Electro Discharge Sawing - - -vis – a – vis Electrodischarge Machining

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ABSTRACT

A modification of electro discharge machining (EDM) is electro discharge sawing (EDS). Both employ high frequency sparks for machining metals that are difficult to machine. However the dielectric used in EDM is replaced by an electrolyte in EDS. Its fast erosion rates makes it a suitable process for large and faster cuts like sawing of huge bars, slabs or billets. It has been developed as a hybrid process combining the features of EDM with those of arc cutting. The electrolyte used is a mixture of sodium silicate plus water with a specific gravity of 1.25.This process is used to promote arcing in place of sparking as well as to produce a passivating film on the work surface to prevent short circuits and to effectively quench the eroded debris and carry them off the inter electrode gap.

This paper brings out the inherent similarities & distinguishing features of these two processes, and also illustrates the high material removal rates of EDS compared to EDM. Finally, the EDS process and experimental results are explained.

INTRODUCTION

The electro discharge machining is well known in two forms whereby the electrode is either in solid and pre shaped 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 EDS is a hybrid process, which combines the features of bandsaw and arc cutting to the EDM process with some modifications in the type of electrode (steel band) and working fluid (electrolyte) as shown in figure (1). The arc cutting is suitable for thick plates but suffers from frequent breakage and low speed. On the other hand EDS is eminently suitable for high strength materials with large cross sections and characterized with fast & neat cuts. The development of such hybrid process to exploit the features of two types of erosive process has been widely adopted in academic research for improved accuracy and erosion rate. Prominent among them is the combination of EDM with ECM (Electro Chemical Machining) and termed as electrochemical discharge machining. Improvement of surface integrity and gap flushing with the combination of ultrasonic machining is among some other approaches. But in all such cases 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, and can be exploited for high machining rates sans accuracy and finish. This is what precisely EDS does with custom-built units for commercial applications.

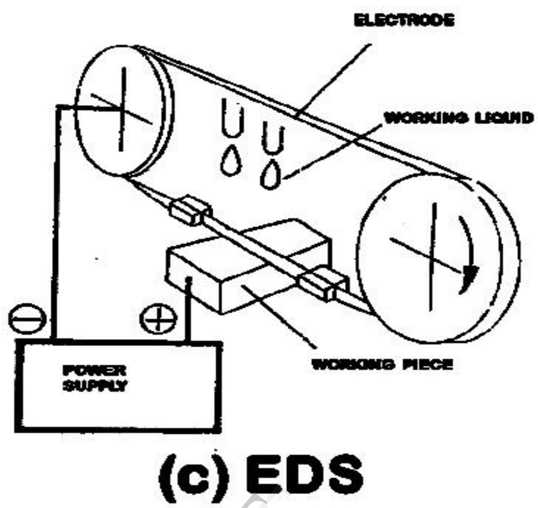


Fig: (1) Schematic Diagram of Electro Discharge Sawing

THEORY

In both the versions EDM employs high frequency electrical sparks for metal erosion figure (2). In the following description typical parameters associated and their values are given alongside in brackets to highlight their difference. 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 50 A) through a liquid dielectric (kerosene in SEDM and deionised water in WEDM). The electrode in SEDM is preshaped to the desired geometry of final component and made of copper (Or graphite or tungsten) whereas in WEDM the electrode is a fine wire (brass) of small diameter (.1 to .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 the 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 100µm) 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 as shown in figures (a) & (b)) the electrode wear is kept very low compared to metal erosion.

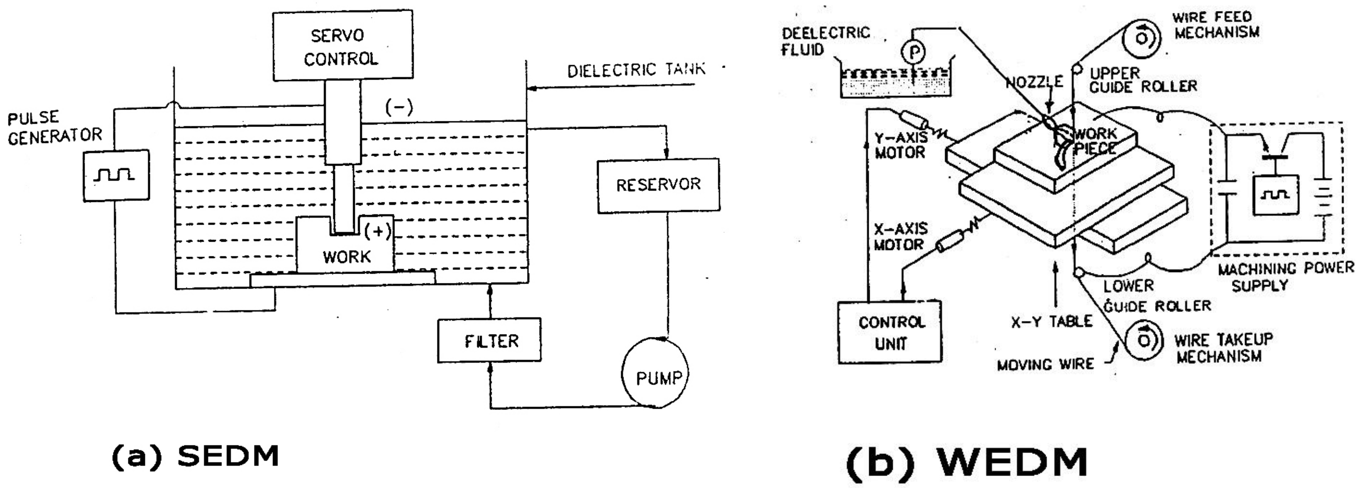


Fig: (2) Schematic Diagram of SEDM & WEDM

THE EDS PROCESS

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

1. **Electrode** is a mild steel belt with typical dimensions of 0.9 x 35 x 7450 mm and guided through ceramic assemblies. The belt is formed by resistance butt-welding and ground to uniform belt thickness. The belt runs similar to band saw and at a speed of 16 m/sec.
2. **Pulse parameters** The voltage (30 to 60) and current (15 to 300 A) are not significantly different than in WEDM. However it is the pulse duration (as high as 20,000 μs compared to 100 μs in EDM) with negligible pulse off time (compared to about 40 to 50 percent in WEDM).
3. **Working fluid** is an electrolyte (sodium silicate plus water with a specific gravity of 1.25). Similar to WEDM it quenches and removes the eroded debris. The additional functions of the electrolyte are (a) form an electrolytic cell. (b) Evolve hydrogen gas to promote ionization and ionic discharge. (c) Form passivation film on anode (wok 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 WEDM 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 WEDM.

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 the electrode feed motion to again create the inter electrode gap. The polarity in EDS 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.

EXPERIMENTAL SETUP

The machining rates were evaluated in the WEDM setup and EDS 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 EDS it was sought through selecting lowest values on EDS and highest possible values in WEDM from the respective technology guidelines provided by the manufacturers of WEDM (Charmiles) and EDS (Electronica).

Morphology of eroded surfaces were studied on roughness on Taylor-Hobson Talysurf.

RESULTS & DISCUSSION

1. Machining Characteristics

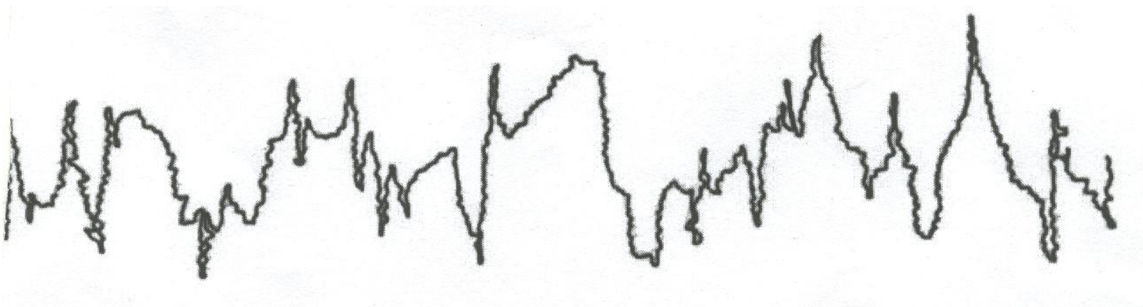
The observed data are recorded in table 1 for machining rates

Table 1. Machining rates (range) in WEDM and EDS with two levels (high and low) current settings mg/min

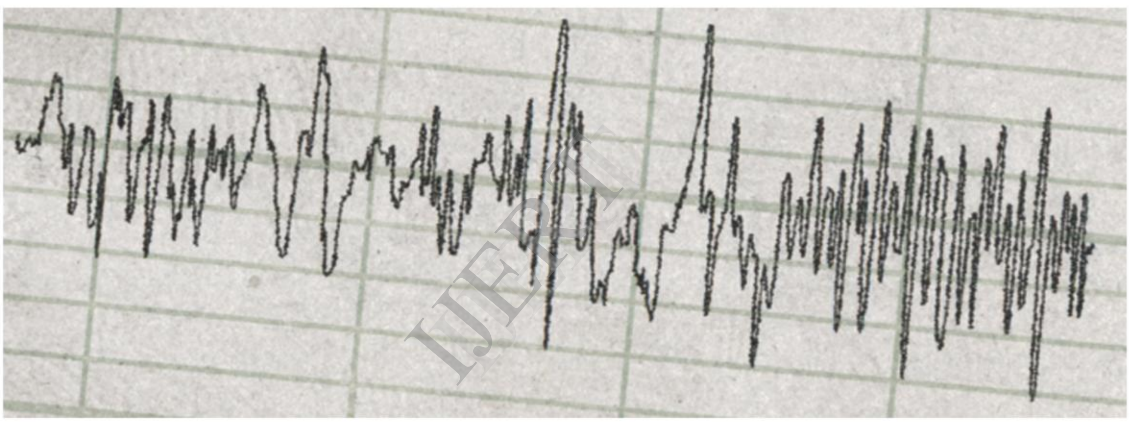
Process	Materials			
	Aluminum		H.S.S	
	Low current	High Current	Low current	High current
EDS	122-164	230-412	178-214	234-268
WEDM	13.6-16.8	24.8-26.4	18.8-21.6	31.6-33.4

The findings are as expected but illustrate the considerably high erosion rates in EDS compared to EDM. The theory presented in the preceding section explains the reasons thereby. The eroded surfaces in EDS were very rough with poor appearance, which interestingly were similar to those from conventional band saw. The geometric accuracy & surface finish of EDS surfaces have considerable superiority over surfaces from electric arc cutting but inferior to WEDM surfaces. Since sawing operation requires only faster cuts but not any type of quality of machined surfaces. EDS is highly suitable for sawing large size bars, ingots etc of high strength materials. The erosion being thermo-electric in nature the tooling is simple. 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.

Another interesting and glaring observation is the higher erosion rates in steel compared to aluminum in both the versions of WEDM and EDS. Among the possible reasons, the major one is the higher thermal and electrical conductivity of aluminum 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 have the obvious reason of higher pulse energies.



(a)



(b)

Fig. 4 – Roughness profiles from (a) WEDM (b) EDS surfaces.

Table 2. Surface roughness (R_a) range in WEDM and EDS (μm)

Process	Materials			
	Aluminium		H.S.S	
	Low current	High Current	Low current	High current
EDS	5.2-9.0	8.6-13.2	4.0-9.4	7.6-12.2
WEDM	1.13-2.12	1.77-2.12	0.91-1.02	1.94-2.63

The higher roughness and turbulence on the eroded surfaces of EDS can be attributed to superior evacuation or expulsion of molten metal from the arc zone.

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 removes in EDS.
3. In both WEDM and EDS aluminum with higher thermal and electrical conductivity shows inferior erosion rates compared to steel.
4. Higher erosion rates with increasing current are in conformity to the theory of electrical methods of machining.
5. One of the reasons for higher erosion rates and surface roughness is the effective expulsion of molten metal in EDS due to arc forces.

REFERENCES

1. Basak.I, Ghosh A., "Mechanism of spark generation during electrochemical discharge machining A theoretical model and experimental verification", Journal of material processing technology, Vol.62 (1996), 46-53.
2. Doloi B., Bhattacharyya B., and sorkhel S.K., "Experimental studies on Electro chemical discharge machining (EDCM) characteristics for machining engineering ceramics, proc. Of 18th AITDR conf., Dec (1998), 322-327.
3. Murti, V.S.R and Philip, P.K., "A comparative analysis of machining characteristics in ultrasonic assisted WEDM by response function modeling", Int. Jl. Prod. Res., Vol.25, (1986), 259-272.