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Comparative Characteristics of Electro Discharge Machining and Micro Electro Discharge Drilling

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ABSTRACT

A variation of electro discharge machining (EDM) is the Micro electro discharge Drilling (MEDD) process. This paper brings out the intrinsic similarity and unique skin texture of these two processes, and illustrates the high material removal rates of MEDD compared to EDM. Along with theoretical discussion on the effects of process parameters. The pulse current (pulse on and pulse off) has been selected for practical evaluation for its influence on the machining rates in both the cases.

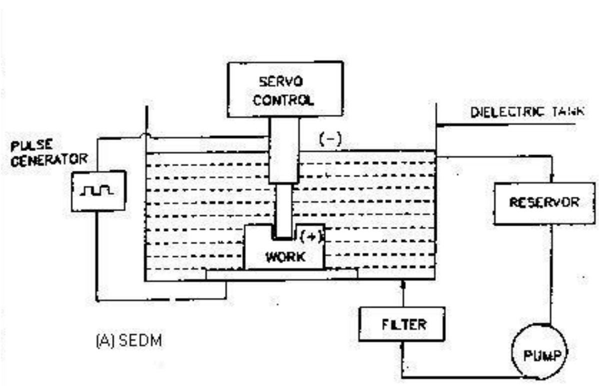
Keywords:— *Micro, Electro Discharge Machining, Comparative, Characteristics*

I. INTRODUCTION

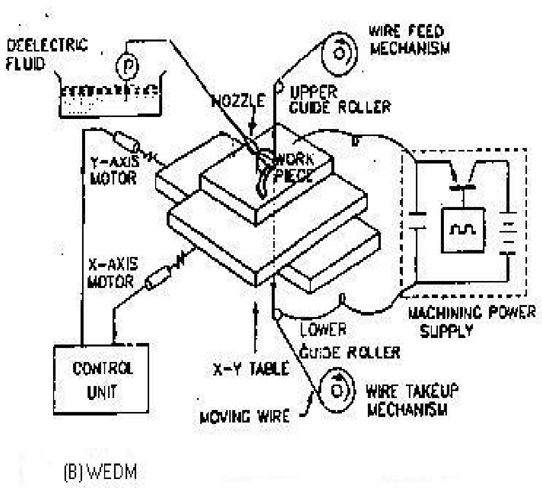
The electro discharge machining is well known in two forms whereby the electrode is either in solid and preshaped form or in a wire form. The former is also known as sinking type EDM and latter as traveling wire EDM. In both cases the erosion is by high frequency sparks generated through a dielectric medium which is kerosene in SEDM and deionised water in WEDM. The erosion rate is very low which makes EDM unsuitable where high machining rates are required for example the sawing operation. The MicroEDMDrill is a hybrid process which combines the features of Wire EDM and arc cutting to the EDM process with some modifications in the type of electrode (steel band) and working fluid (electrolyte). The arc cutting is suitable for thick plates and suffers from frequent breakage and low speed. On the other hand MicroEDMDrill is eminently suitable for high strength materials with large cross sections and characterized with small and neat drills. The development of such hybrid processes to exploit the features of two types of erosive process has been widely adopted in academic research for improved accuracy and erosion rate. Improvement of surface integrity and gap flushing in the combination of ultrasonic machining are some other approaches (4, 5). Prominent among them is the combination of EDM with ECM (Electro Chemical Machining) and termed as electrochemical discharge machining (1, 2, 3). The improvement in process performance was marginal thus limiting such hybridization to academic research without any practical exploitation. However a similar approach of replacing dielectric fluid in EDM with an electrolyte results in arcing in place of sparking which produces high localized erosion, can be exploited for high machining rates sans accuracy and finish. This is what precisely MicroEDMDrill does with custom built units for commercial applications.

II. Theory

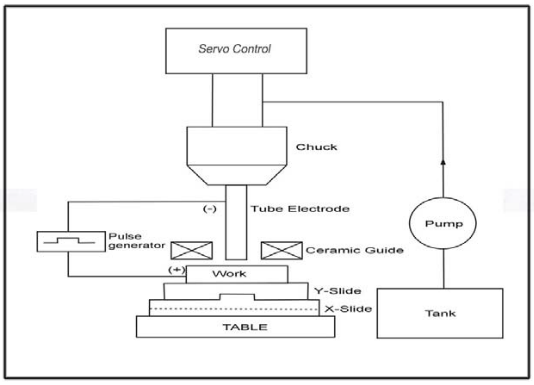
EDM employs high frequency electrical sparks for metal erosion. The typical set up is shown in figure 1. (a) SEDM (b) WEDM and (c) MicroEDMDrill.



(a) SEDM



(b) WEDM



(c) MicroEDMDrill

Figure 1. Schematic diagrams electro discharge Machining Processes (a) SEDM, (b) WEDM c) MicroEDMDrill

In the following description typical parameters associated and their values are given alongside in brackets to highlight their difference. The emphasis on the word 'typical' may be noted since in practice the actual can be different. The sparks are discrete and triggered through electrical pulses of small duration (few tens to a few hundreds of µs), low voltage (80 to 100 v) and currents (5 to 50A) through a liquid dielectric (kerosene in SEDM and deionised water in WEDM). The electrode in SEDM is preshaped to the desired geometry of final machined component and made of copper (or graphite or tungsten) whereas in WEDM the electrode is a fine wire (brass) of small diameter (0.1 to 0.3 mm) which traverses the required geometrical path with CNC control. The WEDM naturally is required to remove small volume of material (similar to trepanning in hole production) compared to SEDM (which is similar to drilling) therefore employs all the listed parameters in the lower range. Modern pulse generators supply square pulses with high frequency (in a range of KHz). Each pulse results in a discrete spark at random locations along the whole tool work interface simultaneously eroding microscopic material at the spot of impingement. Owing to low voltage applied, the spark gaps are very small to facilitate dielectric breakdown and the onset of spark. This spark gap (50 to 100 µm) is servo controlled for efficient sparking without excessive open circuits or short circuits. By judicious selection of polarity (electrode positive in SEDM and negative in WEDM) the electrode wear is kept very low compared to metal erosion.

2.1 The MicroEDMDrill Process

This is a modified EDM process to facilitate high material removal rate. These modifications are listed below.

1. ***Electrode*** is a copper or Brass with typical dimensions of varying from 0.1 mm to 0.3mm guided through ceramic assemblies.
2. ***Pulse parameters*** The voltage (30 to 80V) and current (5 to 50 A) are not significantly different than in EDM. However it is the pulse duration (as high as 50 µs compared to 100µs in EDM) with negligible pulse off time (compared to about 20 to 40 percent in EDM).
3. ***Working fluid*** is an electrolyte (deionized water or tap water). Similar to EDM it quenches and removes the eroded debris. The additional functions of the electrolyte are (a) form an electrolytic cell (b) Promote ionization and ionic discharge (c) form passivation film on anode (work piece) to promote insulation and prevent short circuits. The continuous ionization and insulating film formation facilitates high pulse on time and low off times thus increasing effective pulse energies.

The use of electrolyte in the EDM setup with short off times lead to poor deionization and consequent arcing. This term refers to continuous sparking at the same location rather than at randomly varying locations associated with EDM. The arcs produce high localized material removal and the constantly moving belt electrode ensures the shifting of arcs. The vertically downward feed rate given to electrode occasionally results in short circuiting on touching the work surface. The servo control reverses to electrode feed motion to again create the inter electrode gap.

The polarity in MicroEDMDrill is always electrode negative because in arc discharges the dominant component of pulse energy is liberated at anode which therefore must be the work piece.

III. Experimental Setup

The machining rates were evaluated in the EDM setup and MicroEDMDrill set up. Owing to the absence of exact values of process parameters on the knobs of the control panels on these machines, it was not possible to select similar magnitudes of the process variables for direct and quantitative comparison. However to demonstrate the highly superior erosion rates in MEDMD it was sought through selecting lowest values on MEDMD and highest possible values in EDM from the respective technology guidelines provided by the manufactures and listed below.

EDM (Charmiles): 80 v, 25Amps, pulse time 200 µs, off time 50 µm, MEDMD (Custom built by Electronica): 20 v, 15Amps, lowest pulse times.

IV. Results and Discussion

The observed data are recorded in table 1.

Table 1: Metal erosion rates in EDM and MEDMD (gm/min)

Process	H S S			Ti		
	Pulse Current			Pulse Current		
	L	M	H	L	M	H
E D M	2.61	3.46	4.13	2.54	4.35	6.12
MEDMD	0.19	0.16	0.35	0.26	0.38	0.48

L: Low

M: Medium

H: High

Ti: Titanium, H.S.S: High speed steel.

The findings are as expected but illustrate the considerately high erosion rates in MicroEDMDrill compared to EDM. The theory presented in the preceding section explains the reasons thereby. The eroded surfaces in MicroEDMDrill were very rough with poor appearance which interestingly was similar to those from conventional band saw. However they were highly superior to those from arc cutting plates which are extremely rough with extensive burrs. The geometric accuracy and surface finish of MicroEDMDrill surfaces have considerable superiority over surfaces from electrical arc cutting but inferior to EDM surfaces. Since sawing operation requires only faster cuts but not any type of quality of machined surfaces MicroEDMDrill is a highly suitable process for sawing large size bars, ingots etc of high strength materials. The erosion being thermo-electric in nature the tooling is simple. Incidentally the mechanism of erosion bears considerable similarity to EDM. The debris collected indicates their formation from liquid metal. The high energy densities of arc discharges create melting at the spot of its impingement and atomization of liquid metal by the arc forces and expanding gases. However the erosion rates in MicroEDMDrill are so high that the high energy pulses and arcing alone may not be the reason but also the short circuits between electrode and work with current surge. In normal spark and arc discharge major amount of molten metal is retained and only a small part gets removed as atomized droplets. But the explosive force of short circuits provides much higher expulsion and lower retention of molten metal. This aspect needs further exploration in the erosion mechanism of MicroEDMDrill.

Another interesting and glaring observation is the higher erosion rates in steel compared to aluminum in both the versions of EDM and MicroEDMDrill. Among the possible reasons, the major one is the higher thermal and electrical conductivity of aluminium resulting in lower energy concentration. The other possibilities can be lower share of the pulse energy and poor compatibility with the electrode. The higher erosion rates with increasing pulse current has the obvious reason of higher pulse energies.

V. Conclusions

1. Electro discharge sawing is highly suitable for high strength large bars, slabs or ingots for fast and accurate cuts.

2. Apart from high energy arc discharges, there appears to be considerable assistance from short circuit current surges in the material removal in MicroEDMDrill

3. In both EDM and MicroEDMDrill H S S with higher thermal and electrical conductivity shows inferior erosion rates compared to Titanium.

4. Higher erosion rates with increasing current are in conformity to the theory of electrical methods of machining.

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