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Investigating the Effect of Copper Chromium and Aluminum Electrodes on EN-31 Die Steel on Electric Discharge Machine Using Positive Polarity

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Abstract **Electric discharge machining (EDM) is a ‘newer technology utilized to machine hard metals, alloys, composites and ceramics. This paper reports the experimental investigation carried out on EDM to study the effects of machining parameters such as pulsed current on material removal rate, depth of cut, overcut, tool wear (net weight lost) and hardness on En-31 tool steel The work material was electric discharge machined with copper chromium and brass electrodes by varying the pulsed current at positive polarity. Investigations indicate that brass has better depth of cut and hardness while copper chromium, better MRR with lower tool wear**

Keywords MRR,EDM,EN-31,Hardness,Surface Roughness

I INTRODUCTION

The electro discharge machining (EDM) process involves a controlled erosion of electrically conductive materials by the irritation of rapid and repetitive spark discharged between the cathode (electrode tool) and anode (work piece) separated by small gap of about 0.01 to 0.50 mm known as spark gap. The spark gap is either flooded or immersed under dynamic fluid. The spark discharge is produced by the controlled pulsing of direct current between the work piece and tool. The dielectric fluid is ionized by spark thus enabling spark discharge to pass between the tool and work piece. EDM process in corporate a unique feature absence of any cutting force between the work piece and tool. Electric discharge machining (EDM), sometimes colloquially also referred to as spark machining, spark eroding, burning, die sinking or wire erosion is a manufacturing process . When the distance between the two electrodes is reduced, the intensity of the electric field in the volume between the electrodes becomes greater than the strength of the dielectric which breaks, allowing current to flow between the two electrodes, as a result, material is removed from both the electrodes (cathode and anode)

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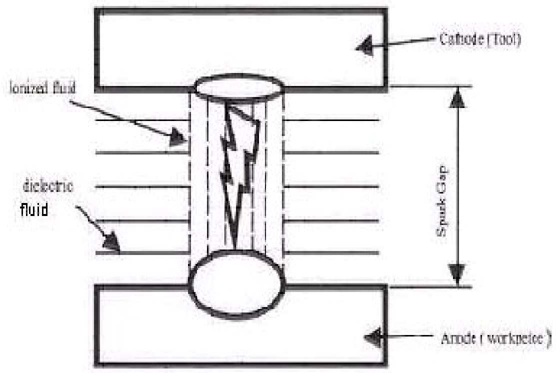

Fig 1 Principal of Working of ED Machine

Once the current flow stops new liquid dielectric is usually conveyed into the inter-electrode volume enabling the solid particles (debris) to be carried away and the insulating

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proprieties of the dielectric to be restored. Adding new liquid dielectric in the inter-electrode volume is commonly referred to as flushing

The parts produced by EDM process generally have intricate shapes, made up of hardened materials and electrically conductive materials .In 1995 the Swiss company CHARMILLE introduced for the first time world wide at European machine tool exhibition in Milan Ital

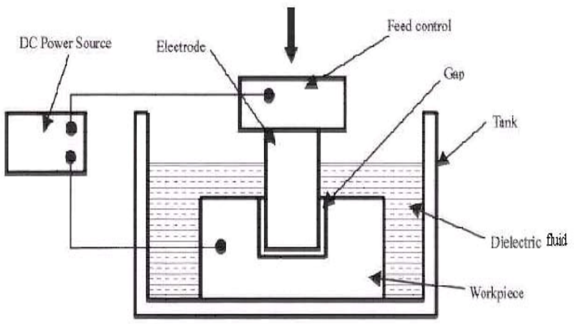

Fig 2 Electric Discharge Machine Description

II LITERATURE REVIEW

Shobert (1983) The thermal energy generates a channel of plasma between the cathode and anode at a temperature in the range of 8000 to 12,000 °C When the pulsating direct current supply occurring at the rate of approximately 15,000–30,000 Hz is turned off, the plasma channel breaks down. This causes a sudden reduction in the temperature allowing the circulating dielectric fluid to implore the plasma channel and flush the molten material from the pole surfaces in the form of microscopic debris.

Tsai et. al (2003)presented the principal of working of EDM in this study The authors reported that the material erosion mechanism primarily makes use of electrical energy and turns it into thermal energy through a series of discrete electrical discharges occurring between the electrode and work piece immersed in a dielectric liquid medium

Garg R.K. et al (2004) reported that the hard composite materials can be machined by many non-traditional methods like water jet and laser cutting but these processes are limited to linear cutting only. Electrical discharge machining (EDM) shows higher capability for cutting difficult to machine shapes with high precision for these materials. Kansal et. al (2005) reported that the higher voltage settings increase the gap, which improves the flushing conditions and helps to stabilize the cut. MRR, tool wear rate (TWR) and surface roughness increases, by increasing open circuit voltage, because electric field strength increases. Discharge voltage in EDM is related to the spark gap and breakdown strength of the dielectric. Rajesha et. al (2006)conducted an experiment that the Inconel 718 was machined on electric discharge machining with a copper electrode Effects of five major process parameters—pulse current, duty factor, sensitivity control, gap control, and flushing pressure on the process responses, material removal rate and surface roughness were studied . Experiments were conducted using steel work pieces and round copper tools with a kerosene dielectric under different dielectric flushing conditions, discharge currents and pulse durations. The experiments have shown that machining parameters and dielectric flushing conditions had a large effect on geometric tool wear characteristics and machining performance outputs. Zarepour et. al (2007) suggested that the electrical discharge machining (EDM) is a widespread process which works very effectively in machining of difficult-to-cut materials and alloys in die and aerospace industries with high dimensional accuracies. Authors experimentally investigated the effect of machining parameters of EDM process including on-time, current, voltage, the engaging time between work piece and electrode, and pre-EDM roughing on electrode wear. Copper was used as electrode to machine the hot work tool steel 1.2714, which is widely used to make forging dies and mandrels.

Mahdavinejad (2008) reported that the electro discharge machining is one of the most effective non-conventional machining methods. This method is the best candidate in machining of ceramics and carbide materials. The results of implementation of control system on a sinking ED machine and an EDM system that has been set with an expert user, has been compared. Boujelbene et. al (2009) presented the study of the influence of machining parameters on the surface integrity in electrical discharge machining. The authors reported that the increasing energy discharge increase instability and therefore, the quality of the workpiece surface becomes rougher. Patel et. al (2010) conducted experiments to determine parameters effecting surface roughness. Mild steel as work piece & copper, brass and graphite as tool electrodes with kerosene oil as dielectric fluid where selected for study. The data compiled during experimentation has been used to yield responses in respect of material removal rate (MRR) and SR which affects machined work piece and hence tool life. While investigating electric discharge machining (EDM) surface by micrographs, it was observed that molten mass has been removed from surface as ligaments and sheets. In some cases, it is removed as chunks, which being in molten state stuck to surface. All three specimens machined by different electrodes showed different pattern of HAZs. Singh (2010) presented that the manufacturing industries are facing challenges from different hard materials, as they are hard and difficult to machine, requiring high precision, surface quality which increases machining cost. These challenges are conquered by using non-conventional machining processes to achieve higher metal removal rate, better surface finish and greater dimensional accuracy, with less tool wear. Electric Discharge Machining (EDM), a non-conventional process, has a wide applications in automotive, defense, aerospace and micro systems industries plays an excellent role in the development of least cost products with more reliable quality assurance. The authers presented different reviews of the state of the art technology of high-performance machining of advanced materials using different EDM technologies. Jahan et. al (2011) reported that the electro discharge machining (EDM) process had the capability of machining intricate features with high dimensional accuracy in hard and difficult-to-cut material The authors reported that the , both EDM and micro-EDM processes are being used extensively in the field of mould making, production of dies, cavities and complex 3D structures The research studies related to the developments in electro discharge machining of tungsten carbide using conventional EDM and micro-EDM are reported in the study. Study presented the problems and challenges in the area of conventional and micro-EDM and the importance of compound and hybrid machining processes. Singh & Bhardwaj (2011) reported that the electrical discharge machining (EDM) is a well-established non-conventional machining process, used for manufacturing geometrically complex or hard and electrically conductive material parts that are extremely difficult-to-cut by other conventional machining processes. Authors suggested that the erosion pulse discharge occurs in a small gap between the work piece and the electrode. This removes the unwanted material from the parent metal through melting and vaporizing in presence of dielectric fluid. Performance measures are different for different materials, process parameters as well as for dielectric fluids. Presence of metal partials in dielectric fluid diverts its properties, which reduces the insulating strength of the dielectric fluid and increases the spark gap between the tool and work piece. As a result, the process becomes more stable and metal removal rate (MRR) and surface finish increases. Murugesan et. al (2012) reported about the comparison of performance of a multihole electrode with a solid electrode in drilling of different Metal Matrix Composite using Electrical Discharge Machining . The authors also reported about the investigation of the EDM process parameters in machining with the multihole electrode. A copper rod (solid electrode) and a copper rod with an array of holes (Multihole electrode) were used as the electrodes. Investigation of the machining parameters namely pulse current (A), pulse on time (B) and pulse off time (C) was carried out to find the optimum conditions for the machining time. The experimental results showed that multihole electrode performed better and the optimized machining parameters proved that the machining performance has been improved

III METHODOLOGY

Experiment was performed on the electric discharge machine by using copper chromium and aluminum as electrodes (tool) and EN-31 die steel as the work piece with kerosene as die electric fluid. Experiment was conducted by varying pulsed current ranging from 6A to 12A with positive polarity settings.

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IV RESULT

Table 1 Over Cut (mm)

	6A	7.5A	9A	10.5A	12A
CuCr	0.056	0.013	0.067	0.10	0.433
Al	0.12	0.087	0.014	0.08	0.153

TABLE 2 Hardness (HRc)

	6A	7.5A	9A	10.5A	12A
CuCr	52	45	44	43	44
Al	52	52	52	52	52

TABLE 3 Net Weights Lost (gm)

	6A	7.5A	9A	10.5A	12A
CuCr	0.0018	0.0011	0.0009	0.0012	0.0018
Al	0.355	0.3087	0.0953	0.2450	0.0292

TABLE 4 MRR (mm^3/min)

	6A	7.5A	9A	10.5A	12A
CuCr	1.43	6.63	9.26	21.87	39.38
Al	3.675	8.469	15.643	34.44	56.285

TABLE 5 Surface Roughness (Ra µm)

	6A	7.5A	9A	10.5A	12A
CuCr	10.86	13.61	6.80	3.805	9.445
Al	3.665	4.515	6.535	11.35	15.87

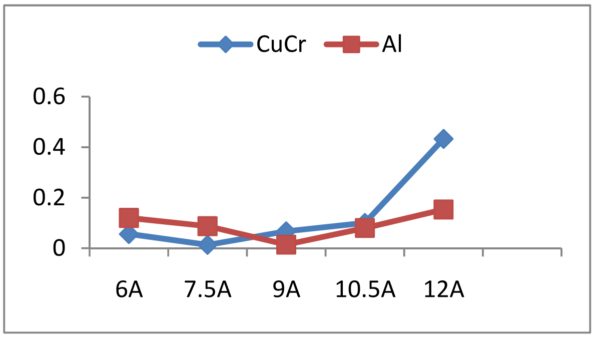

Fig 3 Over Cut (mm)

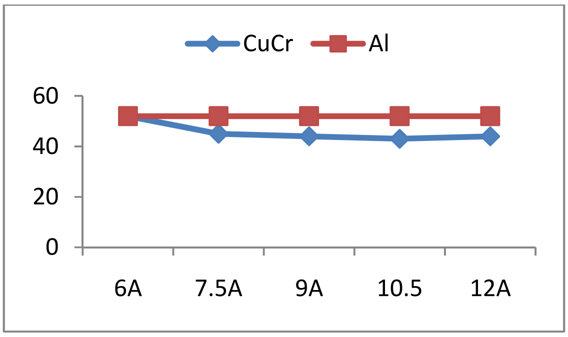

Fig 4 Hardness (HRc)

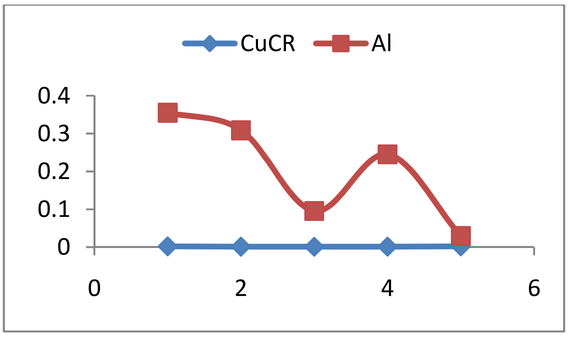

Fig 5 Net Weight Lost (gm)

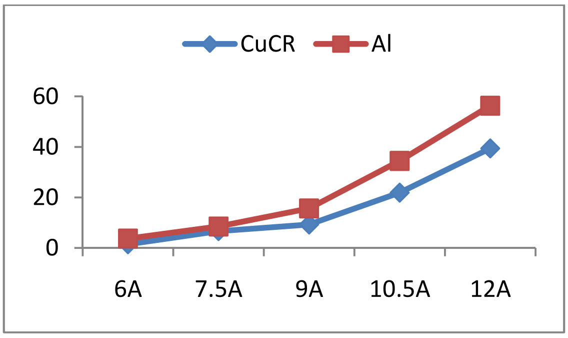

Fig 6 MRR (mm^3/min)

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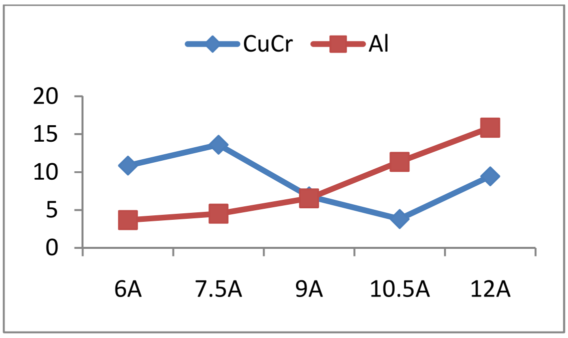

Fig 7 Surface Roughness (Ra µm)

V CONCLUSIONS

1) Depth of cut is better for copper chromium as compared to brass, it increase with increase in pulsed current in case of brass and remains same for copper chromium

2) Over cut is better of brass except at 12A current as compared with copper chromium, best value of over cut is observed at 12A

3) Hardness is better for brass as compared with copper chromium, maximum hardness was obtained at 6A for copper chromium and 12A for brass

4) Copper chromium electrode had less tool wear as compared to brass, maximum weight of electrode is lost at 12A for copper chromium and 7.5A for brass

5) Metal removal rate is better for copper chromium at all the values of pulsated current except at 6A as compared to brass, maximum MRR was obtained at 12A for brass and copper chromium

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