Investigation on the Effect of Nano Fluid in Electro Discharge Machining Of Haste Alloy Using Taguchi Approach

R.Arumugam [1], N.Agnish[2], R.Ajith Kumar[3], Amal Augustine[4], Ashiq Moidutty[5], Jasir Ummer[6]
[1, 2] Assistant Professors, [3,4,5,6] U.G Scholars,
[1,2,3,4,5,6]Department of Mechanical Engineering,
[1,2,3,4,5,6]Sree Sakthi Engineering College, Coimbatore, India.

Abstract: In this project, Taguchi method was employed to optimize the copper powder concentration in dielectric fluid for the machining of haste alloy using Electrical Discharge Machining (EDM). The process parameters such as discharge current (A), powder concentration and pulse on pulse off (T_{on}&T_{off}) were changed to explore their effects on Material Removal Rate (MRR). It was observed from the experimental results that the copper powder added dielectric fluid significantly improved the MRR. Analysis of Variance (ANOVA) and F-test of experimental data values related to the important process parameters of EDM revealed that discharge current and copper powder concentration has more percentage of contribution on the MRR. The main aim of our project is to investigate the effects of nano-fluid in electro discharge machining of haste alloy using taguchi approach.

Index Terms – EDM, Haste Alloy, Taguchi Approach, Nano Fluid, Tool Wear Rate, Material Removal Rate.

I. INTRODUCTION

Electrical discharge machining (EDM), also known as spark machining, spark eroding, burning, die sinking, wire burning or wire erosion, is a manufacturing process whereby a desired shape is obtained by using electrical discharges (sparks). Material is removed from the work piece by a series of rapidly recurring current discharges between two electrodes, separated by a dielectric liquid and subject to an electric voltage. One of the electrodes is called the tool-electrode, or simply the "tool" or "electrode," while the other is called the work piece-electrode, or "work piece." The process depends upon the tool and work piece not making actual contact. Many nickel-based steel alloys exhibit high resistance to corrosion and Hastelloy is one of the best. In addition to outstanding resistance to all manner of pitting and cracking, parts made from Hastelloy metal blends tend to find good use across a wide range of chemical applications that might otherwise oxidize the metal. An additional element such as molybdenum and chromium round out the profile of an alloy that is widely regarded as one of the world's toughest

1.1 COMPOSITION

Nickel	57
Cobalt	2.5max
Chromium	16
Molybdenum	16
Iron	5
Tungsten	4
Manganese	1max
Vanadium	0.35max
Silicon	0.08max
Carbon	0.01max

Copper	0.5max

1.2. NANOFLUIDS

The nano fluid used is ***copper powder (cu).*** Copper is one of the most important elements. It is a reddish metal that is a malleable and ductile with a bright metallic lustre. Copper is a good conductor of heat and electricity (second only to silver in electrical conductivity). Because of its malleability it is readily fashioned into sheets, wire and tubing

1.3. PROPERTIES

Method Of Manufacturing	**Electrolytic**
Atomic Weight	63.54
Copper Contain	99.8% min
Metallic Impurities	0.05 max
Non Metallic Impurities	0.05% max
Insoluble	0.1% max

II. PROJECT DESCRIPTION

Hastealloy is increasingly used in many industrial and commercial applications because of its excellent properties. Hastealloy finds enormous applications in chemical industry, machine building, shipbuilding and auto industry apart from the fabrication of equipment for the oil and gas industry ,food industry, medicine and civil engineering. The largest consumer of hastealloy is the aerospace industry. Hastealloy is being extensively used in engineering applications owing to its outstanding corrosion resistance, fatigue resistance and in many environments especially in high strength applications. Hastealloy has high strength to weight ratio, high temperature strength and it is difficult to machine Hastealloy with the conventional machining process due to its chemical reactivity with almost all cutting tool materials, and its low thermal conductivity and low modulus of elasticity impairs machinability.
Non conventional thermoelectric spark erosion machining process, commonly known as electric discharge machining (EDM) has been successfully used to machine hastealloys effectively regardless of their chemical and mechanical properties. In EDM, electrode and work piece do not come in contact with each other for the machining of the material and the material removal mechanism uses the electrical energy which is converted into thermal energy through a series of discrete electrical discharge energy obtained between the cathode (work piece) and the anode (electrode) sinking in an insulating dielectric fluid. Therefore, hard metals like Titanium, Nickel, ceramics and ferrous alloys can be machined effectively using EDM.

For the EDM machining, selection of proper process parameters is important. An improper combination of process parameters may result in lower MRR, increased SR, high tool wear rate (TWR) that impose higher machining cost.Optimization of EDM process parameters by finding the correct combination of the process parameters available in EDM will enhance the machining productivity and reliability. In the present work, L9 orthogonal array with various sets of experiments at different concentrations of surfactant and graphite powder in the dielectric fluid were carried out to study the effect of these concentrations on the MRR with respect to discharge current.

III. EXPERIMENTS SETUP

Experimental constant parameters are tabulated in Table. The EDM machine has a DC servo system. The work piece was firmly clamped in the vice and immersed in the EDM oil. The maximum discharge current is 2.1 A, power factor is 0.8 and minimum surface finish is 0.8 microns. In this experimental study, spark erosion 450EDM oil was used as dielectric fluid because of its high dielectric strength, high flash point, less surface tensionand less density. The experiments were conducted as per L9 OA selected.. Before machining, the work pieces and electrodes were cleaned.

Table.1:Experiment setup

S no	**Working Parameters**	**Description**
1	work piece material	Haste alloy

2	Size of work piece	100mm*50mm*5mm
3	Electrode material	Tungsten carbide
4	Size of electrode	Φ20mm*200mm
5	Dielectric fluid	Spark erosion 450 EDM oil
6	Flushing pressure	0.75 MPa

IV. PERFORMANCE CHARACTERISTICS CALCULATION

EDM performance characteristics, regardless of the type of the electrode material and dielectric fluid are measured usually by the following criteria:

- Material Removal Rate (MRR) (mm3/min)
- Surface Roughness (Ra)
- Tool wear rate (TWR) (mm3/min)
- Recast layer thickness (mm)

The MRR is defined as the work piece weight loss (WWL) under a period of machining time in minutes, i.e.

MRR(mm3/min) = **Volume of hole drilled**(mm^3) /**Time taken**(min)

Where:
Volume of hole drilled = **Area of hole drilled**(mm^2) * **Depth of hole drilled**(mm)
Area of hole drilled$(A) = \boldsymbol{\pi r^2}$(mm^2)
r= radius of tool

Maximum MRR is an important indicator of the efficiency and cost effectiveness of the EDM process. However, high MRR is not always desirable for all applications, since this may scarify the surface integrity of the work piece.

V. RESULTS AND DISCUSSION

Material removal rate

Table shows the orthogonal array based experimental results of MRR and its corresponding signal to noise ratio (S/N), whose analysis of variance (ANOVA) results are listed in Table 10. The ANOVA results and F-test values indicate that the most significant factor is discharge current (81.83 %) compared to other factors like surfactant concentration (5.97 %) and graphite concentration(10.53 %).

S.No	Process parameters			Material removal rate (mm^3/min)
	Discharge current	Pulse Off	Copper Powder	
1	0.5	3	0	2.8045
2	0.5	3	10	3.9630
3	0.5	3	20	3.6057
4	1.5	2.6	0	5.2503
5	1.5	2.6	10	5.5625
6	1.5	2.6	20	4.4736

7	2.1	2.0	0	5.9367
8	2.1	2.0	10	5.5180
9	2.1	2.0	20	5.1923

Table.2:MRR Rate

VI. CONCUSION

The main S/N ratio response graph shown in table.2 infers that MRR increases with an increase in discharge current. As the discharge current is higher, the discharge energy is also higher. Hence, the higher discharge energy distributed into high melting temperature, it causes high evaporation and high impulsive force acting on machining region related to higher MRR [28]. In other words, higher discharge current is the key factor to obtain the higher material removal rate in EDM of Titanium alloy. The effect of span 20 surfactant concentration on the MRR is illustrated in Fig. 4(B). The material removal rate initially increases with increasing surfactant concentration and then decreases with further increase in surfactant concentration. It is known that increasing the surfactant concentration increases the conductivity of dielectric fluid, the surface tension, dispersion and dissolubility of particles which increases the MRR . The agglomerated copper particles are to be retarded because the stereo-barriers exited or were involved.

Surfactant concentration effect well distributions of graphite powder in the dielectric are accomplished. Concentration of the surfactant increases the viscosity of the dielectric fluid because of whichtheerodedmaterial findsit difficult toexist inthe machined zone. The decrease in MRR is due to the effect of powder particles, vanderwaal forces, electrostatic forces, particle size, magnification and surface properties. This type of organic components has largemolecularstructureandiseasilydecomposedinthedielectric fluid to produce more gases and carbon dregs, which affect the machining zone..The influence of graphite powder concentration on MRR. This figure indicates that the value of MRR in- creases with an increase in graphite powder concentration. When powder is added to dielectric fluid, the powder particles get ener- gized and behave in a zigzag manner when the voltage is applied across the electrodes. They form a chain like structure in the spark gap. This chain helps in bridging the gap between the work piece and the electrode. This also reduces the gap voltage and dielectric strength of dielectric fluid and this initiates series discharge. The sparking frequency is increased with improved flushing of debris effectively away from the gap. This results in effective discharge transmissivity under the sparking area due to increase in the thermal conductivity. Hence, MRR increases in powder mixed dielectric fluid. Fig. 4 shows the A3B2C3 parameters, i.e. discharge current of 20 Amp, surfactant concentration of 6 g/lit and graphite powder concentration of 13.5 g/lit respectively are the optimal conditions for betterMRR. Further the empirical model has been developed to predict the MRR values using regression analysis, including up to the square terms in the model.

REFERENCES

[1] Valentin N. Moiseyev, Titanium Alloy: Russian Aircraft and Aerospace Appli- cations, CRC press, 2006.

[2] Annie Ann Nee Liew, Optimization of Machining Parameters of Titanium Alloy in Electrical Discharge Machining Based on Artificial Neural Network, thesis, Dec 2010.

[3] K.P. Rajurkar, Gu Lin, Review of electrical discharge machining of titanium alloy, in: Proceedings of Seventh International Conference on Precision, Meso, Micro and Nano Engineering at COE, Pune, India, 2011, pp. 10e18.

[4] E.O. Ezugwu, Z.M. Wang, Titanium alloys and their machinability e a review, J. Mater. Process.Technol. 68 (1997) 262e274.

[5] C.H.C. Haron, A. Jawaid, The effect of machining on surface integrity of tita- nium alloy Tie6Ale4V, J. Mater. Process.Technol. 166 (2005) 188e192.

[6] D.A. Dornfeld, J.S. Kim, H. Dechow, J. Hewsow, L.J. Chen, Drilling burr forma- tion in titanium alloy Tie6Ale4V, Ann. CIRP 48 (1999) 73e76.

[7] Takashi Endo, Takayuki Tsujimoto, Kimiyuki Mitsui, The effect of vibration on machining time and stability of discharge processing 32 (2008) 269e27