Modelling and prediction of machining parameters in composite manufacturing using artificial neural network

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Abstract—This paper presents a consistent way to deal with optimize Wire EDM response parameters for the aluminum metal matrix composites utilizing Artificial Neural Network strategies. Wire cut discharge machining is a progressed machining strategy controlled by an outsized scope of assortment of interrelated complex parameters like discharge current, pulse on time, pulse off time and servo speed rate. Any slight variations in one will have an exertion on the machining execution measures like surface roughness and material removal rate. In the present work aluminum 7075 is utilized as matrix and activated carbon as reinforcement metal matrix composites. 27 trails of investigations considering response surface procedure are done and the perceptions are made. ANN has been produced based on back propagation for expectation of the numerous reactions. The ANN was consequently prepared with test information. Testing of the ANN is done utilizing exploratory information not utilized amid preparing. The outcomes demonstrate that the results of the ANN are in great concurrence with the trial information; this shows the created neural system can be utilized as an option path for figuring response parameters for given process parameters.

Keywords—Response surface Methodology, Artificial neural network, Metal matrix composites

1. Introduction

Now a days unconventional machining distinguished to be a committed deep machining system capable of correctly machining states of hard materials like Al7075, Mg ZE42 and so forth concerning site applications, composites at present have an attempted cost of achievement as flourishing building materials in light material goods comparable great superiority to-bulk numerical connection, practical attire protection, and skill of effective nearly heat [1]. Reaction system is a combination of numerical and connected sums procedures for experimental perfect structure. This responsive of analyses, the goal is to advance a reaction of yield flexible that is impacted by various independent factors of info factors relate investigation can be a progression of tests in this progressions unit of estimation shaped among the information factors subsequently on recognize the clarifications for varieties among the yield reaction [2]. On use of antiquated machining procedures to machine challenging composite materials causes genuine apparatus wear inferable from rough nature of fortifying particles shortening device life [3]. However, non-conventional machining procedures like water stream machining and bar machining may likewise be used yet the machining instrumentality expensive, tallness of the work piece could likewise be an imperative, and surface end got isn't sensible [4], in accordance with azlan et al. all through WEDM is right and sparing machining activity though not trading off machining execution is practical [5]. Yousef et al. found the solidified steel with three-sided and sq. devices in
shifted cutting situations and designed the exterior obnoxiousness figurine creator has eased exploratory outcomes of exterior harshness and wounding powers by factual methodology the ramifications of examination exploitation material [6]. Perception and compelling of exertion distributed on consolidated method of neural system and surface methodology demonstrating of input constraints on the execution of whereas machining of activated carbon and Al MMCs. Material removal rate (MRR) and Surface Roughness (SR) are considered here as WEDM inputs concentrated trial effort is then alluring to examination and upgrades the methodology limits to appreciate their effect on nature of the item. Response surface procedure is a blasting system, which helps in closure the investigation of examinations with the most diminutive amount trial control [7]. ANN approach is a fair instrument to conjecture process parameters; it will deliver the yields for an accumulation of data sources that zone unit inside changes of the underlying information sources everywhere throughout the preparation part [8]. The current examination purposes to effort the machining velocity prescient replicas upheld RSM and ANN all through WEDM of PAC/7075 Al MMC. The models of normal machining parameters were produced with the release current (I_A), pulse on time (T_ON), pulse off time (T_OFF) and servo speed (rpm) as the WEDM strategy constraints. The yield data required information to build up each RSM and ANN model investigations.

2. Materials and Methods
Different level used R_{27} examinations have been concentrating in this component according to the BBD plan. This experimentation has been appeared by three manageable four level components and 3 levels. It represents four controllable elements with three levels for every feature. The slicing constraints are agreed to the pre-characterized stages for each test. Aluminium reinforced activated carbonized composites was used in this research. The cutting machine ordinarily comprises of a cut method, a power supply part and blooming unit. In process the wire goes over the material from complex and brings down cable controllers [8]. A metal transmitter has been used in EDM technique the as a result of the device and material part.

3. Response surface methodology for predict machining parameters
Model the experiment inputs are designed by RSM system is that the technique for factor the relationship among various approach constraints through many machining standards and investigating the consequences of these technique constraints on the attached reactions. In the direction of form the effect of WEDM strategy limitations of Al MMC on machining constraints a scientific perfect reaction condition was developed is adjusted keen on the in order condition [9]. Also the WEDM strategy has been learnt in accordance with the experiment design on behalf of four elements are specified in Table. All through this examination 27 trials were directed to predict the responses [10]. In his investigation developed table represents class of the examinations strengthened the rough exteriors and analysis outcomes of the surface of the material. The steadfast information after the arrangement of trials remained used on the grounds that the contributions to mentor the neural network predictive responses.

Table 1. Input process parameters and their levels

| Parameters       | symbol | Level 1 | Level 2 | Level 3 | Units |
|------------------|--------|---------|---------|---------|-------|
| Discharge current| I_A    | 1500    | 1750    | 2000    | mA    |
| Pulse on time    | T_ON   | 5       | 10      | 15      | µs    |
| Pulse off time   | T_OFF  | 25      | 50      | 75      | µs    |
| Servo speed      | SS     | 50      | 100     | 150     | RPM   |

3.1. RSM based predictive models
WEDM technique parameters of Al7075/PAC MMC are built up and response parameters and are featured inside the accompanying reaction condition. In this analysis A is Discharge Current (I_A), B is
pulse on time (μs), C is Pulse off time (μs) and D is Servo speed (RPM). Table 3 demonstrates the investigational beliefs for reaction outline for the 27 test orders.

3.2. Investigation of input parameters on experimental responses

According to the design of experiments the shared effect of process method constraints on machining reactions are examined on the principle of numerical typical appearance found during experimentation standards and Box Behnken design [11]. From Fig. 1(a) demonstrates that the MRR is high as the servo speed increases i.e., when T_{off} is 100μs the servo speed 100rpm. Fig. 1(b) shows the variation graphs of machining parameters on MRR. It is concluded that the major parameters influencing maximum MRR are pulse on time, servo speed and current and the minor influencing parameters is the pulse off time [12]. Similarly Fig. 1(c) SR is low when the servo speed is 150rpm and the T_{on} is 75μs. The experimental data continues to increase surface roughness decreases because the on time and off time increases. But roughness of material is low once on time and discharge current is increases.

| Exp No | I_A | T_{on} | T_{off} | SS | MRR (mm³/min) | SR (μm) |
|--------|-----|--------|---------|----|---------------|---------|
| 1      | 1750| 5      | 50      | 150| 9.54          | 3.37    |
| 2      | 1750| 10     | 75      | 50 | 6.84          | 4.03    |
| 3      | 1500| 10     | 75      | 100| 8.2           | 3.79    |
| 4      | 2000| 10     | 50      | 150| 7.99          | 3.43    |
| 5      | 1750| 10     | 50      | 100| 8.82          | 3.69    |
| 6      | 1750| 10     | 50      | 100| 8.82          | 3.69    |
| 7      | 1750| 10     | 25      | 150| 10.8          | 3.54    |
| 8      | 1500| 10     | 50      | 150| 10.26         | 3.71    |
| 9      | 1500| 15     | 50      | 100| 8.45          | 3.83    |
| 10     | 1750| 5      | 75      | 100| 7.56          | 3.32    |
| 11     | 2000| 15     | 75      | 100| 9.66          | 3.72    |
| 12     | 2000| 5      | 75      | 150| 9.6           | 3.3     |
| 13     | 1750| 15     | 75      | 50 | 8.14          | 4.01    |
| 14     | 1750| 10     | 25      | 100| 9.36          | 3.71    |
| 15     | 1750| 15     | 75      | 50 | 7.62          | 3.11    |
| 16     | 1750| 15     | 50      | 150| 11.1          | 3.71    |
| 17     | 1750| 10     | 75      | 100| 8.34          | 3.63    |
| 18     | 2000| 10     | 25      | 50 | 8.04          | 3.68    |
| 19     | 1750| 5      | 50      | 100| 8.04          | 3.47    |
| 20     | 1750| 5      | 25      | 100| 8.58          | 3.43    |
| 21     | 1750| 15     | 25      | 100| 11.62         | 3.66    |
| 22     | 2000| 10     | 50      | 100| 7.98          | 3.53    |
| 23     | 1500| 15     | 50      | 100| 9.57          | 4.01    |
| 24     | 1500| 10     | 25      | 100| 9.31          | 3.47    |
| 25     | 1500| 10     | 50      | 50 | 6.98          | 4.05    |
| 26     | 1750| 10     | 50      | 100| 8.82          | 3.89    |
| 27     | 2000| 10     | 75      | 100| 8.64          | 3.57    |
Figure 1(a). Average response of SR versus Discharge current and servo speed of MMC

Figure 1(b). Average response of MRR versus pulse off time and servo speed of MMC

Figure 1(c). Average response of MRR versus servo speed and pulse on time of MMC

3.3. Prediction of machining response values using ANN model

Artificial Neural Network design contains some input layer, single or extra of hidden layers and output layer. Not only the output but also the hidden layers have handling elements called synapses and neurons similarly. ANN application in WEDM especially for modeling the performance measures,
monitoring the production process and optimization of parameters. Confirm the neurons number for the output and input layer. The neurons number equals the number of input variables. The training of the ANN for twenty-seven in-out structure has been done out abuse the context available in MATLAB code [13]. BP algorithm and Logsig transfer function is used in this model. 70% of pattern used to train the ANN data, 15% of pattern used to test ANN data and 15% of pattern used to validation [14]. 1000 number of epochs are used. The predicted output values through ANN testing data are presented in the in Table 5.1 for AA7075-PAC metal matrix composite.

3.4. Training and testing the data

Two phases analysis is performed. In the opening it's tried with seen controlled document groups. Inside the portion, the system is knowledgeable about concealed trained record sets.

3.4.1. ANN based results

Contrived neural system display was countered on R27 examination data hubs as portrayed in on high of area. ANN expected esteem for the reaction information for the twenty-seven-instructing set is shown in Figure 2.

4. Evaluation of the RSM and ANN models

ANN model of MRR and SR prophetic models in this manner progressed were looked at on the idea of their expectation data set with the response surface. In the meantime the ANN preparing utilizing LM preparing calculation the mean square error diminished from 0.005 to 0.000005. The LM display has made outright part of change ($R^2$) values in regards to one for the instructing learning, 0.9725 for approval [15] as observed from Figure 2(b).

![Figure 2(a). Post training the ANN, Figure 2(b). Post Validation of ANN](image)

Fig. 3(a) represents the correlation of inaccuracy outline for material cut rate, for the 27 trial data conventional of the effort designs the most extreme total extent blunder classified the ANN expectation of composite cut rate was observed to be about of 4.85%, while for the RSM demonstrate, it completely was about 8.24% so it is everywhere on that the ANN indicators expanded exactly than the reaction value. So this assessment correlation is appeared in Fig. 3(b). It is determined after this assumes the forecast of exterior wear with ANN and RSM esteems from each model nearly consider that of trial results.
ANN Prediction
RSM prediction
Output Range
Exp MRR (mm³/min)

**Figure 3(a).** Assessment of error for Material Removal Rate

3.0 3.2 3.4 3.6 3.8 4.0 4.2
3.0
3.2
3.4
3.6
3.8
4.0
4.2
4.4
ANN Prediction
RSM prediction
Output Range
Exp MRR (mm³/min)

**Figure 3(b).** Assessment of error for Surface Roughness

4.1. Fuzzy logic
The fundamental premise in the theory of Fuzzy logic is that there are inaccuracies in attribute and within the geometry of spatial information. Fuzzy common value presents procedures to address both types of inaccuracies, however fuzzy good judgment, as it pertains to overlay evaluation, makes a specialty of inaccuracies in attribute data. The membership function fuzzy controller operations are shown in fig 4.

**Figure 4.** Membership functions for material removal rate and surface roughness
4.2. Validation of the empirical result

The value of the observational influences is tried by drawing disseminate outline with the exploratory worth and predicted worth on X hub and Y pivot severally as appeared in fig. The scattered plots square degree appallingly on the purpose of the street demonstrating the correct wellness of the created observational connections [14]. Trial were formed exploitation absolutely disparate estimations of things put something aside for those utilized in style lattice and their material removal rate and surface roughness were measurable. The result represents that the expected esteems square measure very attractive than considerable error.

5. Conclusion

In this examination the WEDM responses from trained neural system and response surface strategies have been studied for all through values of a composite material. Trained network displayed enhanced slightest inaccuracy rate profile than RSM demonstrated. ANN exhibited the prediction was concerning higher than RSM. The most extreme extent error inside the ANN forecast of cut rate was recognized to be about of 4.85%, while for the RSM shows, it had been about 8.24%. From the result it is concluded that ANN modelling gives best predictive value and the error rate is minimum for predicting the MRR and SR for AA7075-PAC metal matrix composite.

6. References

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Figure 5. Fuzzy logic rules viewer for MRR