A REVIEW-PARAMETRIC OPTIMIZATION OF WIRE CUT ELECTRO DISCHARGE MACHINING PROCESS FOR SURFACE FINISH, MRR AND KERF WIDTH FOR H-31 TOOLS STEEL

[1] DHAMAT PUNAMBEN D, [2] JITENDRA PRAJAPATI
[1]P.G. Scholar, [2]Assistance professor
M.E. Mechanical (CAD/CAM)Department,
Hasmukh Goswami College of Engineering ,Vahelal,
Ahmedabad-Gujarat

ABSTRACT

Wire electrical discharge machining (WEDM) allowed success in the production of newer materials, especially for the aerospace and medical industries. This process employed for the parts demanding higher accuracy levels with varying hardness or complex shapes. The main objectives of this study investigate and evaluate the effect of different input process parameters (pulse on time, pulse off time, servo voltage) on material removal rate, kerf width and surface roughness as response parameters have been considered for Each Experiment. Rey relational analyses are applied to determine the suitable selection of machining parameters for wire cut EDM process. A grey relational grade obtained from the grey relational analysis is used to optimize the process parameters. By analyzing the Grey relational grade we find the optimum parameters. Confirmation test has been conducted to validate the optimized parameter.

1. INTRODUCTION

EDM has achieved a status of being nearly indispensable in the industry because of its ability to machine any electrically conductive material irrespective of its mechanical strength. Despite its advantages, environmental concerns associated with the process have been a major drawback of EDM. The dielectric fluid used in EDM is the primary source of pollution from the process. Hydrocarbon based oils are the most commonly

Used EDM dielectric. Dielectric wastes generated after machining are very toxic and cannot be recycled. Also, toxic fumes are generated due to high temperature chemical breakdown of dielectric during machining. The use of oil as the dielectric fluid also makes it necessary to take extra precaution to prevent fire hazards. Since an environment friendly alternative for replacing the EDM process is not available, changing or totally eliminating the liquid dielectric medium provides a feasible solution.

De ionized water has been used as a dielectric fluid for quite some time now. However, process performance is generally found to decrease on using water as the dielectric. Replacing liquid dielectric by gases is an emerging field in the environment-friendly EDM technology. High velocity gas flow through the tool can be used to replace liquid dielectric. Such a dry EDM technology would leave behind no toxic waste material.

1.2 CONVENTIONAL MACHINING PROCESSES

Examples of conventional machining processes are turning, boring, milling, shaping, broaching, slotting, grinding etc. Conventional Machining Processes mostly remove material in the form of chips by applying forces on the work material with a wedge shaped cutting tool that is harder than the work material under machining condition. Such forces induce plastic deformation within the work piece leading to shear deformation along the shear plane and chip formation

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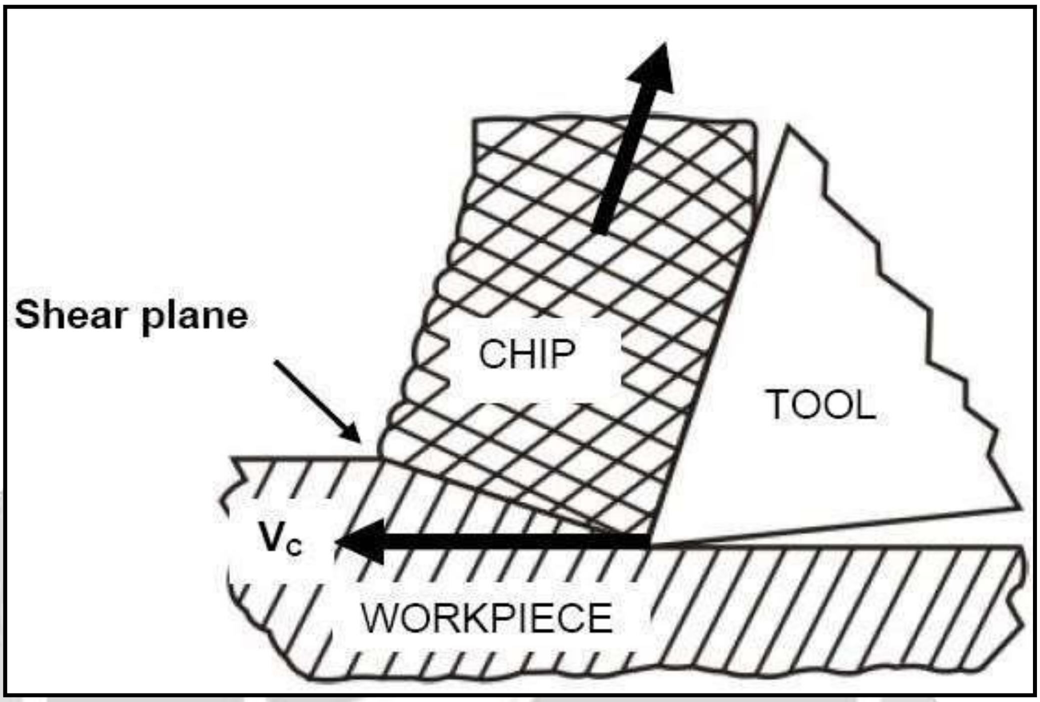


Fig. 1.1: Mechanism of Material Removal

Thus the major characteristics of conventional machining are: Generally macroscopic chip formation by shear deformation Material removal takes place due to application of cutting forces – energy domain can be classified as mechanical. Cutting tool is harder than work piece at room temperature as well as under machining conditions.

1.3 NON TRADITIONAL MACHINING PROCESSES

Abrasive Jet Machining (AJM), Ultrasonic Machining (USM), Water Jet and Abrasive Water Jet Machining (WJM and AWJM), Electro-discharge Machining (EDM) are some of the Non Traditional Machining (NTM) Processes. To classify Non Traditional Machining Processes (NTM), one needs to understand and analyze the differences and similar characteristics between conventional machining processes and NTM processes.

Non Traditional Machining (NTM) Processes on the other hand are characterized as follows:

- Material removal may occur with chip formation or even no chip formation may take place. For example in AJM, chips are of microscopic size and in case of Electrochemical machining material removal occurs due to electrochemical dissolution at atomic level.

- In NTM, there may not be a physical tool present. For example in laser jet machining, machining is carried out by laser beam. However in Electrochemical Machining there is a physical tool that is very much required for machining.

- In NTM, the tool need not be harder than the work piece material. For example, in EDM, copper is used as the tool material to machine hardened steels.

- Mostly NTM processes do not necessarily use mechanical energy to provide material removal. They use different energy domains to provide machining. For example, in USM, AJM, WJM mechanical energy is used to machine material, whereas in ECM electrochemical dissolution constitutes material removal.

2. LITTERATURE REVIEW

Literature review is one of the scope studies. It works as guide to run this analysis. It will give part in order to get the information about Wire electrical discharge machine (Wire EDM) and will gives idea to operate the test. From the early stage of the project, various literature studies have been done. Research journals, books, printed or online conference article were the main source in the project guides. This part will include almost operation including the test, history, machining properties and results. Literature review section work as reference, to give information and guide base on journal and other source in the media.

2.1RESEACH PAPER

Title :- "MULTI-OBJECTIVE OPTIMIZATION OF PARAMETERS DURING EDM OF ALUMINIUM ALLOY 6082 USING GREY RELATIONAL ANALYSIS"
Author :- V.Vikram Reddy, M.Jawahar [2]
Work :-

We have variation "MULTI-OBJECTIVE OPTIMIZATION OF PARAMETERS DURING EDM OF ALUMINIUM ALLOY 6082 USING GREY RELATIONAL ANALYSIS." In this work, an optional combination of process parameters such as peak current, pulse on time and pulse off time was obtained during Electrical Discharge Machining (EDM) of Aluminum Alloy AA6082 with electrolyte copper as the too electrode using multi-response optimization Gray Relational Analysis (GRA) method. The performance characteristics namely material removal rates (MRR), tool wear rate (TWR) and surface roughness (SR) selected for this study. Experiments are designed based on Taguchi method with L9 orthogonal array. Using Gray Relational Analysis a gray relational grade (GRG) was calculated. Further this gray relational gray is used to obtain optimal combination of the EDM process parameters considering multiple performance characteristics. Performance characteristics (MRR, TWR, SR) were estimated/predicated at optimal combination of process parameters using Taguchi based GRA. To validate these predicate values confirmation experiments were conducted at optimal parametric setting. It was noticed that the predicted values of selected performance characteristics at optimal combination of parameters are in good agreement with the experimental results. It was also observed that considerable improvement in machining performance using this approach.

Title :- "OPTIMIZATION OF MULTIPLE RESPONSE CHARACTERISTICS ON EDM USING THE TAGUCHI METHOD AND GREY RELATIONAL ANALYSIS"
Author :- Dr.V.Chittaranjan Das, Dr.C.Srinivas [3]
Work :-

We have variation "OPTIMIZATION OF MULTIPLE RESPONSE CHARACTERISTICS ON EDM USING THE TAGUCHI METHOD AND GREY RELATIONAL ANALYSIS." In this work, a new approach for the optimization of the electrical discharge machining (EDM) process with multiple performance characteristics based on the orthogonal array with the grey relational analysis has been studied on Ti–6Al–4V alloy. A grey relational grade obtained from the grey relational analysis is used to solve the EDM process with the multiple performance characteristics. Optimal machining parameters can then be determined by the grey relational grade as the performance index. In this study, the machining parameters using discharge current, gap voltage, pulse-on time and duty cycle as typical process parameters are optimized with considerations of multiple performance characteristics including material removal rate, electrode wear rate and surface roughness. The optimized process parameters simultaneously leading to a lower electrode wear ratio, higher material removal rate and better surface roughness are then verified through a confirmation experiment. Analysis of variance was used to study the significance of process variables on grey relational grade which showed discharge current, duty cycle, pulse-on time and gap voltage have been found to be the order of significant parameters. Confirmation experiment has been carried out at optimum set of parameters and predicted results have been found to be in good agreement with experimental findings. Experimental results have shown that machining performance in the EDM process can be improved effectively through this approach.

Title :- "EXPERIMENTAL STUDY OF SURFACE ROUGHNESS IN ELECTRIC DISCHARGE MACHINING (EDM) BASED ON GREY RELATIONAL ANALYSIS"
Author :- Ashanira Mat Deris1, Azlan Mohd Zain1, Roselina Sallehuddin, and Safian Sharif [4]
Work :-

We have variation "EXPERIMENTAL STUDY OF SURFACE ROUGHNESS IN ELECTRIC DISCHARGE MACHINING (EDM) BASED ON GREY RELATIONAL ANALYSIS." In this work, Electric Discharge Machining (EDM) is one of the modern machining which is capable in handling hard and difficult-to-machine material. The successful of EDM basically depends on its performances such as surface roughness (Ra), material removal rate (MRR), electrode wear rate (EWR) and dimensional accuracy (DA). Ra is considered as the most important performance due to it role as a technological quality measurement for a product and also a factor that significantly affects the manufacturing process. This paper presents the experimental study of surface roughness in die sinking EDM using stainless steel SS316L with copper impregnated graphite electrode. The machining experimental is conducted based on the two levels full factorial design of design of experiment (DOE) with five machining parameters which are peak current, servo voltage, servo speed, pulse on time and pulse off time. The results were analyzed using grey relational analysis (GRA) and it was found that pulse on time and servo voltage give the most influence to the Ra value.

Title :- "OPTIMIZATION OF MACHINING PARAMETERS IN ELECTRICAL DISCHARGE MACHINING OF 304 STAINLESS STEEL."
Author :- Rajmohan t., prabhu r.,subbarao g., palanikumar k., [5]
Work :-
We have variation **"OPTIMIZATION OF MACHINING PARAMETERS IN ELECTRICAL DISCHARGE MACHINING OF 304 STAINLESS STEEL."** in this work
optimization of machining parameters in electrical discharge machining of 304 stainless steel. Author experimented that the effect of electrical discharge machining parameter such as pulse on time, pulse off time, voltage and current on material removal rate in 304 stainless steel was studied. The experiment was carried out as per design of experiments approach using L9 orthogonal array. The results were analyzed using analysis of variance and response graphs. From this study, it is found that different combination of EDM process parameters is required to achieve higher MRR for 304 stainless steel. Signal to noise ratio and analysis of variance is used to analyze the effect of parameters towards the MRR is also identified.

Author concluded that, the current and pulse OFF time are most significant machining parameter for MRR in EDM of 304 stainless steel. For higher material removal rate, the recommended parametric combination is pulse on time at level 1, pulse off time at level 2, voltage at level 2 and current at level 2.for EDM of 304 stainless steel. Based on minimum number of trails conducted to arrive at the optimum cutting parameters, Taguchi method seems to be an efficient methodology to find the optimum cutting parameters.

Title :- "INVESTIGATION AND OPTIMIZATION OF SURFACE ROUGHNESS FOR WIRE CUT ELECTRO DISCHARGE MACHINING OF SS 304L USING TAGUCHI DYNAMIC EXPERIMENTS"

Author :- Vishal Parashar, A. Rehman, J.L. Bhagoria, Y.M. Puri,, [6]

Work :-

We have variation **"INVESTIGATION AND OPTIMIZATION OF SURFACE ROUGHNESS FOR WIRE CUT ELECTRO DISCHARGE MACHINING OF SS 304L USING TAGUCHI DYNAMIC EXPERIMENTS"** in this work have studied Investigation and Optimization of Surface Roughness for Wire Cut Electro Discharge Machining of SS 304L using Taguchi Dynamic Experiments. Optimization of surface roughness using Taguchi's dynamic design of experiments is proposed for WEDM operations. Experimentation was planned as per Taguchi's L'32 mixed orthogonal array. Each experiment has been performed under different cutting conditions of gap voltage, pulse ON time, pulse OFF time, wire feed and dielectric flushing pressure. Stainless Steel grade 304L was selected as a work material to conduct the experiments. From experimental results, the surface roughness was determined for each machining performance criteria. Signal to noise ratio was applied to measure the performance characteristics deviating from the actual value. Finally, experimental confirmation was carried out to identify the effectiveness of this proposed method.

The authors conclude that, the S/N ratio with Taguchi's parameter design is a simple, systematic, reliable and efficient tool for optimizing the performance characteristics of WEDM process parameters. The effect of various machining parameters such as gap voltage, pulse on time, pulse off time, wire feed speed and flushing pressure were studied while machining of SS 304L. Pulse On time is the most influencing machining parameter for surface roughness. The gap voltage, pulse Off time and flushing pressure as the little effect on surface roughness. The wire feed has the lowest effect on the surface roughness. For smooth cutting and better surface finish, the recommended parametric combination is A1C1D4E2F3. The confirmation test indicates that it is possible to decrease the surface roughness by using the proposed Taguchi methodology. The surface roughness is decreased by 2.15times.

6.MULTI RESPONSE OPTIMIZATION

6.1 Grey relational analysis for multi objective optimization

In grey relational analysis, the function of factors is neglected in situations where the range of the sequence is large or the standard value is enormous .However, this analysis might produce incorrect results if the factors ,goal and directions are different .therefore one has to preprocess the data which are related to a group of sequence ,which is called “grey relational generation “data pre-processing is a process of transferring the original sequence to a comparable sequence for this purpose the experimental result are normalized in the range between zero and one the normalization can be done from three different approaches.

Table No: 6.1 Quality characteristics of the machining performance

Sr. No	Machine Characteristic	Quality Characteristic
1	MRR (Material Removal Rate)	Maximum
2	SR (Surface Roughness)	Minimum
3	KW (Kerf Width)	Minimum

6.4 Process steps for multi response optimization

The basic process steps for multi-response optimization are given below.

(a) Normalization of experimental results for all performance characteristics.

(b) Calculation of deviation sequence

(c) Calculation of grey relational coefficient (GRC).

(d) Calculation of grey relational grade (GRG) using weighing factor for performance characteristics.

(e) Analysis of experimental results using GRG.

(f) Selection of optimal levels of process parameters.

(g) Conducting confirmation experiment to verify optimal process parameter settings.

6.6 Calculation of deviation sequence

In this work, to find out grey relation coefficient, one has to calculate deviation sequence using equation (6.4) shown in table 6.3.The deviation sequences Δoi, Δmax (k), and Δmin (k) for i=1-27 and k=1-3 can be calculated as follows:

$$\Delta 01\ (1) = |x0\ (1) - x1(1)| = |1.0000 - 0.5041| = 0.4959$$

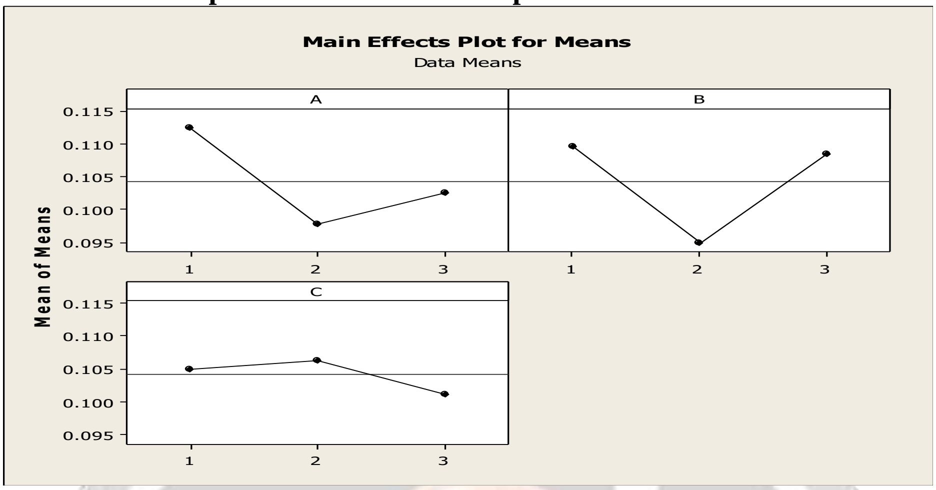
$$\Delta 01\ (2) = |x0\ (2) - x1(2)| = |1.0000 - 0.9539| = 0.0461$$

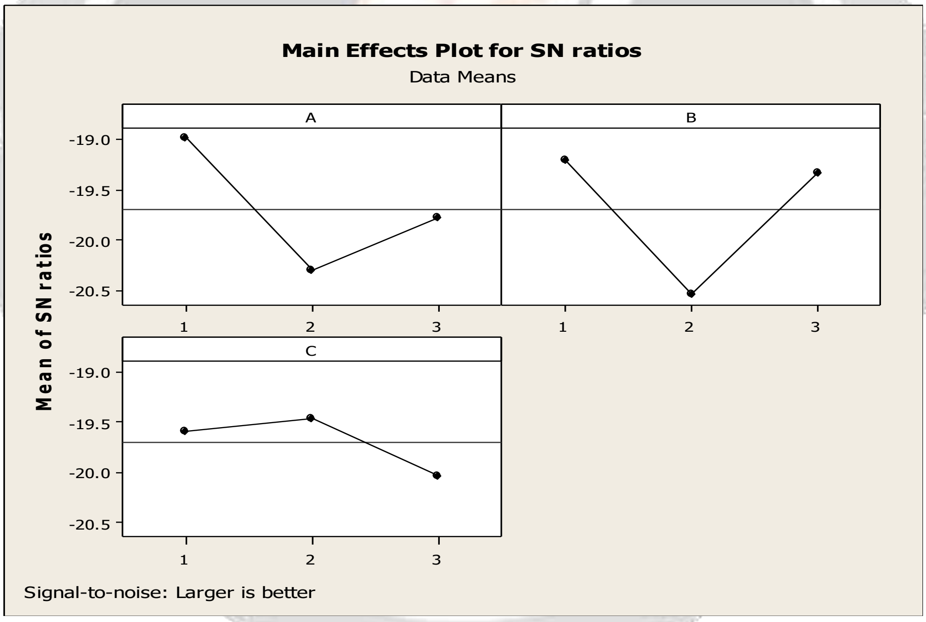
$$\Delta 01\ (3) = |x0\ (3) - x1(3)| = |1.0000 - 0.1276| = 0.8724$$

7 RESULTS AND DISCUSSION

After performing the experiment for all 9 runs and measuring the output parameters like material removal rate, surface roughness and kerf width for wire cut EDM of H-31 is discussed.

7.1 Main Effect Plots for Input Parameters V/S Output Parameters





TON	TOFF	SV	MRR	KW	SR
5	30	20	0.1116	0.324	1.085
5	35	25	0.1060	0.302	1.257
5	40	30	0.1198	0.291	1.243
10	30	25	0.1114	0.293	1.434
10	35	30	0.0780	0.294	1.554
10	40	30	0.1032	0.304	1.856
15	30	30	0.1017	0.305	1.812
15	35	20	0.1000	0.303	1.917
15	40	25	0.1018	0.302	1.654

7.2 Regression Analysis

In statistical modeling, regression analysis is a statistical process for estimating the relationships among variables. It includes many techniques for modeling and analyzing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables (or 'predictors'). More specifically, regression analysis helps one understand how the typical value of the dependent variable (or 'criterion variable') changes when any one of the independent variables is varied, while the other independent variables are held fixed. Most commonly, regression analysis estimates the conditional expectation of the dependent variable given the independent variables – that is, the average value of the dependent variable when the independent variables are fixed. Less commonly, the focus is on a quantile, or other location parameter of the conditional distribution of the dependent variable given the independent variables. In all cases, the estimation target is a function of the independent variables called the regression function. In regression analysis, it is also of interest to characterize the variation of the dependent variable around the regression function which can be described by a probability distribution. A related but distinct approach is necessary condition analysis[1] (NCA), which estimates the maximum (rather than average) value of the dependent variable for a given value of the independent variable (ceiling line rather than central line) in order to identify what value of the independent variable is necessary but not sufficient for a given value of the dependent variable.

Regression analysis is widely used for prediction and forecasting, where its use has substantial overlap with the field of machine learning. Regression analysis is also used to understand which among the independent variables are related to the dependent variable, and to explore the forms of these relationships. In restricted circumstances, regression analysis can be used to infer causal relationships between the independent and dependent variables. However this can lead to illusions or false relationships, so caution is advisable; or example, correlation does not imply causation.

In a narrower sense, regression may refer specifically to the estimation of continuous response variables, as opposed to the discrete response variables used in classification. The case of a continuous output variable may be more specifically referred to as metric regression to distinguish it from related problems.

8. CONCLUSIONS

In the presented work, experiments are carried out for material removal rate, surface roughness and kerf width with variables as pulse on time, pulse off time and servo voltage. there are 9 experimental readings taken for all variables to conduct the parametric study. Finally it can be concluded that :

- Grey relational analysis is done to find out optimal parameter levels. After grey relational analysis, it is found that pulse on time at level 3 (130 µs), pulse off time at level 3 (60 µs), servo voltage at level 2 (30volts) are the best process parameter for the MRR, Kerf width and Surface roughness.
- Process parameters do not have some little effect for every response. Significant parameters and its percentage contribution changes as per the behaviour of the parameter with objective response.
- Increase of Pulse on time generates more spark energy as the length of time that electricity supply increases. MRR, Kerf width and SR all response increasing with pulse on time. Pulse on time found most significant parameter in all response. Surface roughness also increases with increase of pulse on time because the increases of pulse on time produce crater with broader and deeper characteristic.
- Pulse off time has opposite effect to pulse on time. MRR decrease with increase of pulse off time, while surface roughness reduces. During off time removed material flushed away. More the off time better the flushing.
- Servo voltage has little effect on SR and kerf width but it has more effect over MRR. Surface roughness reduces with increase of servo voltage.

9.REFERANCES

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