Study Of Investigations On Process Parameters Of Electro Discharge Sawing Using Taguchi Approach

Kalley Harinarayana
Research Scholar, Jawaharlal Nehru Technological University, Hyderabad

Dr. B. Balu Naik
Professor, Jawaharlal Nehru Technological University, Hyderabad

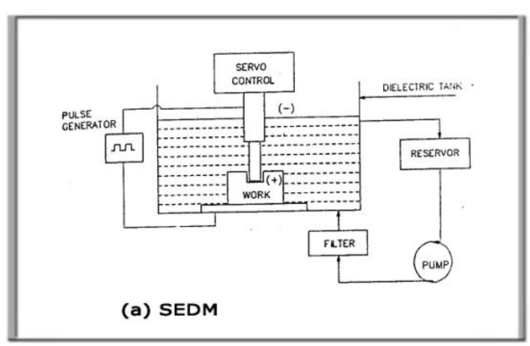
Dr. N. N.Ramesh
Professor, JawaharlalNehru Technological University, Hyderabad

Abstract

The Electro Discharge Sawing (EDS) process is a modified Electro Discharge Machining (EDM) process to obtain high material removal rates in sawing of large bar stocks and billets of high strength materials. The effect of type of electrolyte, pulse current pulse times and work material on machining rates and surface roughness are analysed. The experimental plan was based on Taguchi method of orthogonal arrays. The results are interesting. Generally higher machining rates are associated with higher roughness and this was witnessed with water electrolyte compared to silicic acid soda. However in the case of work materials aluminium exhibited higher erosion rates but lower roughness compared to HSS. Relatively the effect of work material was highest on machining rate followed by current, electrolyte and pulse times. But for surface roughness the order of influence was pulse current, work material, electrolyte and pulse times

1.Introduction

Electro discharge machining (EDM) process employs high frequency electrical sparks for machining complex shapes and exotic materials. (Fig.1.a) The preshaped tool and workpiece form a pair of electrodes separated by a small spark gap which is flooded by a dielectric (generally kerosene). The slow machining rate of EDM makes it unsuitable for sawing which requires high metal removal rates. This led to the development of a modified EDM process called as Electro – discharge sawing (EDS). It employs a mild steel belt as electrode with typical dimensions of 0.9x35x7450mm and guided through ceramic assemblies. (Fig.1.b) The dielectric fluid is replaced by an electrolyte to promote arcing in place of sparking owing to poor deionization characteristic of the electrolyte. Consecutive sparks are located at the same spot and their shift occurs due to rotating belt electrode. The electrolytic reactions produce hydrogen at cathode, which promotes ionisation and sparking and oxygen at anode leading to the formation of a passivating film. This is an important requirement and for this reason the electrolyte employed is silicic acid soda solution. For aluminium, which has high affinity to oxygen this non - conducting film is formed by an oxide layer. Therefore for machining aluminium water dielectric can be used. The insulating film prevents a conducting path between electrodes. As the advancing electrode scrapes the work surface, a short circuit is established. The servo control reverses the electrode and a spark is initiated through the gap, promoted by the gaseous presence from the aforementioned evolution at the electrode [1]. The arc discharge from continuous sparking needs very low pulse off times thus the spark energy is high which is further boosted with the employment of very high current (up to 300 Amp) which facilitates high machining rates associated with sawing. This also enlarges the interelectrode gap extinguishing the arc. The resulting pause time reestablishes the passivation film on anodic work pieces and the cycle is repeated.



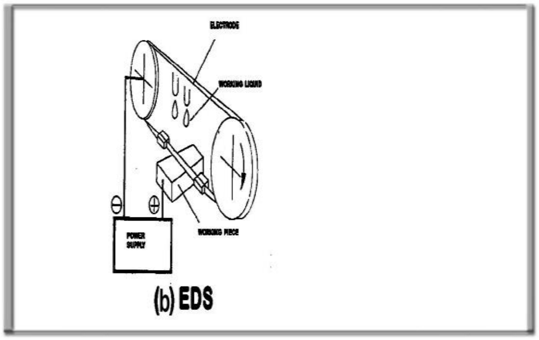


Fig: 1 Schematic Layout of the two types of Electro discharge machining processes a) EDM b) EDS

2.Experiment Plan

All experimental investigation pertaining to machining processes include the evaluation of machining characteristics particularly machining rate and surface roughness. For an orthogonal experiment particularly when one does not aim for any regression modelling it is better to keep the factors level at two but separated such that their influence is clearly evident from observed results. In EDS process there is another problem whereby the machine control panel does not specifically display the quantitative levels of the factors but their variations is steps of 1 to 10 indicated on the dials. For the purpose of analysing the relative effects of process parameters it becomes easy to select the factor levels as two i.e. Low and High. The experiment therefore follow this procedure for simplifying the investigations.

For A, B and C Low level = -1, High level = 1
Electrolyte –1 = Na_2SiO_3, +1 = water

Table 1. L_8 (2^4) O.A. Selected for EDS

Expt. No.	A Current	B DVR	C Work Mat	D Electrol yte
1	-1	-1	-1	-1
2.	-1	-1	-1	1
3.	-1	1	1	-1
4.	-1	1	1	1
5.	1	-1	1	-1
6.	1	-1	1	1
7.	1	1	-1	-1
8	1	1	-1	1

The selected process parameters are listed in Table 2.

Table 2. The selected factors and their coded levels.

S. No.	Factors	Codes		Remarks
		-1	+1	
1.	Work material	Alum inium	HSS	Based on melting point and thermal resistivity (opposite to conductivity)
2.	Current	Low	High	Dial setting at lower and higher number
3.	Pulse times	Low	High	Ratio of pulse ON and OFF times. Typically it is referred as duty volume ratio.
4.	Electrol yte	SAS	Water	Based on their low and high electrolytic reaction in the formation of passivation film.

3. Results and Discussions

Machining rates

The machining rates (Kerf) estimated in terms of mm^3/min. This approach of volumetric erosion rate becomes important for a suitable comparative evaluation by avoiding the effect of work material density since EDS is a non – contact erosion process. This effect can be gauged from the fact that erosion rates in mg/min are low for Aluminium compared to H.S.S but when estimated in mm^3/min, the erosion rates of aluminium are very high compared to H.S.S. (Table 3 and Fig. 2). The erosion rates for aluminium are high as expected owing to its low melting point and latent heat of melting compared to H.S.S. With higher current and pulse on times the erosion rates are higher for both aluminium and H.S.S. Their effect on increasing pulse energy also results on higher selecting the pulse time in terms of "Duty Volume" ratio (DVR) which means for the same total pulse time, the ON time will be more than OFF time for a higher DVR. The combination of pulse on time with off time leads to a complex relationship. Higher on time produces higher pulse energy but corresponding lower off time can lead to poor deionisation. Another adverse effect of higher pulse on time can lead to two different effects. However in EDM the net effect is an increase in pulse energy and the resultant erosion rates. The effect of pulse times time is the expansion of plasma channel due to mutual repulsion of similar charge carriers i.e. This effectively reduces energy density. Thus an increase in pulse on and current are identical. Their increase causes increase in pulse energy which results in higher material removal rates. The effect of electrolyte is very significant particularly in combination with work material. Being highly susceptible to oxidation aluminum forms faster the insulating film essential for the arc gap formation and arc extinction before the onset of next arc discharge. On the other hand for H.S.S. silicic acid soda is superior working fluid for the formation of passivating film between subsequent arc discharges.

Surface Roughness

The results of the surface roughness in EDS are shown in Table 4 and plotted in Fig.3. Similar to the case of machining rate the roughness is also very erosion rates. But the effect of current is more compared to pulse times. This is typical the result of high in EDS. The reason is obvious. The erosion pits or craters produced by the erosive effects of arcing and sparking in the respective cases will have sizes corresponding to the erosion rates [4]. This pattern is common to all the machining processes. The effect of work material on the resultant surface is high for aluminium compared to H.S.S and follows the aforesaid pattern analogous to erosion rate. The overlapping spark craters considerably offset the effect of their size. The effect is minor particularly since the erosion is violent with EDS where the arcs and short circuits create considerable splash [5]. Considering the effect of current and pulse on times, the results are significant. Though increase in either of them leads to increased pulse energy and higher erosion rates and surface roughness. The effect of current is significantly high compared to pulse times. This effect was observed in machining rates also and is again observed in the case of surface roughness. The reasoning in the former case is valid for the latter effect also. A higher magnitude of current causes a corresponding high pulse energy producing a large depth of crater for the same pulse times. But for same pulse energy a higher pulse on time leads to expansion of plasma column and larger crater diameter. In other words the effect of current in generating craters of larger depth and effect of pulse time in increasing crater diameter. The former leads to higher roughness heights and the latter to smaller ones.

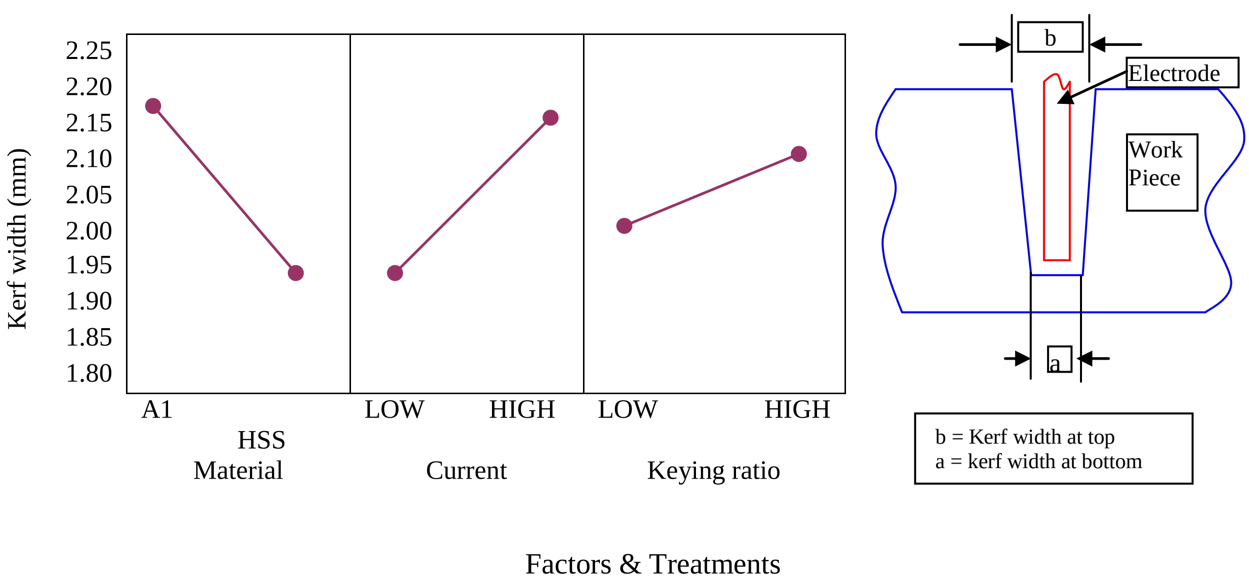


Fig 2 Graphic display of factor effects on machining rates (Kerf) in EDS corresponding to Table 3.

TABLE 3 : Response table for EDS Machining Rates (Kerf) width at top surface

S.No.	Random expt no.		Kerf width mm	Work mat		Current		Pulse time keying ratio	
	Set-1	Set-2		-1(A1)	+1(HSS)	-1 (Low)	+1 (High)	-1 (Low)	+1(High)
1	3	6	1.92	1.92	-	1.92	-	1.92	-
2.	8	7	2.16	2.16	-	2.16	-	-	2.16
3.	6	8	2.28	2.28	-	-	2.28	2.28	-
4	1	2	2.36	2.36	-	-	2.36	-	2.36
5.	4	5	1.84	-	1.84	1.84	-	1.84	-
6.	2	3	1.82	-	1.82	1.82	-	-	1.82
7.	5	1	1.98	-	1.98	-	1.98	1.98	-
8.	7	4	1.96	-	1.96	-	1.96	-	1.96
Total			8	4	4	4	4	4	4
No.of data points			16.32	8.72	7.6	7.74	8.58	8.02	8.3
Average			2.04	2.18	1.9	1.935	2.145	2.005	2.075
Estimated main effect				-0.285		0.21		0.07	

TABLE 4: Response table for EDS Roughness: Ra (μm)

S.No	Random exp. No.		Roughness	Work material.		Electrolyte		Current		Pulse DVR	
	Set 1	Set 2	Ra(μm)	-1(A1)	+1(HSS)	-1(SAS)	+1(water)	-1 (Low)	+1 (high)	-1 (Low)	+1 (High)
1	3	4	7.1	7.1	-	7.1	-	7.1	-	7.1	-
2.	7	7	6.9	6.9	-	6.9	-	6.9	-	-	6.9
3.	2	6	10.8	10.8	-	-	10.8	-	10.8	10.8	-
4.	5	3	8.6	8.6	-	-	8.6	-	8.6	-	8.6
5.	1	8	7.9	-	7.9	7.9	-	-	7.9	7.9	-
6.	8	5	6.7	-	6.7	6.7	-	-	6.7	-	6.7
7.	4	2	6.3	-	6.3	-	6.3	6.3	--	6.3	-
8.	6	1	5.8	-	5.8	-	5.8	5.8	-	-	5.8
Total			60.1	33.4	26.7	28.6	31.5	26.1	34	32.1	28
No.of data points			8	4	4	4	4	4	4	4	4
Average			7.5125	8.35	6.675	7.15	7.875	6.525	8.5	8.025	7
Estimated main effect				-1.675		0.725		1.975		-1.25	

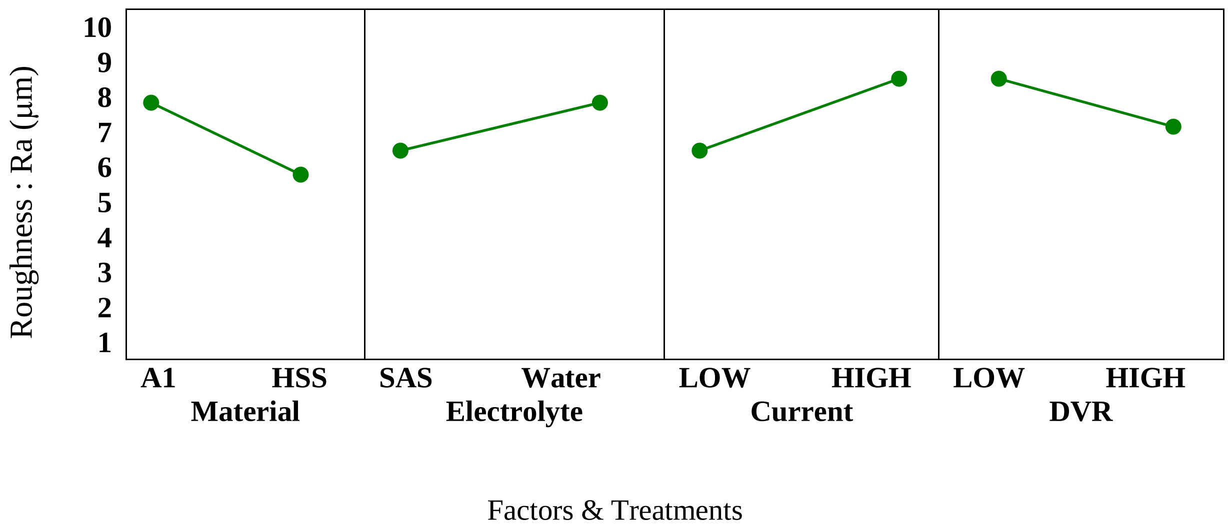


Fig 3 Graphic display of factor effects on Surface roughness in EDS corresponding to Table 4

4. Conclusions

Basically the erosion rates in EDS are very high owing to high current, successive sparks occurring at the same spot leading to arc discharges, very high pulse on times and negligible off times. High erosion rates are also associated with higher roughness. The affecting process parameters are pulse current, thermal conductivity (Lower the better), latent heat of melting (Lower the better) and pulse on time in that order. But at high pulse on time, there is a reduction in the erosion rates, and roughness which can be attributed to plasma channel expansion and reduced energy density. The machining rates (Kerf) for aluminium in EDS is significantly high with water as electrolyte owing to its high affinity to oxygen and formation of hard, brittle and passivating layer of aluminium oxide whereas for HSS silicate electrolyte is more effective for the formation of such a passivating film.

5.References

[1]. Ignacz. P. “Explanation of bubble creation in high electric fields by a new consideration on the structure of a liquid”, VI Int. Conf. Breakdown in dielectric liquid, 1976, pp.261-266.

[2].Bagchi, T.C., Taguchi methods explained, Prentice Hall of India, 1994.

[3]. Tzeng, Y.F. and Fu – Chen Chen, “A simple approach for robust design of high speed electrical discharge machining technology”, Int. Jl. of Machine Tools & Manufacture, Vol. 43, 2003, pp. 217 – 227.

[4]. McGeough, J.A., and Rasmussem, H. “A theoretical model of electrical discharge texturing”, Jl. of Materials Processing Technology, Vol. 68, 1997, pp.172 –178.

[5]. Murti, V.S.R. “Variant Electro discharge Machining (EDM) processes for diverse applications, Proc. AMT – 2005 Conf., Canada, 2005. pp. 255 –260.

[6]. Jaganathan P, Naveen Kumar T, Dr. R.Sivasubramanian, Machining Parameters Optimization of WEDM Process using Taguchi Method, Int. J. Scintific and Researc Publications, Vol.2, Issue 12 (2012), ISSN 2250-3153

[7]. MA. Norliana, DG Solomon, Md. F. Bahari, A Review on current research trends in electrical discharge machining (EDM), Int. J. Machine Tools and Manufacture, 47 (2007), 1214-1228.

[8]. Operating and Maintenance Manual of Electronica Machine Tools LTD., Electric Discharge Saw, EDS-400, EDC 500.