EXPERIMENTAL ANALYSIS AND OPTIMIZATION OF EDM PROCESS PARAMETERS

R.Velavan[1],P.Ramkumar[2],N.Seenivasan[3],K.Vignesh Guru[4],A.Vincent[5]

[1]*Assistant Professor, Department of Mechanical Engineering, VSB Engineering College, Karur.*

[2,3,4,5]*Final Year, Department of Mechanical Engineering, VSB Engineering College, Karur.*

ABSTRACT

The paper presents the experimental analysis and multi-response optimization of EDMprocess parameters during machining of Nimonic 90 work material. The experiment has beenconducted at different parametric setting considering discharge current, pulse-on-time and pulseoff-time as process parameters. Taguchi L9 orthogonal array has been used for experimental design. The effect of various parameters on response such as material removal rate and surface roughness has been studied with the help of suitable plots. The Grey Relational Analysis has been utilised for obtaining the optimal parametric combination.

INTRODUCTION

Electric discharge machining (EDM) is one of the most advanced method for precise machining of hardmaterials where the material is removed due to melting and vapourization. The voltage in pulsed form isapplied within the small electrode gap immersed in dielectric fluid which generates a spark. The thermalenergy of this spark melts and vapourizes the material which upon cooling, solidifies to form debris. Theremoved material is flushed away by the pressure of the dielectric fluid during pulse-off-time. Generally, the workpiece replicates the image of the tool electrode [1]. EDM machine in cooperates a servo- mechanism to control the movement of the tool and also to compensate for the tool wear. A small gap always exists between the electrodes in the machining zone which prevents their direct contact. Therefore, the process is advantageous in having less defects like mechanical stresses, clattering and vibration [2].

The growing trend to use slim, light and compact mechanical components in automobile, aerospace, medical, missile, and nuclear reactor industries has led to the development of high strength, temperature resistant, and hard materials during last few decades. It is almost impossible to find sufficiently strong and hard tools to machine aforesaid materials at economic cutting speeds. Moreover, machining of complex shapes in these materials with low tolerances and high surface finish by conventional methods is even more troublesome. Hence, there is great demand for new machining technologies to cut these ‘difficult-to-machine’ materials with ease and precision. Among modern machining processes, electric discharge machining (EDM) has become highly popular in manufacturing industries due to its capability to machine any electrically conductive material into desired shape with required dimensional accuracy irrespective of its mechanical strength.

Joseph Priestley, The English physicist, first noted the erosion of metals by electric sparks in 1770. However, Russian scientists B. R. Lazarenko and N. I. Lazarenko first introduced controlled machining by electric discharges in 1943. Intermittent arcing in air between tool electrode and workpiece material, connected to a DC electric supply, caused the erosion of material. The process was not very accurate due to overheating of the machining region and may be defined as 'arc machining' rather than 'spark machining'. During 1980s, the efficiency of EDM raised extraordinarily with the introduction of computer numerical control (CNC). Self- regulated and unattended machining from loading the electrodes into the tool changer to a finished smooth cut was possible with CNC control system. Since then, these emergent virtues of EDM have been vigorously sought after by the manufacturing industries producing tremendous economic advantage and creating keen research interest.

LITERATURE SURVEY

Chen.et.al [3] performed various experiments on EDM with discharge current, pulse-on-time (Ton) and pulseoff-time (Toff). The results revealed a factor (Fc) that showed MRR to vary directly to the discharge energy, which followed identical trend. Lonardo.et.al[4] studied the influence on wearing of the tool taking electrode material, dimension and depth of cut as parameters. The tool wear was found to be high with copper (Cu) electrode. However, the surface finish was observed to be better. The size of the electrode was noted to have significant effect wear on tool wear.Tzeng.et.al [5] investigated the powder characteristics in EDM machining. The machining was carried out using various powders mixed in dielectric with concentration of 0.5 cm^3/ltr. It was found that chromium (Cr) gave the highest material removal rate (MRR), followed be aluminum (Al) and silicon carbide (Sic).

Mohan.et.al [6] performed machining of aluminium - silicon carbide (Al-SiC) metal matrix using a tubeelectrode composed of brass with induced rotary motion. They concluded that the rotating tube type electrodeproduced high MRR compared to solid one. Better MRR was observed with smaller tube diameter of the toolelectrode with an expense in surface roughness (Ra). Lauwers.et.al [7] performed a detailed investigation onMRR of ZrO_2, Si_3N_4 and Al_2O_3 based ceramic materials with addition of titanium carbide (TiN) and titanium
carbonitride (TiCN) phase to make them electrically conductive. Chen.et.al [8] studied the machiningcharacteristics of titanium superalloy (Ti-6Al-4V). The dielectric fluids were selected as kerosene and distilledwater. MRR was found to be higher with less wearing of tool with distilled water. Khan.et.al [9] analyzed thewear process along the cross-section and length of Cu and brass tool electrode while machining Al and mildsteel (MS). The tool wear increased with increase in current and voltage, showing more wear on the crosssection than the length. M. L. Jeswani [10] studied the influence of graphite (Gr) powder of mean size 10, mixedwith kerosene for machining of MS taking Cu tools of 4mm diameter. The concentration of the powder variedfrom 0.25 to 6.0 g/lit. The results showed that 4 g/lit of powder concentration produced highest MRR, lowest cool wear rate (TWR) leading to decreased wear ratio (WR). This effect was attributed to the fact that thepowder lowered the dielectric strength of kerosene causing early discharge. Wong.et.al [11] used Al, Gr, silicon
(Si), crushed glass, SiC and molybdenum sulphide (MoS2) powders of size 40 μm with concentration of 2 g/l toinvestigate the effect of machining of AISI-01 and SKH-54 tool steel. They found that the powder addeddielectric increased the gap between the electrodes in the machining zone. No such effect was observed withcrushed glass. Very fine surface finish was produced by MoS2 and Si powder on SKH-54 and by Al powderon AISI-01 tool steel.

EXPERIMENTAL SETUP AND CONDITIONS

The experiments were performed on EDM, Sparkonix MOS, 35A, ZNC coupled with normal controller asshown in figure 1. EDM oil is selected as dielectric. The material is selected as Nimonic 90 having dimensionof 10 x 10 x 4.1 mm, Inconel 718 having dimension of 10 x 10 x 3.1 mm and Stainless Steel having dimensionof 10 x 10 x 2.1 mm. Brass electrodes of 2 mm diameter was used as tool. Table 1 lists the process parametersand their respective levels considered for experimentation. The output responses were identified as materialremoval rate (MRR) and the surface roughness (Ra).

PROBLEM IDENTIFICATION

Among the carbon-based heat-treated alloy steels, D2 as a material that is difficult to machining which has a wide range of application in Pharma, Marine field often machined by EDM. From the available literature, it can be seen that a comprehensive knowledge of electro discharge machining with a wide parametric range is lacking, especially the Discharge current, Pulse ON Tine, Pulse OFF time with Taguchi technique.

SELECTION OF OBJECTIVE

To study of the machining parameters influencing Surface roughness, Material Removal Rate& Machining Time using Taguchi design model and determining the optimum setting to minimize Ra.

SCOPE OF THE PROJECT

This investigation is to find out the optimum combination of machining process parameters within a given range for better responses in EDM using Taguchi approach Three process parameter viz., pulse on time, pulse off time, Gap current are considered Electrodes(Copper). Discharge current, Pulse ON Tine, Pulse OFF time are considered as the out put responses.

EXPERIMENTAL METHODOLOGY

To attain the main objectives of the present investigation, the experimental work has been planned in the following sequences.

- Selecting of base material for Spark EDM process.
- Studying the effect of process parameter on Copper electrode.
- Sample preparation & heat treatment
- Parameter selection through Taguchi design
- Conduct the EDM machining process.
- Evaluation of out put Response
- Optimization and confirm the output response.
- Conclusion

MATERIAL-D2 STEEL

SL.NO	ELEMENT	COMPOSITION IN WEIGHT % MAX
1	Carbon, C	1.50
2	Manganese, Mn	0.30
3	Silicon, Si	0.30
4	Molybdenum, Mo	0.75
5	Chromium,Cr	11.75
6	Sulphur	0.005
7	phosphorous	0.020

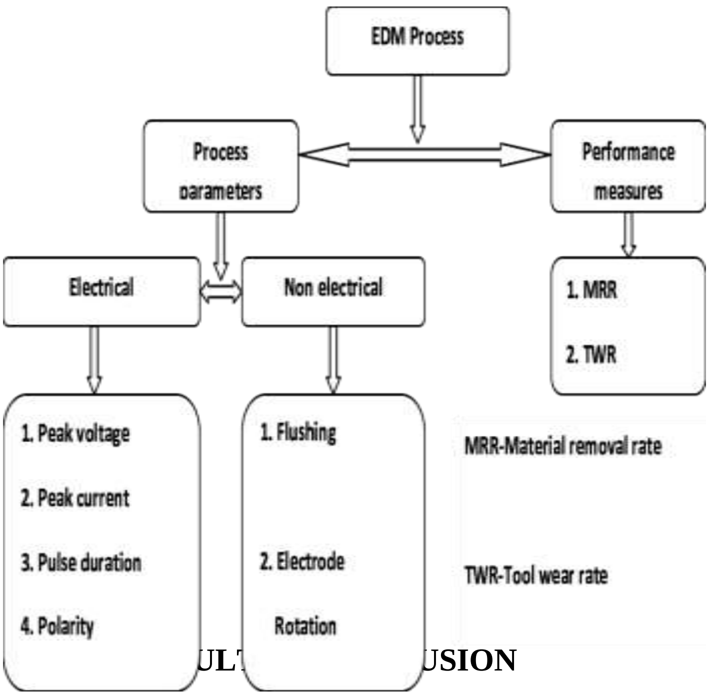
APPLICATIONS

D2 is suitable for the manufacturing of parts such as general purpose

- ✓ Axial & shaft
- ✓ Gears
- ✓ Bolt & studs
- ✓ All types of dies
- ✓ Jigs & fixtures (body and drill bushes).

HARDENING PROCESS

Material is heated up to the suitable temperature and then quenched in water or oil to harden to full hardness according to the kind of steel. Material is heated to the suitable temperature for hardening, then cooled rapidly by immersing the hot part is water, oil or another suitable liquid to transform the material to a fully hardened structure. In this process with the help of AAA medium type of oil and End quenching process used for increase the hardness of the D2.



ULT USION

The aim of the research work was to investigate the machinability of D2 EDM.

OPTIMAL CONTROL FACTOR

1. Surface Roughness- A_1 (Pulse on time -7μs) B_2 (Pulse off time -12 μs) C_3 (Amps-6)
2. Machining Timing- A_1 (Pulse on time-7μs) B_3 (Pulse off time -12 μs) C_2 (Amps-6)
3. Material Removal Rate- A_2 (Pulse on time -8μs) B_1 (Pulse off time -10 μs) C_3 (Amps-7)

Minimum Surface finish and machining timing were held at through lower level pulse on time and higher rating of amps.MRR were held at through medium level pulse on time and minimum rating of pulse off and higher level Amps rating.

PERCENTAGE CONTRIBUTION OF PROCESS PARAMETER

1. Surface Roughness- Pulse on time-37%.
2. Machining Timing -Pulse on time- 46%.
3. Material Removal – Amps- 29%.

REFERENCES

[1] E.C. Jameson, “Description and development of electrical discharge machining (EDM), Electrical Discharge Machining,” Society of Manufacturing Engineers, Dearbern, Michigan,2001, pp. 16.

[2] W.S. Zhao, Q.G. Meng, Z.L. Wang, “The application of research on powder mixed EDM in rough machining.” Journal of Material Processing. Technol, Vol 129, 2002, pp. 30–33.

[3] Chen, S.M. Mahdivia., “Analysis of electro-discharge machining process and its comparison with experiments” Journal of Materials Processing Technology,Vol 104, 2000, pp.150-157.

[4] P. M. Lonardo, A.A.Bruzzone., “Effect of Flushing and Electrode Material on Die Sinking EDM”, International Journal of

Machine Tools & Manufacture, Vol 45, 2005, pp. 194–200.
[5] Y.-F. Tzeng, C.-Y. Lee., “Effects of Powder Characteristics on Electro discharge Machining Efficiency” International Journal Advance ManufacturingTechnology, Vol 17,2001, pp. 586–592.
[6] B. Mohan, A.Rajadurai, K.G.Satyanarayana, “Electric Discharge Machining of Al-SiC metal matrix composites using rotary tube electrode, Journal of Materials Processing Technology, Vol 124, 2002,pp. 297-304.
[7] B. Lauwers, J.P. Kruth, W. Liu, W. Eeraerts, B. Schacht, P. Bley., “Investigation of material removalmechanisms in EDM of composite ceramic materials”, Journal of Materials Processing Technology,Vol 149, 2004, pp. 347–352.
[8] S.L. Chen, B.H. Yan , F.Y. Huang., “Influence of kerosene and distilled water as dielectrics on the electric discharge machining characteristics of Ti–6A1–4V”, Journal of Materials Processing Technology, Vol 87, 1999, pp. 107–111.
[9] A.A.Khan, “Electrode wear and material removal rate during EDM of aluminum and mild steel using copper and brass electrodes” International Journal of Advanced Manufacturing Technology, Vol 39, 2008, pp. 482-487.
[10] Jeswani, M.L., “Effect of the addition of graphite powder to kerosene used as the dielectric fluid in electrical discharge machining.” Wear,Vol 70, 1981, pp. 133 – 139S.
[11] Wong, Y.S., Lim, L. C., Rahuman, I., Tee, W. M., “Near mirror finish phenomenon in EDM using powder mixed dielectric.”.Journal of Material Processing Technology, Vol 79, 1998, pp. 30-40.