Mathematical Modeling and Process Parameters Optimization for Surface Roughness in EDM for EN31 Material by Response Surface Methodology

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***Abstract*- Present work aimed to investigate the surface roughness process parameter optimization during WEDM process for steel. Response Surface Methodology (RSM) is use to investigate the effect of five independent input parameter namely gap voltage (Vg), Pulse on time (Ton), pulse off time (Toff), wire feed (Wf) and flush rate (Fr) over CLA value of surface roughness (Ra).A fractional factorial Design of Experiment of two level were employed to conducted the experiment on EN-31 die steel with chromium coated copper alloy wire electrode. The responses were observed by mathematical modelling using RSM on experimental data. The significance coefficients were observed by performing analysis of variance (ANOVA) at 95% confidence level. Second order RSM modelling technique is the best method to found the significance factor affecting the surface roughness by conducting only very less experimentation. Keywords: WEDM, RSM, SR and ANOVA etc.**

I. INTRODUCTION

An electrical discharge machining (EDM) is based on the eroding effect of an electric spark on both the electrodes used. Electrical discharge machining (EDM) actually is a process of utilizing the removal phenomenon of electrical-discharge in dielectric. Therefore, the electrode plays an important role

The electrode material selected for the present investigation is conventional copper (Cu) and copper tungsten (75% Cu and 25% W) electrodes. CuW electrodes are made through powder metallurgy technique by mixing weight of copper and tungsten in blenders.

- The mixture is then compacted in a die to form green compact.
- For the present study EN 31 hot work tool steel is selected as work piece material
- EN 31 is basically 5% chromium hot work steel. The 1.5% molybdenum imparts very high hardenability to this grade and makes difficult to machine by traditional machining methods. Hence EDM is considered
- It has good resistance to softening at elevated temperatures,
- It has high toughness.

1.2 ELECTRICAL DISCHARGE MACHINING

Principles of EDM Electrical Discharge Machining (EDM) are a controlled metal-removal process that is used to remove metal by means of electric spark erosion. In this process an electric spark is used as the cutting tool to cut (erode) the work piece to produce the finished part to the desired shape.

The metal-removal process is performed by applying a pulsating (ON/OFF) electrical charge of high-frequency current through the electrode to the work piece. This removes (erodes) very tiny pieces of metal from the work piece at a controlled rate.

1.3 EDM PROCESS

EDM spark erosion is the same as having an electrical short that burns a small hole in a piece of metal it contacts. With the EDM process both the work piece material and the electrode material must be conductors of electricity. The EDM process can be used in two different ways:

1. A preshaped or formed electrode (tool), usually made from graphite or copper, is shaped to the form of the cavity it is to reproduce. The formed electrode is fed vertically down and the reverse shape of the electrode is eroded (burned) into the solid work piece.

2. A continuous-travelling vertical-wire electrode, the diameter of a small needle or less, is controlled by the computer to follow a programmed path to erode or cut a narrow slot through the work piece to produce the required shape.

The EDM milling machine used in this work is s shown in figure 1.1.

Fig: 1.1: EDM milling machine

1.3.1Conventional EDM

In the EDM process an electric spark is used to cut the work piece, which takes the shape opposite to that of the cutting tool or electrode. The electrode and the work piece are both 2 submerged in a dielectric fluid, which is generally light lubricating oil.

A servomechanism maintains a space of about the thickness of a human hair between the electrode and the work, preventing them from contacting each other. In EDM ram or sinker machining, a relatively soft graphite or metallic electrode can be used to cut hardened steel, or even carbide. The EDM process produces a cavity slightly larger than the electrode because of the overcut.

1.3.2 Wire-cut EDM

The wire-cut EDM is a discharge machine that uses CNC movement to produce the desired contour or shape. It does not require a special shaped electrode, instead it uses a continuous-traveling vertical wire under tension as the electrode. The electrode in wire-cut EDM is about as thick as a small diameter needle whose path is controlled by the machine computer to produce the shape required.

1.3.3 Dielectric fluids - conventional EDM

During the EDM process the work piece and the electrode are submerged in the dielectric oil, which is an electrical insulator that helps to control the arc discharge. The dielectric oil, that provides a means of flushing, is pumped through the arc gap. This removes suspended particles of work piece material and electrode from the work cavity.

1.3.4 Flushing

One of the most important factors in a successful EDM operation is the removal of the metal particles (chips) from the working gap. Flushing these particles out of the gap between the works piece to prevent them from forming bridges that cause short circuits.

1.3.5 Flushing ram type EDM

Flushing is the most important function in any electrical discharge machining operation. Flushing is the process of introducing clean filtered dielectric fluid into the spark gap.

Flushing applied incorrectly can result in erratic cutting and poor machining conditions. There are a number of flushing methods used to remove the metal particles efficiently while assisting in the machining process. Too much fluid pressure will remove the chips before they can assist in the cutting action, resulting in slower metal removal. Too little pressure will not remove the chips quickly enough and may result in short-circuiting the erosion process

1.3.6 Wire EDM dielectric fluids

The dielectric fluid must be circulated under constant pressure to flush (wash) away the metal particles and assist in the machining or erosion process. If red sparks occur during the 3 cutting operation, the water supply is inadequate. To overcome this problem, increase the flow of water until blue sparks appear.

1.3.7 The servo mechanism

Both wire and vertical EDM machines are equipped with a servo control mechanism that automatically maintains a constant gap of about the thickness of a human hair between the electrode and the work piece.

It is important for both machine types that there is no physical contact between the electrode and the work piece, otherwise arcing could damage the work piece and break the wire. The servomechanism advances the electrode into the work piece as the operation progresses and senses the work-wire spacing and controls it to maintain the proper arc gap which is essential to a successful machining operation.

1.3.8 Advantages of EDM

Conventional EDM machines can be programmed for vertical machining, orbital, vectorial, directional, helical, conical, rotational, spin and indexing machining cycles. This versatility gives Electrical Discharge Machines many advantages over conventional machine tools.

- Any material that is electrically conductive can be cut using the EDM process.
- Hardened work pieces can be machined eliminating the deformation caused by heat treatment.
- X, Y, and Z axes movements allow for the programming of complex profiles using simple electrodes.
- Complex dies sections and molds can be produced accurately, faster, and at lower costs.
- The EDM process is burr-free.

1.4EN 31STEEL

AISI EN 31 hot work Tool Steel could be a five-hitter Cr, general hot work steel that is characterized by glorious impact toughness. It contains less vanadium than the widely-used AISI EN 31 hot work tool steel, and also the tungsten content provides higher temper resistance. it has smart resistance to thermal fatigue cracking (heat checking) and excellent resistance to gross cracking and thermal shock once water cooled in commission.TLS EN 31 hot work tool steel is usually recommended for warm tooling applications wherever most resistance to cracking is needed. Such applications embrace hot punches, die casting dies, shaping dies, hot shear blades, hot gripper dies, and extrusion tooling.

Characteristics

1. Excellent Resistance to Wear, High Strength at Elevated Temperature.
2. Good Homogenizing with High Toughness.
3. Extra- Fine- Structure without Grain-Boundary Carbide.
4. Inclusion Shape Controlled with High Cleanliness.

II. LITERATURER SURVEY

Elmon C. Jameson[1] EDM is a controlled metal-removal process that is used to remove metal by means of electric spark erosion. In this process an electric spark is used as the cutting tool to cut (erode) the workpiece to produce the finished part to the desired shape. EDM spark erosion is the same as having an electrical short that burns a small hole in apiece of metal it contacts.

Hamidah Md. Soot [2]in EDM machine copper electrode is used for machining with different factors at various levels and found that its machining rate is better. The MRR is 20% less than copper electrode

Jahan [3]inEDM machine copper electrode is usedfor machining with different factors at various levels and found that its machining rate is better. MRRfor copper electrode is high in peak current variant.

Mehmet Baki Karamis [4] the method of removal of metal from the work piece is by melting and vaporizing minute amounts of electrode material, which are ejected and flushed away by dielectric fluid. The electric energy is discharged into the gap and multifactor's actions take place electrodynamics waves set in and travel at high speed.

Muthuramalingam and Mohan [5] the growth of a strong electrostatic field. Owing to the electric field, electrons are emitted from the cathode toward the anode on the electrode surfaces having the shortest distance between (EDM) These electrons impinge on the dielectric molecules of thermal erosion process, the fluid column and causing an electrical discharge in the breakdown of dielectric medium between them happens due to shortest distance point between the tool and the workpiece.

Syed Asghar Hussian Rizvi [6] an investigation on surface integrity in EDM process with a copper tungsten electrode. The die sinking electro discharge machining process (EDM) is a thermal process, whereby material is removed by the action of high energy electrical spark the main advantage of this process is that very hard conductive materials can be machined into desired complex shapes without any contact between the tool and the workpiece. To avoid possible failures arising from the surface defects it is vital that there is an adequate.

Takayuki Nakagawa and MesujiSampei [7]High-speed electrical discharge machining (EDM) milling is investigated with working gap control.It is confirmed that the proposed controller achieves machining speeds that are 2–6 times faster in a straight line and greater than 30% higher in the profile machining than in the conventional one.

Torres C J Luis and Puertas [8] As is well-known, titanium diboride has a very high melting point (above 2000°C) .it is resistant to oxidation in air up to about 1000 °C. It is also resistant to most chemical reagents, and has excellent weld ability and stability in liquid metals such as aluminum and zinc. . Currently, its use is limited to specialized applications such as cutting tools, crucibles, wear-resistant parts.

III. EXPERIMENTAL WORK

3.1 INTRODUCTION

In EDM machine various factors can be changed and machining in different levels and output parameters can be calculated. In edm machine main factors is gap voltage and peak current it changed simultaneous values and machined different levels.

3.2 FABRICATION OF H12 STEEL

H12 Steels for structural uses may be classified by chemical composition, tensile properties, and method of manufacture as carbon steels, high-strength low-alloy (HSLA) steels, heat-treated carbon steels, and heat treated constructional alloy steels. A typical stress-strain curve for steel in each classification to illustrate the increasing strength levels provided by the four classifications of steel.

The availability of this wide range of specified minimum strengths, as well as other material properties, enables the designer to select an economical material that will perform the required function for each application.

Some of the most widely used steels in each classification are listed with their specified strengths in shapes and plates. These steels are weld able, but the welding materials and procedures for each steel must be in accordance with approved methods. Welding information for each of the steels is available in publications of the American Welding Society.

3.3 MACHINING PROCESS IN EDM MACHINE

Electrical Discharge Machining (EDM) is a controlled metal-removal process that is used to remove metal by means of electric spark erosion. In this process an electric spark is used as the cutting tool to cut (erode) the workpiece to produce the finished part to the desired shape. The metal-removal process is performed by applying a pulsating (ON/OFF) electrical charge of high-frequency current through the electrode to the workpiece. This removes (erodes) very tiny workpiece of metal from the workpiece at a controlled rate.

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Fig:3.1: EDM milling machine used

Fig: 3.2: EDM machine during machining of EN 31 steel

IV. RESULTS AND DISCUSSIONS

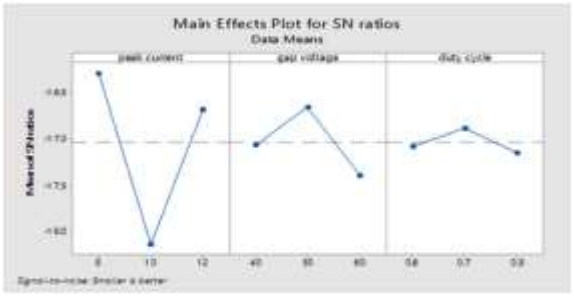

Fig. : 4.1:Main effects plot for S/N ratio for surface roughness

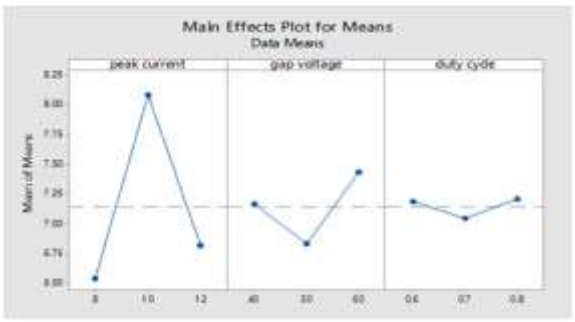

Fig. 4.2: Main effects plot for means for surface roughness

VI. CONCLUSION

1. The surface roughness and material removal rate were measured under different electrode machining conditions for machining parameters. The final conclusions arrived, at the end of this work are as follows:
2. The same experiment can performed by changing parameter i.e. by taking parameters like electrode, pulse on time, pulse off time, work piece material etc. or by taking different level of process parameter.
3. The response parameter can also be added like electrode wear rate.
4. The latest technique for optimization like fuzzy logic, Genetic algorithm, response surface methodology, artificial neural network etc. can be used for optimization.

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