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AN EMERGING TELE-HYBRID MODEL TO ABRASIVE ASSISTED ELECTRIC DISCHARGE MACHINING (AAEDM)

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Abstract: The Electric Discharge Machine (EDM) has progressed from a novel technology to a critical standard machine in industry. It serves a variety of functions and can precisely create a geometrically complex component of any hardness in difficult-to-machine ways. Its output is reduced due to the poor MRR. Their productivity. Another versatile technique, the Abrasive Jet Machinery (AJM), has the advantage of being able to set up a machine, nearly any material rapidly. Its primary advantage is that no heat zone is damaged; it is also flexible and capable of machining tough and fragile materials. This procedure establishes a connection. The major stumbling blocks, Hybridization is a method for addressing several processes in order to maximize advantages and avoid boundaries. Using an indigenous hybrid system, this research intends to make the most of each of the above processes. Abrasive Assisted Electronic Discharge Machining (AAEDM) and EDM hybrid techniques are routed together with pressured air via the hollow electrode (AAEDM). Findings are validated in order to assess the benefits of the hybrid technique over the traditional EDM. The impact of critical process parameters on material removal rates and surface integrity was investigated. According to the results of the tests, AAEDM's hybrid process enhances machining efficiency, and the hybrid process produced can match the needs of today's manufacturing.

Keywords: Hybrid Machining, Electrical Discharge Machining, Abrasive Jet Machining, Material Removal Rate, Abrasive Assisted EDM

1. INTRODUCTION

Machine electrical discharge (EDM) and AJM are widely utilized in industry, therefore they are attracting the attention of researchers. The creation of a hybrid process combines the results of two or more distinct processes, either collectively or jointly, to avoid or at least mitigate some of the fundamental processes' effects. The development of hybrid machining processes is said to have increased productivity in some tasks. [1-3] A few numbers were investigated and found to be extremely effective in the processing of new and complex machines. Abrasive Assisted Electrical Discharge machining: An innovative hybrid approach

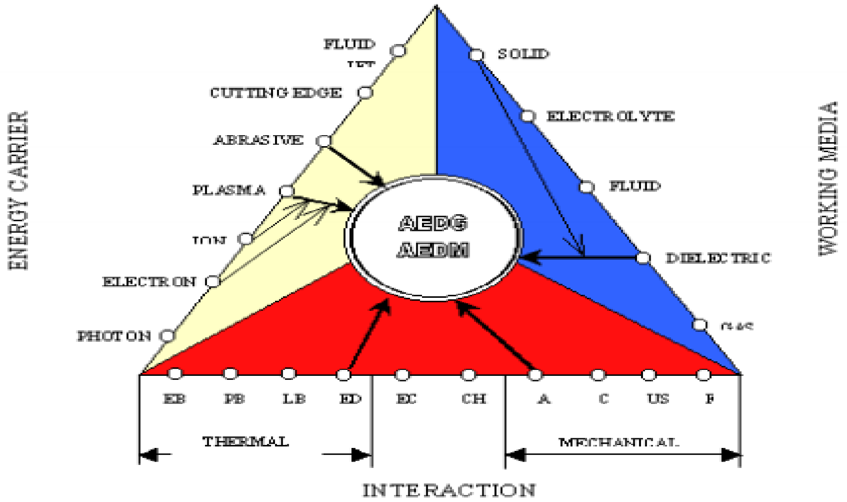

Fig. 1. Diagram of principle of Abrasive Assisted EDM

The basis of the triangle is, as shown on Fig. 1: the kind of interaction: thermal [Electron Beam (EB), Plasma Beam (PB)]; electrical (EC) and chemical (CH); mechanical [Abrasion [A], Cutting (C), Ultrasonic Wave (US) and Flow Fluid action [F]. A process known as Powder-mixed EDM is used to provide a superior polish of a machined surface upwards to a mirror with no breaks and pores, in particular compositions, size and concentrations of grit in the dielectric liquid. A stirrer is continually needed to detect the presence of abrasives in the working zone. The effectiveness of the system is maintained by the development of a technique whereby the abrasives are sent directly to the processing region using compressed air and are referred to as Abrasive Assisted Discharge Machining (AAEDM). This procedure is designed by producing hollow electrode and attached vents so that the abrasives are present through full processing within the zones of spark. [4-7]

For the selection of workpiece material, extensive research and field surveys have been conducted. The work piece material chosen for study is aluminium and is chosen based on the expanding number of applications in production and the constraints on which EDM can be machined have unwanted consequences. The huge number of waste particles produced in this process which can quickly block an EDM filter system is one of the key problems for milling aluminium with EDM. The generated particles are exceedingly tiny and rigid. This shortens filter media life and leads to the more frequent modification of filter cartridges. Filters with these particles are expensive to remove. These particles (where they stay in the dielectric fluid) are hard to recycle and may interfere with the cutting of other materials or contaminate the surface of the component. There are a number of health risks associated with the usage of abrasives in dry air [9]. AAEDM will thereby boost MRRs and give solutions for overcoming EDM, AJM and aluminum machining restrictions. [5-10]

2. EXPERIMENTAL WORK

AGIEPULS Die Sinking EDM machine experiments are carried out. As illustrated in Fig. 2 an attachment for the abrasive is conceived and created using compressed air with a pressure of 0.3 kilowatt kgf/cm2 via the hollow cylindric tool electrode. An attachment was developed to assemble the workpiece easily, quickly and accurately. For dielectric fluid feeding a separate tank and pump was added. Electrolytic copper, which has holes of 18 mm diameter with a positive polarity, is the electrode material employed for these tests. The vertical axis had been boiled at the base at an angle of 450 to fuse in a rolling hole, as illustrated in Fig. 3. The employed workpiece of aluminium alloy (6082) was cylindrical, with a diameter of 20 mm and a length of 15 mm. Commercial grade EDM oil was utilised as dielectric fluid (specific gravity=0.763; freezing point=94 bis C; manufacture IPOL lubricants) A hollow electrode was routed by a compressed air at a pressure of 0.3 kgf/cms with the Al2O3 abrasives of 80 and 280 mesh dimensions. Machining up to a depth of 1.6mm was carried out. The 'Solaris CCD plus' Spark test has been conducted and aluminium (6082) and electrolyte copper are composed.

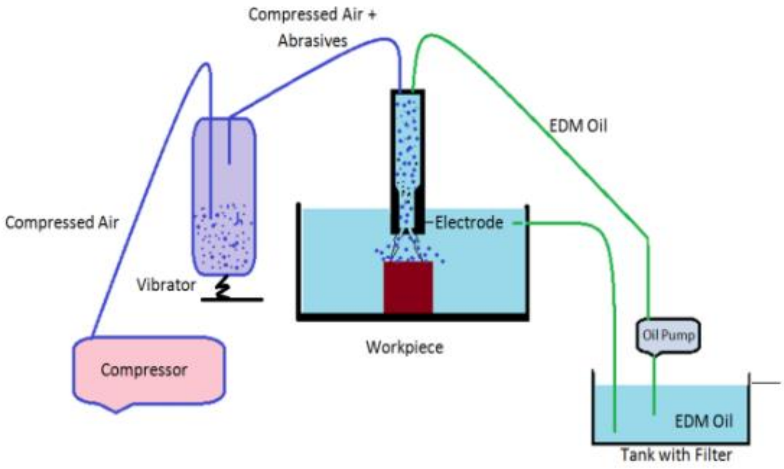

Fig. 2. Schematic of AAEDM process

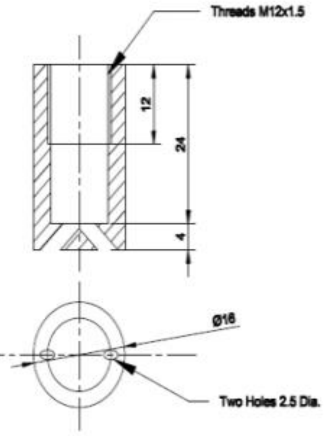

Fig. 3. Schematic of electrode

3. EXPERIMENTAL INVESTIGATION

On the successful fabrication and assembly of the experimental set up, first trial operations were undertaken, during which it was established that the elements worth considering were Peak Current (Ip), Pulse on Time (Ton) and Duty Factor (τ). Other elements under consideration to be adjusted were Gap voltage and Compressed air pressure utilised to convey the abrasives to the sparking zone, however it was found that these elements required to be set at a constant value in order to obtain consistent sparking in the AAEDM process. The abrasive grains used are selected on the basis of field study which is commercially utilised in industries and made by Grindwell Norton Ltd. It was shown through pilot trials that the greatest influence on MRR is of the factor Peak current (Ip) (Ip). Manifesting the same, acceptable values for screening processes were discovered and concluded as presented in Table 1.

Table 1: Factors and standards for test screening

SN	Factor	Unit	Levels
1	Pulse Current (I_p)	A	5, 10, 15
2	Pulse on time (T_{on})	µs	100, 120, 140, 160, 180, 200
3	Duty factor (τ)	%	60, 75, 85

MRR (gm/min) = [W (initial weight) – W (final weight)] / (machining time) min
TWR (percentage)= [T (initial weight of tool)– (final weight of tool) gm] /(Wi-Wf) x100
Where- MRR= metal removal rate, TWR= tool wear rate, Wi= initial weight of workpiece.
Wf= final weight of workpiece 18 tests was undertaken at each factor Ip level in accordance with Table 1. Three repetition sets have been made to eliminate the variances.

4. RESULT AND DISCUSSION

The tests were conducted and the study was carried out in order to grasp the advantages of Abrasive Assisted EDM over Standard EDM.

A. Material Removal Rate

The experiments show the Abrasive Assisted EDM in terms of its performance in relation to standard EDM.
Results are shown as showing the MRR values in Fig. 4 for Std EDM v/s AAEDM WalOx90, and for AAEDM v/s AAEDM WAlOx220, the abrasive assisted EDM for white aluminium oxide abrasives in 220 mesh size. The results are presented in Fig. 5. The conclusions are deduced and framed in order to enhance pulse current, as seen in the plots in Fig. 4 and Fig. 5.

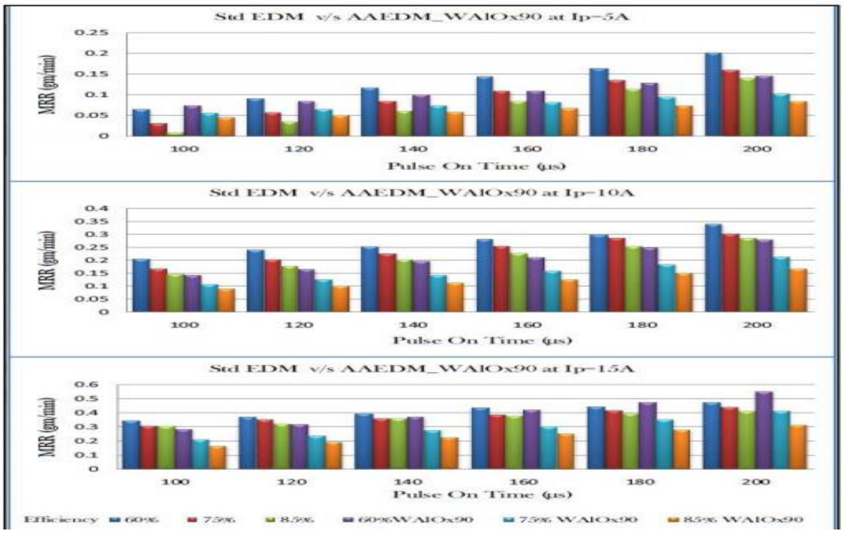

Fig. 4. Values of MRR for Std EDM v/s AAEDM_WAlOx90

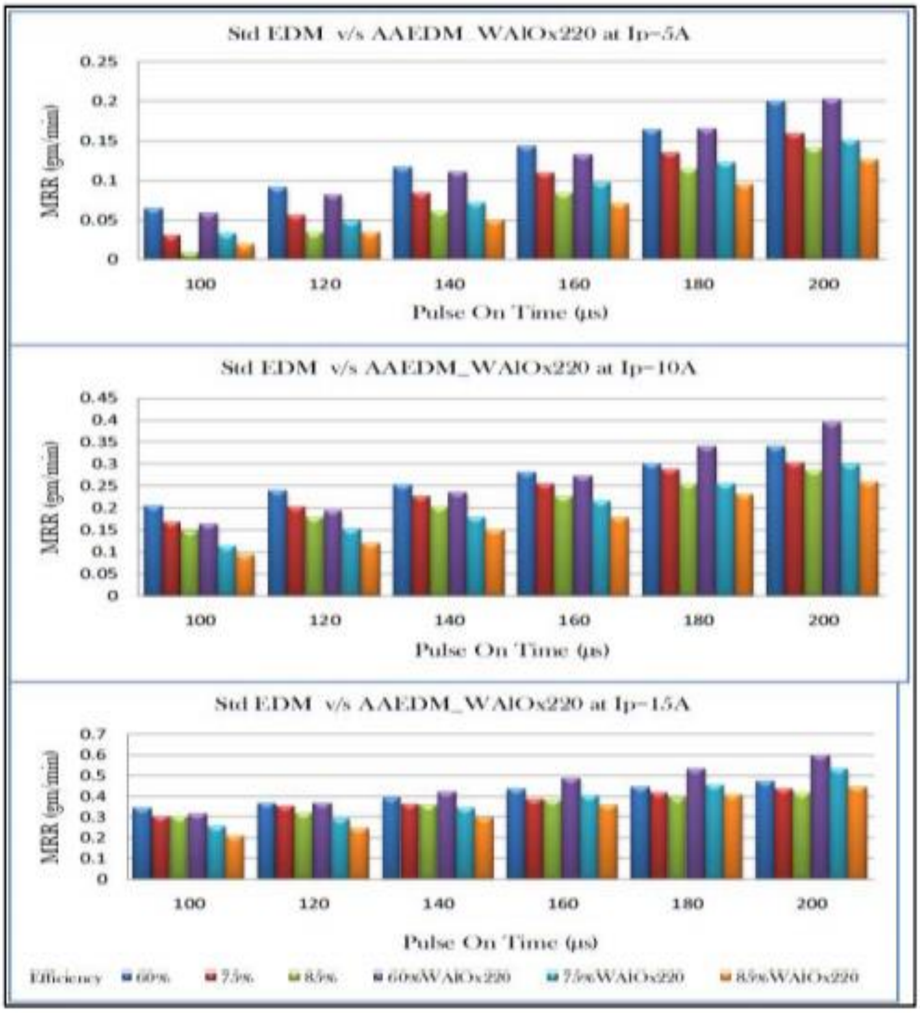

Fig. 5. Values of MRR for Std EDM v/s AAEDM_WAlOx220

B. At low Ip (5 A)

The WAlOx90 abrasives appear to have a detrimental impact on MRR; the high resistance of white aluminium oxide (WAlOx) abrasives is difficult to overcome. The MRR is nonetheless larger than StdEDM at Ton = 100 µs, as at the bottom of the tone, the spark gap is smaller than that, and because the powder coarser, not more sparkle has flowed. Although these abrasives might be abrasive on the workpiece in lower amounts. The temperature in the sparking zone also rises when the duty factor is increased, causing additional metal melting which is affected by the abrasives. While AAEDM WAlOx220 results in a reduction of MRR by the pattern of impact of increase of the duty factor with StdEDM. For AAEDM, the mRR until Ton = 160 µs is lower, as the tiny powders in the narrower spark gap have been introduced in a significant quantity that leads to high resistance. With the Ton growing beyond the average 180 µs, the spark gap is growing and the tiny abrasives are causing secondary spark, together with greater swing and abrasion times, enhance AAEDM MRR.

C. At Ip = 10 A:

AAEDM WAlOx90: Duty factor trend remains inversely commensurate with MRR. Rather, the amount of the reduction of the MRR is greater, since abrasives are rough, therefore they are less flowable and thus piled in the sparky area, which causes unstable discharge. The StdEDM MRR is shown across the experimental range to be better than the AAEDM. This is because the abrasives are still coarseness. At Ip = 10 A, the chip gap is increasing and the spark gap in the chip zone is increasing. Because of the high resistivity and the limited flowability of these abrasives, the sparkle causes impairment. The strength of the discharge is not sufficient to overcome the abrasives' resistance. The limited flowability also increases the accumulation of abrasives and waste in the spark gap.

AAEDM WAlOx220: the AAEDM MRR at Ip = 10A is lower than StdEDM until Ton=140 µs, as the release strength is reduced when the abrasive offers to overcome resistivity, smaller abrasives are stored in greater quantities in the narrow zones of the spark. As the sound moves beyond 160 µs, the spark breach rises and, together with the improved spark release, it facilitates abrasion and swaying action of molten metal. The linear increase in MRR was found.

D. At Ip = 15 A:

AAEDM WAlOx90: Ip=15A shows that AAEDM has low MRR up to Ton=160 µs compared to StdEDM. The Spark gap grew at high power, resulting in higher abrasion and more resistance to flow into the spark region. The MRR grows at low tariffs with tone exceeding 160 µs. The release pulse is now longer and it takes more time for the drug to be removed. The extended duration allows molten metal to be rough and swayed without being allowed to attach to the surface. It's got more time.
Higher peak current (ip = 15A) reduces the abrasive resistivity threshold to 120 µs. Aaedm WAlOx220: Later, the material removal will be longer due to the bigger tone separation due to the longer pulse discharge length. This extra duration allows you to swing abrasives and molten metals on the workpiece surface more.
ANOVA was run in order to assess the statistical importance of the predictors. The importance of the factor was shown by the P-value in ANOVA. The majority of P values are less than the selected alpha value (0.05%) and hence play an important role in defining the MRR. The analytical results against fit demonstrated that unbiased coefficient estimates were generated by the AAEDM procedures via least variance.

E. Tool Wear Rate

AAEDM's WAlOx90 has a lower TWR for Ton and vice versa. Low discharge produces resistivity. The low tone spark gap makes the process less stable and gives the tool more abrasively. Higher tonnes, which enables smoother abrasive flow and reduces abrasive effect on instruments. This describes the reduced TWR by a bigger sound. The TWR decreases due to the increase of Ip. The abrasive may decrease the resistance only after 160 µs. The TWR begins to fall when the chips and abrasion of tools both develop.
AAEDM WAlOx220 demonstrates that StdEDM and AAEDM WAlOx220 have the same propensity to increase TWR at low sound levels. TWR has low trans-values and high trans-values. The increasing¨ enhances the abrasive flow rate in the sparking zone, and the spark distance therefore increases considerably. In addition, µ leads to extended intervals between successive pulses, which lead to less time following the previous discharge for the dielectric strength recovery. Unstable sparking creates an unsettled gap, which increases the wear of tools.

F. Taguchi Analysis

For each factor level combination, the S/N ratio is computed. A greater S/N ratio is used for the improvement of the material removal rate. Minitab® 17.1.0 analyses are performed. Table 2 has three components, each at three levels, to illustrate the impact of process parameters on Standard EDM and abrasive granules

Table 2: Process variables and Taguchi analytical levels

SN	Variable/ Factor	Unit	Levels		
			1	2	3
1	I_p	A	5	10	15
2	T_{on}	µs	100	150	200
3	τ	%	60	75	85

Table 3 analyses and summarises the ranking, the connection of factors to maximal RRM, the effects of individual components and interactions and sets criteria for greater RRM. The AAEDM procedures were examined and the Response Surface Methodology (RSM) defined the parameters, with different parameters and various abrasive grains and outcomes.

Table 3: AAEDM process classification based on MRR

Ranking	AAEDM Process	I_p (A)	T_{on} (µs)	T (%)	MRR	TWR
1	WAlOx220	15	200	60	0.589	0.581
2	W AlOx90	15	200	75	0.446	0.193
3	Std EDM	15	200	75	0.427	3.447

G. Confirmation Experiments

In order to validate results derived through statistical analysis, confirmation experiments are planned and undertaken. These trials serve the goal of validating the levels produced from the proposed Taguchi trials. the desired response (MRR) was raised while the deleterious (TWR) was lowered, keeping the level of the factors at the levels set earlier by S/N ratio in Taguchi experiments Three confirmation tests were done at the optimal process settings. Table 4 shows the values of the performance parameters, MRR and TWR. The most significant factors for enhancing MRR and lowering TWR have been found using Taguchi and experimental verification.

Table 4: Confirmation experiments on optimal process parameter setup

AAEDM Process	I_p (A)	T_{on} (μs)	τ (%)	Material Removal Rate (gm/min)				Tool Wear Rate (%)			
				R1	R2	R3	Mean	R1	R2	R3	Mean
WAlOx220	15	200	60	0.546	0.589	0.531	0.555	0.603	0.661	0.621	0.628
WAlOx90	15	200	75	0.501	0.483	0.453	0.479	0.092	0.096	0.102	0.097
Std EDM	15	200	75	0.433	0.402	0.436	0.424	3.921	4.011	4.203	4.045

5. CONCLUSION

1. The AAEDM approach yields better MRR than the Standard EDM.
2. The TWR in Hybrid AAEDM is shown to be smaller than the StdEDM procedure
3. It has been shown that, with increasing Peak Current and Pulse on Time, the MRR increases; nevertheless, the Duty Factor shown inverse behaviour.
4. AAEDM with WAlOx220 and WAlOx90 grits produces 29% and 12% greater MRR in comparison to standard EDM.
5. Hybrid AAEDM using WAlOx220 delivers a superior MRR due to its smaller particle size, which helps overcome the resistance.
6. Reduced EDM oil usage means less pollution
7. Simple and cheap to install
8. More money for EDM job-shops
9. The risk of inhaling dry abrasive granules is avoided.

6. COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of Conflict of Interest

The authors declare that there is no conflict of interest regarding the main research, authorship and publication of this paper

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