AN APPLICATION OF ARTIFICIAL NEURAL NETWORK TO PREDICT SURFACE ROUGHNESS DURING DRILLING OF AISI 1020 STEEL

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ABSTRACT
Metal machining has been an interesting topic of research for decades. Early research efforts include topics, such as, chip formation, heat generation at tool-chip and tool-work interfaces, tool wear, tool life, cutting force analysis, machinability, power requirements, manufacturing cost and productivity etc. With more emphasis on quality of surface finish with high production rate, in past few decades, research efforts seem to have been diverted towards the study of surface finish/roughness in metal machining.

The objectives of the present study is the development of the surface roughness prediction model using Artificial neural network in terms of feed, cutting speed and depth of hole during the drilling of AISI 1020 steel and to investigate the effect of drilling parameters on surface roughness using 3D plots between the parameters and surface roughness.

In the present research a multilayer feed-forward neural network has been employed using MATLAB software. The input layer has four neurons corresponding to each of the three input variables (cutting speed, feed and depth of cut) and one neuron in the output layer corresponding to output variable (surface roughness). The number of hidden layers and neurons in hidden layers has been determined on the basis of trial and error method. The mean square error has been selected as performance function. The ANN training simulation was carried out using batch gradient descent with variable learning rate procedure “traingdx”. This procedure helps in improving the performance of back propagation algorithm by allowing the learning rate to change during the training process based on the complexity of the local error surface. In this research, a portable surface roughness tester has been used to measure surface roughness indicators of finished work pieces.

Keywords: Artificial neural network, surface roughness, AISI 1020 steel.

I. INTRODUCTION
In the manufacturing industries, various machining processes (turning, milling, drilling etc.) are adopted for removing the material from the workpiece to obtain finished product. Among the various metal removing processes, drilling is the one of most important metal removing process as compared to other traditional machining processes. Drilling is used for making the hole in the workpieces. Hole making is a most important machining process in manufacturing. During the drilling, the drill rotates and feeds into the work piece to remove the material in the form of chips that move along the fluted shank of the drill. Different drilling tools and hole making methods are used for drilling. The selection of different tools and methods depends on the type of workpiece, size of the hole, the quantity of holes, and the quantity of the holes in given time periods. Also, drilling is used as an initial process for many machining operations, such as reaming, tapping and boring. Drilling process is widely used in the aerospace, aircraft and automotive industries. Now days, due to global competitiveness, manufacturing industries are more concerned about the quality of their products with high metal removal rate. These focus on producing high quality products in time at minimum cost.

The surface roughness is considered to be a measure of the technological quality of a product. Surface roughness is the one of the critical performance parameter that has an appreciable effect on several mechanical properties of machined parts such as fatigue behaviour, corrosion resistance, creep life, etc. It also affects other functional attributes of machined parts like friction, wear, light reflection, heat transmission, lubrication, electrical conductivity, etc. Hence, achieving the desired surface quality is of great importance for the functional behaviour of the mechanical parts.

During the drilling of the workpiece, it has long been recognized that the drilling conditions (drill point geometry, drill and workpiece materials, drilling parameters like feed rate and spindle speed) affect the performance of the operation to a greater extent. These drilling conditions should be selected to optimize the economics of drilling operations. So it can be achieved by empirical modeling of performance as a function of machining conditions using artificial neural network. The proposed work will be employed for investigate the effect of drilling parameters on surface roughness and development of surface roughness prediction model using artificial neural network (ANN).
II. OBJECTIVES

- Development of the surface roughness prediction model using Artificial neural network in terms of feed, cutting speed and depth of hole during the drilling of AISI 1020 steel.
- Investigating the effect of drilling parameters on surface roughness using 3D plots between the parameters and surface roughness.
- To investigate the most significant parameters that affects the surface roughness.

III. ARTIFICIAL NEURAL NETWORK

Artificial neural network (ANN) is a most attractive branch of artificial intelligence. It is based on the basic model of the human brain with the capability of generalization and learning. An ANN has the potential to handle problems such as modeling, estimating, prediction, optimization, diagnosis, and adaptive control in complex nonlinear systems. It can acquire, store, and utilize knowledge gained from experience. The capabilities of ANNs in capturing the mathematical mapping between input variables and output features are of primary significance for modeling machining processes.

IV. PROPOSED NEURAL NETWORK MODELS

In the present research a multilayer feed-forward neural network has been employed using MATLAB software. The input layer has four neurons corresponding to each of the three input variables (cutting speed, feed and depth of cut) and one neuron in the output layer corresponding to output variable (surface roughness). The number of hidden layers and neurons in hidden layers has been determined on the basis of trial and error method. The mean square error has been selected as performance function. The ANN training simulation was carried out using batch gradient descent with variable learning rate procedure “trainingdx”. This procedure helps in improving the performance of back-propagation algorithm by allowing the learning rate to change during the training process based on the complexity of the local error surface.

V. EXPERIMENTAL WORK

The process parameters that were chosen for experimentation are given as under:

1. Spindle speed (RPM)
2. Feed (mm/rev.)
3. Depth of hole (mm)

MACHINE USED:
The drilling operations have been carried out on a CNC MILL MT250 Machining Center.

CUTTING INSERTS:
Coated carbide tool performs better than uncoated carbide tools. On this basis, commercially accessible K-series, tungsten carbide high speed core drills with Tialn coating having 10 mm diameter with two flute has been used for experimentation.

COOLANT:
Coolant has been used in all the experiments. SUPERCUT cutting oil by SHELL COMPANY has been used in the ratio of 20:1 i.e 20 litres of water and 1 litre of cutting oil in it.

S/R MEASUREMENT
Surface roughness is defined as the finer irregularities of the surface texture that usually result from the inherent action of the machining process or material condition. There are many parameters used related to surface roughness in literatures. In this research, a portable surface roughness tester (Model No TR 210 manufactured by Beijing TIME High Technology Ltd. Beijing City, China) has been used to measure surface roughness indicators of finished work pieces.

![Surface roughness tester](image)

**Fig 4: surface roughness tester**

### FORMATION OF DESIGN MATRIX:

<table>
<thead>
<tr>
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<th>Spindle speed</th>
<th>Feed</th>
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<th>Surface roughness</th>
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### DEVELOPMENT OF ANN MODEL FOR SURFACE ROUGHNESS:

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**Neural network design and training:**

The simulation for ANN training was conducted using batch gradient descent with variable learning rate procedure “trainingdx”. The trial and error method was used for values of training parameters for “trainingdx” and is shown in table.

<table>
<thead>
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<th>Training parameters</th>
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<td>Maximum number of epochs to train</td>
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<td>Minimum performance gradient</td>
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<td>Number of patterns used for testing</td>
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<td>Number of patterns used for validation</td>
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**TRAINING OF MODEL:**
Fig 5: Correlation between the experimental (Target) and predicted (Output) surface roughness in training.

Fig 6: Comparison of the experimental and predicted values of surface roughness in training.

Fig 7: Correlation between the target and output surface roughness in testing.

Fig 8: Comparison of the experimental and predicted values of surface roughness in testing.

Fig 9: Comparison of the experimental and predicted values of surface roughness in validation.

Fig 10: Correlation between the experimental (Target) and predicted (Output) surface roughness for entire data set.

VALUES OF PREDICTED SURFACE ROUGHNESS:

<table>
<thead>
<tr>
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7 600 0.03 10 1.133 1.077
8 600 0.02 10 1.011 1.021
9 300 0.01 15 1.301 1.361
10 900 0.01 15 1.311 1.295
11 600 0.03 20 1.527 1.574
12 300 0.01 20 1.485 1.467
13 600 0.02 20 1.229 1.272
14 900 0.02 20 1.782 1.742
15 900 0.03 10 1.608 1.613
16 900 0.03 20 2.182 2.156
17 900 0.03 15 1.811 1.841
18 600 0.03 15 1.342 1.334
19 300 0.02 15 1.474 1.403
20 900 0.02 10 1.259 1.271
21 300 0.03 20 1.972 1.886
22 300 0.01 10 1.182 1.116
23 600 0.02 15 1.199 1.207
24 300 0.03 10 1.54 1.568
25 900 0.01 20 1.438 1.480
26 600 0.01 10 0.784 0.839
27 300 0.03 15 1.774 1.794

**EFFECT OF DRILLING PARAMETERS ON S/R:**

Fig 11: Plot between spindle speeds on surface roughness

Fig 12: Plot between feed on surface roughness

Fig 13: Plot between depth of hole and surface roughness

Fig 14: 3D plot for surface roughness between spindle speed and feed

Fig 15: 3D plot for surface roughness between spindle speed and depth of hole.

Fig 16: 3D plot for surface roughness between feed and depth of hole.
VI. CONCLUSION & FUTURE SCOPE

The objective of the present work is to optimize drilling parameters for minimum surface roughness. An attempt has also been made to investigate the effects of the drilling parameters on surface roughness. The important conclusions drawn from the present work are summarized as follows:

1. The predicted values of surface roughness using proposed ANN model was found to be in close agreement with the experimental data.
2. The results so obtained clearly illustrates that the as the spindle speed increase the surface roughness decreases up to a certain value of spindle speed afterward roughness increases with increase in spindle speed.
3. The surface roughness increases with increase in feed.
4. The surface roughness increases with increases in depth of hole.
5. The minimum surface roughness is achieved at low level of feed, low level of depth of hole and middle level of spindle speed.

REFERENCES