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Study of Interdisciplinary Effects of Machining Parameters in EDM Process through GP

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ABSTRACT

Electric discharge machining (EDM) is an electro thermal non conventional machining process or Non-Traditional manufacturing processes. In this machining process preferred shape is obtained with the help of electrical spark which is generated with the help of electrical energy, and material is removed from the work piece by a series of rapidly frequent current discharges between two electrodes, separated by a dielectric liquid. A range of dependent & independent machining parameters play a very important role in EDM. This paper gives a brief review and analyzes various effects of machining parameters and suggested a GP model for Optimization of response parameters.

KEYWORDS: *EDM, WEDM, Goal programming*

I. INTRODUCTION

1.1 Background of EDM

EDM is a most efficient non-conventional machining process and used widely. During late 1770, it was founded by British scientist Joseph Priestly, at that time it was not in full utilize and machine is very imprecise. It comes in after 1943 with full advantage. In start of 1970's with the commercial development of wire EDM machines, a variable technique has began that helps in shaping the metal working industries[1]. Non conventional machining techniques are employed for effective machining to enhance surface finish work piece material and low tool wear. WEDM is modified form of the conventional EDM process, which uses an electrode to initialize the sparking process. WEDM utilizes a continuously traveling wire electrode made of copper, brass, tungsten or molybdenum of diameter 0.05-0.30mm.[2, 5].

The principle on which EDM works that metal has been removed from the surface of work-piece due to continuous erosion of molten metal caused by continuously spark discharge between the tool and the work piece, whereas tool and work-piece are generally connected through D.C. Power supply. Tool acts as anode which is connected positive terminal and work-piece acts as cathode is connected to negative terminal. A gap (known as 'spark gap') of range 0.005mm to 0.05mm is left between the tool and the work-piece. After reviewing literatures from many researchers those has work done on EDM process, response parameters are determined by machining parameters. Singh [4] et.al. have observed the effect of machining parameters on material removal rate in wire EDM process and as per their report, increase in material removal rate is observed for increasing pulse on time while with pulse off time it shows negative effect i.e. material removal rate decreases with increasing pulse off time. R.N. Ahmad[9] et.al. were carried out by considering the variables like pulse off time, servo voltage and wire tension on Wire EDM. They used regression analysis for results. Conclusion was found that

servo voltage has significant effect on material removal rate. Pulse off time and wire tension must be set to maximum value to get maximum material removal rate. Patil [6, 7] et. al. have worked on wire EDM with purpose of material removal rate in machining of metal matrix composites using dimensional analysis.

Sornakumar [3] et.al. have observed material removal rate increases with increase in current and decreases with increase in reinforcement percentage. K. Kumar [10] et al. had done a comparison between optimization of material removal rate (MRR) of two different materials EN41 and EN19, for this experiment they have chosen two input variables i.e. discharge current and discharge voltage. Senthilvelan.T et al.[11] taken cutting parameters for study in their work includes pulse-on time, pulse off time and wire feed rate. The measured response includes surface roughness and material removal rate. They optimize the cutting conditions of Wire-EDM for better surface roughness and material removal rate. They observed pulse on time and pulse off time are the important parameter that influences the surface roughness whereas the pulse off time has major influence on material removal rate (MRR).

Pandey et al.[12] evaluates the effect of machining parameters (pulse-on time, pulse-off time, wire speed) on the performance measure like cutting speed, kerf width and surface roughness(SR) on WEDM. They found the main significant factors that affect the Cutting speed are pulse on time. Prajapati and Patel et al.[13] had worked on the effect of pulse On-Off time, voltage, wire feed and wire tension on MRR, SR, kerf in Wire EDM. Analysis of data optimization and performance is done by Response Surface Methodology. Narender Singh [8] et.al. were used Taguchi design of experiment technique for designing the experiments and ANOVA for analyzing the results and the significant factor affecting the machining. Goal Programming often represents a substantial improvement in the modeling and analysis of multi-objective problems (Charnes and Cooper [14] and Hada et.al[15]). Application of a multi-objective programming model like goal programming model is an important tool for studying in various aspects (Hada et.al.[16-19]).

As per past research work it is clear that selection of process parameters is an important task. Best selected input parameters were help in getting better results in the optimization of output parameters. Response parameters are those which get affected by any change in input parameter values, they are considered for the optimization. for optimization purpose, there are many approaches available for the researchers i.e. Taguchi, Response surface methodology, Algorithm like ANN, ANOVA, ABC, FUZZY LOGICS etc., in the present work, we are suggested general GP model for the optimization work.

II. Important Parameters of EDM

The important parameters of EDM are as follows:

2.1Spark on-time or Pulse on-time (Ton):

It is the duration of time for which output voltage from D.C. Supply is applied per cycle. Material removal rate which is one of the response factor is directly affected by the amount of voltage applied during this time and this voltage or energy applied is controlled by two factors i.e. pulse on-time and peak current.

2.2 Spark off-time or Pulse off-time (Toff):

A small time lap between the two consecutive sparks produced by electrode is known as Spark off-time. This parameter is responsible for influencing cutting speed and cutting stability. The metal in the molten form solidifies and flushes out from the spark gap during this time, too short spark off-time, result into unstable spark.

2.3 Spark-Gap:

It is the distance between the work-piece and tool, where the spark generates and continuously revolves. It plays an important role in material removal. It is also abbreviate as Arc-gap and the work of maintaining Spark-gap is done by servo system attached to the machine.

2.4 Sparking Current (I_D):

A parameter which is directly proportional to metal removal rate and most significant in EDM is known as pulse current, because it is related to the consumption of power during machining process. It is measured in Amp current allowed per cycle, i.e. specific value up to which current increases.

2.5 Discharge Voltage (V):

The voltage applied from a D.C. Supply in an open circuit between the electrodes is known as Discharge Voltage, it is measured by Volt, the amount of discharge voltage depends on several

factors like electrode gap and dielectric fluid medium, primary work of it is to control the flow of current and helps in de-ionized of electric medium. This parameter effect Material Removal Rate (MRR) and Tool Wear Rate (TWR) to a great extent.

2.6 Duty Cycle (τ):

The percentage of on-time cycle relative to the total time cycle is known as Duty cycle.

2.7 Dielectric fluid:

A dielectric fluid is the medium where exchange of ions between different electrodes take place, it may be kerosene/water mixture or EDM oil/water mixture.

2.8 Polarity:

work piece is enriched with positive polarity and the tool has given negative polarity, generally work piece with positive polarity has less wear rate as compared with negative polarity, because of this reason that metal removes more faster in negative polarity then in positive polarity, metals such as metal carbides, titanium and copper are provided with negative polarity while they are introduced in cutting process.

2.9 Over-cut:

An overcut as the name replies, is the difference diameter of hole and the diameter of tool divided by2, the diameter of hole gets increased because the spark gap which is used to produce spark and remove material, produces more spark than that requires, this will result in removing more material than required. This is also achieved as the spark necessary for removal of material can be made to impact at comparatively smaller area.

III. Response Parameters Chosen

Response parameters are very important to pay attention during selection of parameters because all the research depends for the optimization of these parameters. The response parameters that were chosen for our work are Material Removal Rate, Tool Wear Rate and Surface Roughness.

3.1 Material Removal Rate:

The rate at which metal has been removed from the surface of the work piece. In general M.R.R. is greatly influenced by the input factor chosen. Sparking current is one of the most influencing factors other than this pulse on-time also has a great influence on metal removal rate.

3.2 Surface Roughness:

Surface roughness, As the name indicates, is the degree of roughness left behind the surface of the work piece which has been worked recently, the rough surface is been improved after machining continuously under the machine.

3.3 Tool Wear Rate:

In EDM machining process tool wear rate should be minimize. This paper helps in complete reviewing research on surface roughness and material removal rate that had been already carried out by different researchers on EDM and already published in different journals. This research review helps in finding the research gap which helps in choosing the material of work-piece, material of tool, responses for study and methodology used for optimization.

IV. Optimization

Optimization is a process of achieving optimal values of process parameters so that can help in getting quality /improved responses. In this paper we have focused on optimize the values of different combinations of process/input parameters for minimum surface roughness, tool wear rate and maximum M.R.R.

A. Goal Programming Model

With 'm' goals, the general goal programming model may be stated as:

$$\text{Minimize } z = \sum_{i=1}^{m} (w_i^- d_i^- + w_i^+ d_i^+) \quad \dots (1)$$

Subject to the goal constraints

$$\sum_{j=1}^{n} A_{ij} X_j + d_i^- - d_i^+ = b_{MRR} \quad \dots (2)$$

$$\sum_{j=1}^{n} A_{ij} X_j + d_i^- - d_i^+ = b_{SR} \quad \dots (3)$$

$$\sum_{j=1}^{n} A_{ij} X_j + d_i^- - d_i^+ = b_{TWR} \quad \dots (4)$$

Non-negativity constraint

$$X_j \geq 0,$$

$$w_i^- \geq 0, \quad w_i^+ \geq 0,$$

$d_i^- \geq 0, \quad d_i^+ \geq 0,$

Complementary constraints

$d_i^- \times d_i^+ = 0$

$i = 1,2,\ldots,m$ and $j = 1,2,\ldots,n$

The parameters w_i^- and w_i^+ represent weights to be assigned to the deviational variables d_i^- and d_i^+. These weights reflect the decision maker's preferences regarding the relative importance of each goal. These deviational variables d_i^- and d_i^+ represent underachievement and overachievement of goal respectively. Where $A_{ij}X_j$ shows process parameters with corresponding allocation if any and b_{MRR}, b_{SR}, b_{TWR} are Response Parameters.

V. Conclusion

In this paper we suggested Multi-objective programming as GP Model for optimization of multi-objective as tool wear rate, surface roughness and material removal rate in terms of process factors, this can be done by setting up the criteria i.e. Surface Roughness, Tool wear rate should minimum and MRR at maximum. The range of process parameter can chosen for the experimental work and change to different level to get different results. It can be performed on many available materials to find out which is better material to work by comparatively study. Solution of various problems can obtained through presented goal programming technique using various software packages like Microsoft Office Excel, SPSS and Tora.

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