Predict the Surface Finish by using Fuzzy Logic Techniques in ECM Processes

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Abstract: Electrochemical machining (ECM) is one of the best alternatives for producing complex shapes in advanced materials used in aircraft and aerospace industries. Notwithstanding, the decrease of the stray material removal continues to be a major challenge for industries in addressing accuracy and improvement. This experiment highlights features of the development of a comprehensive mathematical model for correlating the interactive and higher-order influences of various machining parameters on the dominant machining criteria, i.e. the surface roughness (SR). This experiment also highlights the various test results that also confirm the validity and creativeness of the developed mathematical models for analyzing the effects of various process parameters on SR. The value of SR is predicted by fuzzy logic techniques. If two suitable metal poles are placed in a conducting electrolyte and a direct current passed through them, the metal on the positive shaft get exhausted and its material is deposited on the negative post. Keeping this in view, the present work has been undertaken to finding the material removal rate by electrochemical dissolution of an anodically polarized work piece with a cylindrical copper electrode. In the experiment, Mild steel is utilized as example. Tests were completed to study the influence of machining parameters such as feed rate, applied voltage and conductivity on the SR. The results of experiment show the increase in the feed and concentration the SR value is also increase.

Key Words: Full Factorial Design; Electrochemical machining (ECM); Surface Roughness; Fuzzy Logic.

1. INTRODUCTION

Electrochemical Machining (ECM) is a non-traditional machining (NTM) process belonging to electrochemical classification. ECM is inverse of electrochemical or galvanic coating or testimony process. Hence ECM can be thought about a controlled anodic dissolution at atomic level of the work piece that is electrically conductive by a shaped tool due to flow of high current at relatively low potential difference through an electrolyte which is quite often water based neutral salt solution [1-5]. The electrochemical machining is using only for hard material like as tool steel and other type of material [6] The objective of present works an attempt to finding out surface roughness and also predicts this value in electrochemical machining. The surface roughness prediction applied advance techniques that are fuzzy logic techniques. In these techniques predicted surface roughness value is easy for other techniques.

Experimental details

The present experimental investigation deals with the analysis of the experiment by the Full Factorial methodology. . Based on the main effects plots obtained through Full Factorial design, a total of 8 tests were carried out ,optimum level for SR were chosen from the two levels of cutting parameters considered. The range of each parameter is set at two different levels, namely low and high. Mathematical models were deduced by software design Expert in order to express the influence degree of the main cutting variables such as voltage; feed rate and consternation of solution with combination of different cutting parameters were randomly repeated. The machining parameters and their levels are shown in table.

Table 1 Machining parameters and their levels

Control Parameter				
Parameter	Symbol	Levels		Unit
		Low	High	
Voltage	V	5	11	Volt
Feed	F	0.2	0.6	RPM
Concentration	C	20	40	mm

1.2 FUZZY LOGIC SYSTEM

Fuzzy logic is a mathematical theory of inexact reasoning that allows modelling of the reasoning process of human in linguistic terms. Fuzzy logic system (in this study, Mamdani system considered) as shown in Fig. 4.6, comprises a fuzzifier, participation works, a fluffy principle base, a derivation motor, and defuzzifier. The fuzzifier utilizes participation functions to fuzzify signal –to-noise ratios of each performance characteristic [7]. Next, the inference engine (Mamdani fuzzy inference system) performs fuzzy reasoning on fuzzy rules to generate a fuzzy value. At long last, the defuzzifier converts fuzzy predicted value into an output response which can be used to find the better accuracy of output of the SR in ECM using full factorial design.

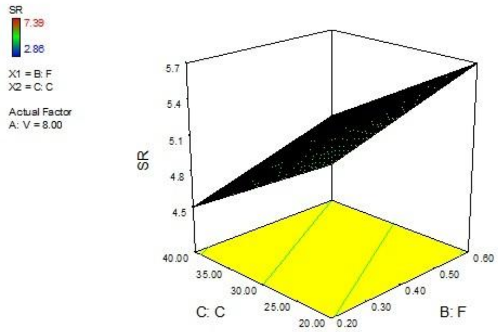
The machinability of a material in ECM depends on many factors as voltage, feed rate, design & diameter of tool, concentration, electrolyte flow rate and many more.in my case of study voltage, tool feed rate and concentration are input factors and others are kept constant. The full factorial experiment design and their value of SR are shown in Table 2.

Table 2 Surface roughness prediction by factorial design of experiments in ECM processes

Run	Block	Voltage	feed	Conc.	SR
1	Block 1	11.00	0.60	20.00	5.46
2	Block 1	11.00	0.60	40.00	7.39
3	Block 1	5.00	0.20	40.00	4.79
4	Block 1	5.00	0.20	20.00	6.46
5	Block 1	5.00	0.60	40.00	3.79
6	Block 1	5.00	0.60	20.00	4.59
7	Block 1	11.00	0.20	40.00	2.86
8	Block 1	11.00	0.20	20.00	5.46

3. INFLUENCE OF SURFACE ROUGHNESS (RESULTS)

The effect of these parameters on SR (Surface plots) are shown in Fig. Surface roughness value of mild steel increases with increase in voltage from 5V to 11V. Surface roughness increases with increase in slightly with feed rate from 0.2mm/min to 0.4mm/min and then decreases with increase in value of feed rate from 0.4-0.6mm/min. In case of concentration surface roughness decreases with increase in value of concentration from 22.03-30.06g/l and then increases with increase in concentration from 30.06-35g/l.so most effective factor looks to be tool feed rate and then concentration.



Surface plot for SR Vs feed and cons.

Graph 1

The analysis of variance of Surface roughness is described in Table. According to this table the concentration of solution is most important factor of surface roughness then feed and voltage. In same table give the information about the % contribution of all input parameters. In the ANOVA (Analysis of variance) is give the information about which factor is most important and how many presentence effect the response. The experiment using full factorial design the regration equation can also be found out for this experiment. Equation 1 is shown the SR value prediction for any type of experiment settings. For further predicted the experimental value can be using fuzzy logic toolbar using Matlab-13 software

Table 3

Analysis of Variance of Surface roughness

Sources	Sum of square	DF	Mean Square	F Value	% Contribution
Model	8.72	4	2.18	1.14	60.39
A-V	0.30	1	0.30	0.16	2.08
B-F	0.34	1	0.34	0.18	2.35
C-C	1.23	1	1.23	0.65	8.52
AB	6.85	1	6.85	3.59	47.44
Residual	5.72	3	1.91		39.61
Cor Total	14.44	7			

$$S = +10.28250 - 0.55250 * V - 11.29583 * F - 0.039250 * C + 1.54167 * V * F \quad (1)$$

4. PREDICTED THE SR USING FUZZY LOGIC

The effect of the machining parameters (V, F and C) on the response SR have been evaluated by conducting experiments as design expert and MATLAB R2013a are used for further analysis. The second-order model was proposed to find the correlation between the SR and the process variables taken into account. The analysis of variance (ANOVA) was used to check the sufficiency of the second order model. Prediction of the responses using

Fuzzy decision making logic is compared with the results obtained from the experiments. Average percentage error is 7.33percent calculated as the difference between the observed and predicted value. In the present study, Voltage (x_1), Feed (x_2) and Consecration (x_3) is taken as input and SR(Y) as output of Fuzzy logic approach. Fig. 5 are showing the graphical representation of input and output fuzzy logic and membership functions respectively. Three fuzzy subsets [x_1,x_2,x_3 = Small, Medium ,Large] are assigned in three input membership functions and five subsets [Y = Very Small, Small, Medium, Large, Very Large] are assigned to one output membership function.

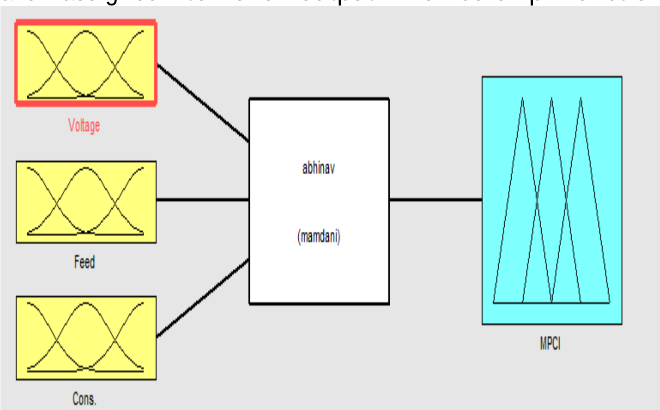


Fig. 1 Input output fuzzy logic system

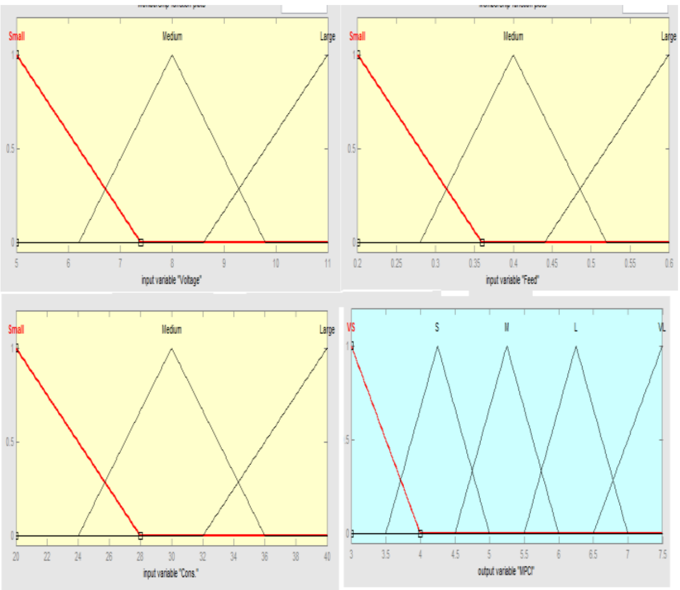


Fig. 2 Membership function of input and output

The relationship between three inputs, x_1, x_2 and x_3 and one output Y where represented in the form of if-then control rules that is:

Rule 1: if x_1 is A_1, x_2 is B_1 and x_3 is C_1 then Y is D_1 else

Rule 2 : if x_1 is A_2, X_2 is B_2 and x_3 is C_2 then Y is D_2 else……

Rule 20 : if x_1 is A_{20}, X_2 is B_{20} and x_3 is C_{20} then Y is D_{20}.

The fuzzy rules are also described in Fig 5.5. A_1, B_1, C_1 and D_1 to A_{20}, B_{20}, C_{20} and D_{20} are subset define by the corresponding membership functions, i.e. μ_{A1}, μ_{B1}, μ_{C1} and μ_{D1}. Eight fuzzy rules are directly derived based on the fact that the larger the better characteristic. By attaching greatest least compositional operation, the fuzzy thinking of these guidelines yields a fuzzy output.Finally, a defuzzification method, is embraced to change the fuzzy inference output μ_D (Y) into a non-fuzzy value Y0, which is known as the crisp output values .That is shown in equation 2.

$$Yo = \frac{\Sigma Y \mu D(Y)}{\Sigma \mu D\ (Y)}$$

(2)

Based on the above discussion during the process of ECM, the influence of various machining parameter like V, F and C has significant effect on SR.

5. CONCLUSIONS

In the present work, fuzzy logic in integration with full factorial design has been used to obtain better SR through selection of optimal parameters settings. Experimental results are provided for prediction of the performance characteristics through fuzzy logic approach. The predicted values show an average error of less than 7.33 percent. The second-order response models have been validated with analysis of variance. It has been found that all the three machining parameters have significant effect on SR.

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