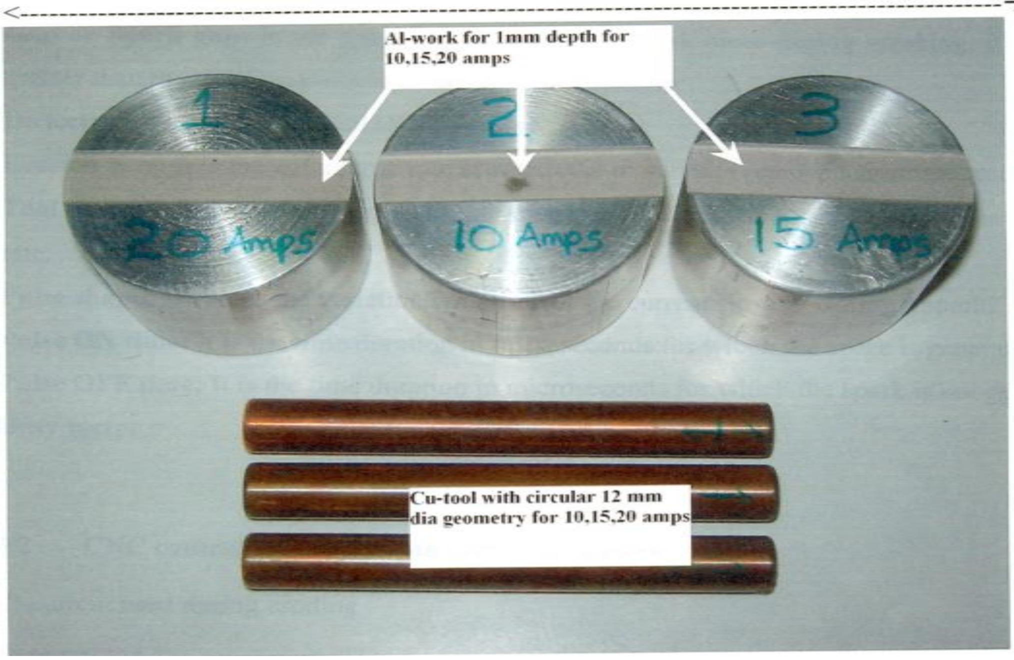

Photo-6-Copper tool, Aluminium work piece (above)

III. RESULTS AND ANALYSIS

3.1 EXPERIMENTAL DATA AND GRAPHS

Table 1 and 2 shows the MRR and TWR of Al and Die steel (work piece) with Cu-electrode (tool) for 1mm depth of machining duration.

Table-1 Determination of MRR of tool and work piece – (Non ferrous combination)

		Aluminum (work piece)					Cu-electrode-tool				
Sl. No	Current Amps	Weight (gms)			Time (min)	MRR x 10^{-3} (gm/min)	Weight (gms)			Time (min)	TWR x 10^{-3} (gm/min)
		Before	After	Diff.			Before	After	Diff.		
1	10	213.40	212.08	1.32	212	6.22	96.68	96.32	0.36	212	1.70
2	15	212.40	210.90	1.50	162	9.25	95.16	94.74	0.42	162	2.60
3	20	218.30	216.50	1.74	160	10.87	98.02	96.76	1.20	160	7.80

Table-2 Determination of MRR and TWR between tool and work piece – (Ferrous combination)

		Die steel (work piece)					Cu-electrode-tool				
Sl. No	Current Amps	Weight (gms)			Time (min)	MRR x 10^{-3} (gm/min)	Weight (gms)			Time (min)	TWR x 10-3 (gm/min)
		Before	After	Diff.			Before	After	Diff.		
1	10	589.24	586.46	2.78	302	9.20	96.32	95.64	0.68	302	2.20
2	15	587.04	583.64	3.40	231	14.71	93.04	91.66	1.38	231	5.97
3	20	575.78	571.36	4.12	229	17.99	130.60	128.4	2.20	229	9.60

3.2 Figures below shows the tool wear rate and material removal rate

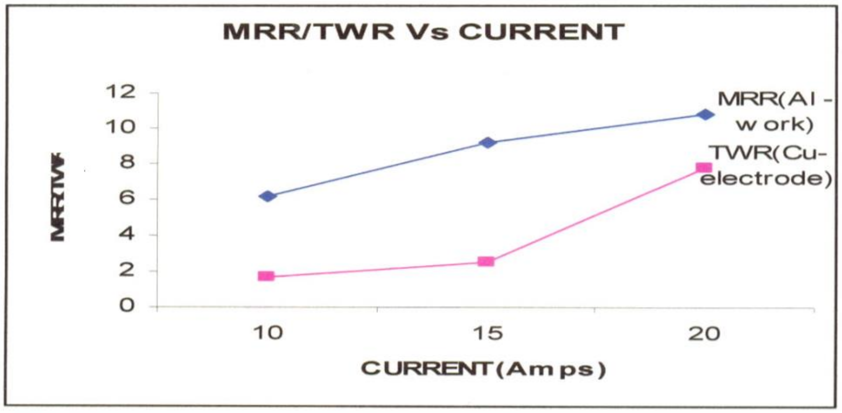

Fig 1-MRR (Al-work) and TWR (Cu-tool) combination for increasing current

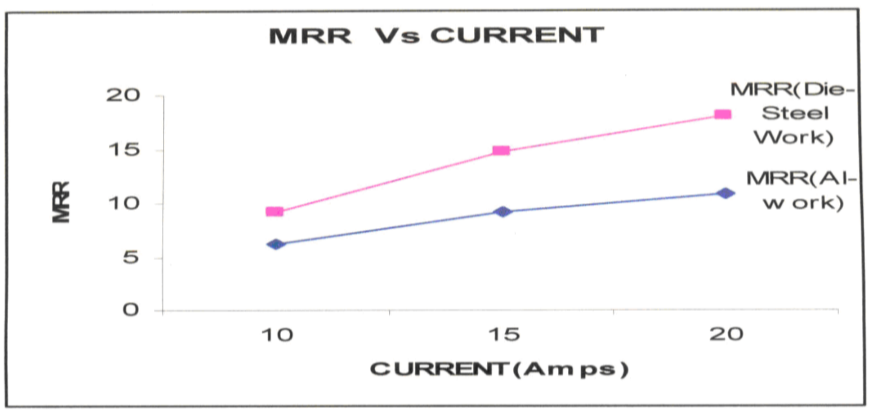

Fig 2-MRR (Al-work) and TWR (Cu-tool) combination for increasing current

Table-3 Machining times

Sl.No	Current amp	Machining time (minutes) for 1mm Depth for Cu –electrode of 12mm diameter circular geometry	
		Aluminum	**Die steel**
1	10	212.00	302.00
2	15	162.00	231.00
3	20	160.00	229.00

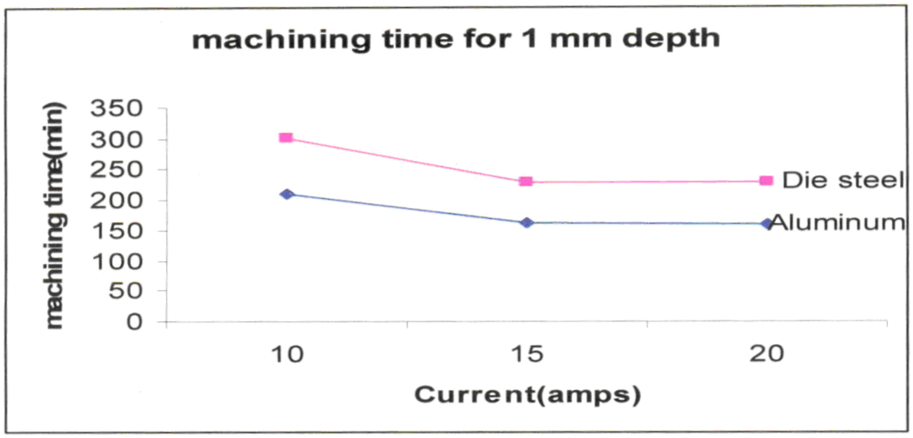

Fig 3. Machining time for 1mm depth spark erosion

The dominant factor affecting the erosion rates is the polarity setting. EDM equipment prescribes electrode positive for steel and copper, work –electrode materials combinations. This is clearly seen to be superior to electrode negative setup in the form of high erosion of work material and low erosion of electrode which in machining terminology is equivalent to high machining rates and low tool wear rate. This is due to higher liberation of spark energy at cathode which absorbs ions with a molecular weight of parent molecules with smaller channel dimension compared to electrons absorbed at anode. Next in importance is the effect of pulse current on erosion rate. The pulse energy is being a product of pulse voltage, current and on time, naturally any increase in these variables results in higher erosion rates both at work and electrode surfaces. Of these the effect of pulse current is highly significant. Pulse voltage and on time have very small effect owing to reduction in energy density with an increase in them.

IV. CONCLUSIONS

The experiments were conducted with the view of determining the material removal rate of ferrous (Die steel) and Non-ferrous (Aluminum) with 100% purity Cu electrode with circular geometry for 1mm depth of spark erosion with Ruslic oil (trade name) as dielectric fluid. The studies were conducted with variation of current at three levels of 10, 15 and 20amps. The tool and work piece was taken out at intermittent intervals for measuring the metal removal both materials and corresponding machining time for soft materials was also noted. The experiments were conducted by straight polarity. The conclusions are follows.

From the experimental study the following conclusions are drawn

- With increasing current TWR (Cu) is less compared to MRR in Al work. Here both soft metals and are Non-ferrous. Al is having more MRR because of conductivity as compared to Cu, but both follow the same trend with increasing currents. But higher current both non ferrous metal have chances of erosion at same rate.
- When compared TWR of Cu electrode with MRR of die steel (very hard ferrous) of both follow the same trend with higher currents, wear quantity ratio is seems to be constant for both tool and work. This point is important from the view point of predicting wear mechanism both tool and work in for material combination and other mechanical properties may also be considered for predicting spark erosion mechanism.
- Increasing current means higher spark erosion. TWR of Cu is more while machining hard (Die steel) and less for soft (Al) components. This provides the prediction with higher TWR for hard materials as compared and lower for soft materials can be assessed.
- MRR is compared for increasing currents for different materials it is more for hard (Die steel) materials as compared to soft non ferrous (Al). MRR is having steep gradient trend for die steel than Aluminum with low constant gradient. This lead us to conclude that there may chances of very higher MRR for die steel may be because of its ferrous composition.

Although the MRR is high for Die Steel (Ferrous) material, machining time for 1 mm depth of 12mm diameter with same Cu- electrode takes longer than Al material. But machining time decreases with increase current for both ferrous and non-ferrous materials.

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