Enhancement of surface quality in Wire EDM machining of Magnesium alloy using ANN modeling approach

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Abstract: Wire electrical discharge machining is an sophisticated technology that contracts with very high speed cutting performance characteristics and precision machining process. In this paper deals about the surface quality enhancement by demonstrating various device parameters using ANN modeling for wire EDM process and the work piece required for machining was magnesium mix alloy. For exploratory game plan the machining parameters for example pulse off time, pulse on time, wire feed and current(voltage) were considered. The experiment was organized by Response Surface Methodology (RSM), Central Composite Design (CCD) was used. Surface quality was foreseen by ANN modeling. Different enlistment limits were utilized to improve the methodology parameters for surface quality. The foreseen characteristics were uncommonly near the test regard and the best assortment was 4.3%. Confirmation test was moreover coordinated to endorse the results and ANN predicted results have been seen as in exceptional concurrence with test revelations.

1. Introduction
It is a non-conventional material removing process which cuts precisely of any shape with high accuracy. It has ability to machine the hard machined tools and it machines only electrically conductive materials. wire is used for cutting the material and ignition of rapid spark generates between tool electrode and work piece removes material. With respect to present day applications, metal matrix composites now considering as better alternatives for their improved properties by comparing with others [1-3]. Many industrial applications are solved by using them. Unwavering surface quality is one of the most tremendous response in bunch encounters which influence the performance of mechanical parts. Mechanical properties for example absence of from corrosion, creep life and fatigue behaviour relies upon surface consistency [4-5].It is very important to keep surface finish is good and ensure that it may affect its properties. A convincing approach to address this issue is to explore the relation between surface roughness and device parameters by illustrating the technique by applying computational techniques and optimizing with a rational estimate of improvements [6]. Computerized reasoning methodologies are getting regular over conventional methodologies for assembling process displaying and advancement [7-8]. Progressed from the human neural structure, ANN is one of the fundamental sensitive figuring methods used to make judicious and complex models. It is equipped for gathering, preparing and utilizing the information picked up from exploratory information assortment to disclose with extraordinary accomplishment to the nonlinear and association impacts. It has some of the features like Non linearity, adaptability, input to output mapping and evidential response for making right decision.
2. Experiment Detail
In this investigation, the magnesium alloys AZ91 has been used [10]. Before starting the experimental work we must prepare the Design of Experiments. For this we have used four factor-3-levels Central Composite Design (CCD) of Response surface methodology has been utilized. In RSM the CCD is very effective to suit the second order model with the minimum number of experiments possible. In the present study, CCD design consists of four parameters and 30 runs. Therefore the four parameter CCD require 30 runs in which 3 imitates at the central point. Firstly the workpiece was machined on WEDM and note down the experimental values and after that compare with the ANN modeling values. The trial tests are carried out to determine the conditions, using one factor at a time. Based on the experimental work carried out and subsequent study of the test results, a set of process parameter ranges is selected for efficient magnesium alloy machining with minimum surface roughness.

| Table 1. Process Parameters and their Levels. |
|-----------------|-----------------|---------------|
| Real Parameters | Levels          |               |
| Factors         | -1              | 1             |
| Ton             | Pulse on Time(µs) | 110           |
| Toff            | Pulse off Time(µs) | 48            |
| IP              | Peak Current(Amp)        | 120           |
| CS              | Control speed(Rpm)      | 50            |

For conducting the experiment Electronica Sprint cut CNC WEDM model was used for machining of magnesium alloy. There are 30 experiments performed by a mix of modifying method parameters. In which 6 runs were used for neural network training and 24 were performed for testing. During machining the flashes are formed between the wire terminal and the work piece. The dielectric fluid is flown through continuously into the machining environment. The machined particles were carried away by the dielectric fluid’s persistent stream. The wire will be held by a stick as to move along the machining surface. The machining workpiece was about 90 x 80 x 8 mm rectangular plate. The electrode used for this machining process was 0.25 mm of zinc coated brass wire. The medium used to reduce the heat generation was Deionized water as it shows better properties as dielectric solvent at room temperature. After the machining was done the samples were cleaned with acid. SR is find at three locations on each machined surface using Surfcorder-SE1200, Kosaka. The machined work piece is shown in Fig 4. The surface roughness Ra is measured in the direction perpendicular to feed given. The composite three-measurement values are known as test results and used for further study [10].

3. Result & discussion
3.1. Effect of process parameters on surface roughness
For studying the effect of control variables on surface roughness, the response surface graph is plotted and it is shown in Figures 2-3. From Fig 2 it is obvious that the surface unevenness rises with the rise of pulse on time and drops with the increase of pulse off time. The surface unevenness was most exaggerated by pulse on time which discharges more spark duration. Surface quality will varies on crater formed during machining [9]. A thin crater formed during machining process will be good at better surface finish. For getting a flat crater, it is vital to minimize the pulse on time (Ton). we would be ensuring that more discharging energy will create violent sparks and causes the deeper erosion on the surface. Also, higher discharge energy will be able to generate a larger crater which causes a higher surface unevenness value. The perfect result for the surface roughness (Ra = 1.35 µm) was found as follows at pulse on time (115), pulse off time (50), input current(180) and servo voltage (50V). To approve, confirmation tests have been done with multiple times. The normal average experiment value was 1.42 microns and it was great concurrence with predicted value.
3.2. Modeling using ANN Modeling Approach:
The model created is a neural stream forward back propagation connect with a levenberg-marquardt preparing calculation involving 2 concealed layers 9 neurons in first masked layer and 2 neurons in second masked layer. The most preferable network for the task is 4-9-2-1 structure. The developed model is shown schematically in Fig. 3. The neural network will be trained with some samples before testing for obtaining the best results. The bias will be added to weights to obtain the required output. The attained weights and bias values are 4-9-2-1 structure.

The network has four inputs of Ton, Toff, IP and CS and one outputs SR. Matlab software has been used to forecast responses; ANN prediction data separates test data and training data into two categories. From the literature, it has been found that training data are 70% then it gives more accurate values of responses [9]. For present study 70% data was kept in training and rest of the data was test data during the prediction. Figure 3 shows the ANN architecture. The ANN design preparation, checking, and validation efficiency is shown in figure 1. The R-values are respectively 0.96, 0.95 and 0.99 during the preparation, checking, and acceptance. The model's final R-estimate is 0.97. Table 2 exhibits the percentage of error for SR. The percentages of errors are also calculated and the average error obtained was 1.95% and Maximum 9% of error for SR has been recorded during the benchmark of experimental values and ANN foreseen values. The comparison between experimental value and ANN predicted values is shown in figure 5. Hence ANN predicted values of outputs found more accurate comparatively similar work has been reported by Shandilya et al. [8] Anticipated benefits of cutting speed of wire electric release machining of magnesium combination after their similar investigation with RSM and ANN.
Figure 2. Mean squared error Vs Epoch in ANN training.

Figure 3. ANN Architecture.

Figure 4. WEDM machined work piece.
Table 2. Actual & Predicted value of Surface roughness.

| Exp No | Pulse on time | Pulse off time | Current | Control speed | actual SR | ANN SR | Error % |
|--------|---------------|----------------|---------|---------------|-----------|--------|---------|
| 1      | 117           | 52             | 160     | 60            | 2.55      | 2.75   | -7.85   |
| 2      | 124           | 56             | 120     | 60            | 3.79      | 3.71   | 2.02    |
| 3      | 124           | 48             | 200     | 40            | 3.38      | 3.54   | -4.72   |
| 4      | 117           | 56             | 160     | 50            | 3.65      | 4.01   | -9.99   |
| 5      | 117           | 48             | 160     | 50            | 3.67      | 3.51   | 4.27    |
| 6      | 110           | 56             | 200     | 60            | 3.5       | 3.37   | 3.82    |
| 7      | 110           | 52             | 160     | 50            | 3.23      | 3.39   | -4.83   |
| 8      | 110           | 56             | 120     | 40            | 4.17      | 4.07   | 2.40    |
| 9      | 124           | 56             | 200     | 40            | 5.41      | 4.98   | 7.91    |
| 10     | 124           | 48             | 120     | 40            | 3.53      | 3.37   | 4.42    |
| 11     | 124           | 52             | 160     | 50            | 3.44      | 3.36   | 2.39    |
| 12     | 124           | 56             | 200     | 60            | 4.11      | 3.83   | 6.85    |
| 13     | 110           | 48             | 200     | 40            | 3.85      | 3.72   | 3.30    |
| 14     | 110           | 48             | 120     | 40            | 3.24      | 3.00   | 7.34    |
| 15     | 124           | 48             | 200     | 60            | 3.17      | 2.97   | 6.23    |
| 16     | 117           | 52             | 160     | 50            | 3.75      | 3.57   | 4.72    |
| 17     | 110           | 56             | 120     | 60            | 3.8       | 3.95   | -4.05   |
| 18     | 110           | 48             | 220     | 60            | 3.8       | 3.56   | 6.42    |
| 19     | 124           | 56             | 120     | 40            | 3.94      | 4.13   | -4.89   |
| 20     | 124           | 48             | 120     | 60            | 3.09      | 2.84   | 7.98    |
| 21     | 117           | 52             | 160     | 40            | 3.84      | 3.79   | 1.20    |
| 22     | 117           | 52             | 160     | 40            | 3.6       | 3.79   | -5.39   |
| 23     | 117           | 52             | 160     | 50            | 3.09      | 3.27   | -5.92   |
| 24     | 117           | 52             | 160     | 50            | 3.09      | 3.27   | -5.92   |
4. Conclusion
The results of each experimental run on SR have been shown to record less values of these outputs at pulse off time (52), current (160), pulse on time (117) and control speed (60) while. The present study compared the ANN and experimental values for SR during the WEDM process and ANN based predicted values of SR found more accurate. Maximum error 9 % for SR has been noticed when compare the ANN predicted values to experimental values. From the current model, a significant improvement in magnesium alloy surface strength for WEDM could be accomplished without any post-processing or pre-treatment, thus minimizing both machining time and cost.

5. References
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