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Optimization of Machining Parameters in CNC Milling for Surface Roughness and Material Removal Rate: A Review

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Abstract

Quality and productivity play important role in today's manufacturing market. Now a day's due to very stiff and cut throat competitive market condition in manufacturing industries, the main objective of industries reveal with producing better quality product at minimum cost and increase productivity. CNC machining is most vital and common operation use for produce machine part with desire surface quality and higher productivity with less time and cost constrain. In this paper an attempt is made to understand the effect of machining parameters such as cutting speed (m/min), feed rate (mm/min), depth of cut (mm) that influence the responsive output parameters such as Surface Roughness and Material Removal Rate by using optimization philosophy. An effort is made to predict the surface roughness value and optimize machining parameters to get better surface finish and more material removal rate.

Keywords*: Surface Roughness, Material Removal Rate, Back Propagation Algorithm, ANN, RMS, Kurtosis.*

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1. Introduction

Among different types of milling processes, end milling is one of the most vital and common metal cutting operations used for machining parts because of its capability to remove materials at faster rate with a reasonably good surface quality [1]. There are several milling operations like face milling, end milling, tracer milling, plunging etc. Out of which an end milling is mostly preferred because of its wide applications such as cutting slots, machining accurate holes, producing narrow flat surfaces and for profile milling operations. Many researchers had carried experimentation on end milling as it is most simplest and accurate milling operation. The end milling operation is shown in the figure 1. The quality of product is most important factor in any manufacturing industry. Thus, to improve quality of product it is necessary to achieve better surface finish of machined products. To obtain better surface finish and

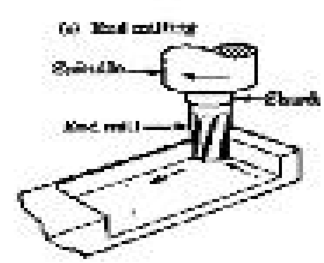
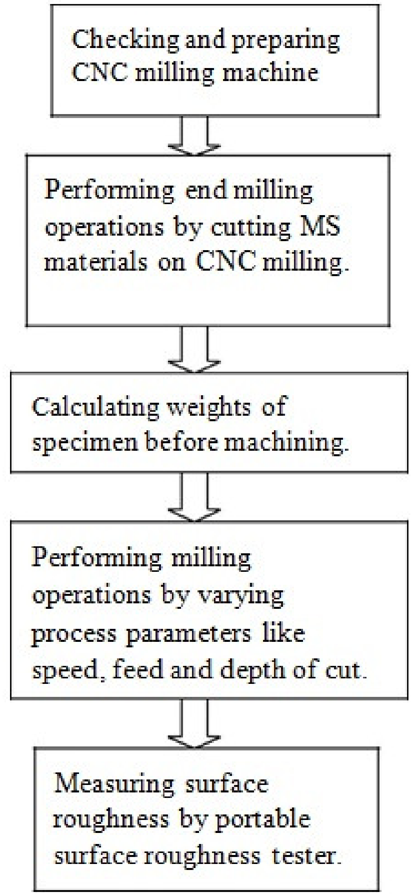


Fig. 1: End milling operation

maximum material removal rate of machined components, there is a need to optimize machining parameters like spindle speed, feed rate and depth of cut. Thus, many researchers developed ANN technique to predict surface roughness which quantifies the good surface quality and to optimize the different machining parameters.

2. Methodology

Literature depicts that a considerable amount of work has been carried out by previous investigators for modeling, simulation and parametric optimization of surface properties of the product in milling operation. Apart from optimizing a single response (process output), multi objective optimization problems have also been solved using Acoustic Method followed by Artificial Neural Network (ANN) which is the proposed method of optimization. It will validate its effectiveness through case studies in which correlated multiple surface roughness characteristics, MRR of product. The following plan of experiment to be performed:



3. Methods and Materials

The experiment will be performed by using CNC milling machine shown in Figure 2. The work piece material will be mild steel MS of grade C20. A two-flute carbide ball end mill cutter will be selected as the cutting tool. The cutter movement directions have been shown in Figure 3. The design of experiments will be carried out considering parameter variations around the cutting tool provider recommendations and the machine tool capabilities. In order to detect the average surface roughness value, experiments will be carried out by varying spindle speed, the feed rate along *y*-axis, feed along *x*-axis or radial depth of cut and the axial depth of cut. For each of the experiments, three sample readings will be taken and their average value will be considered.

Fig. 2: CNC Milling Machine

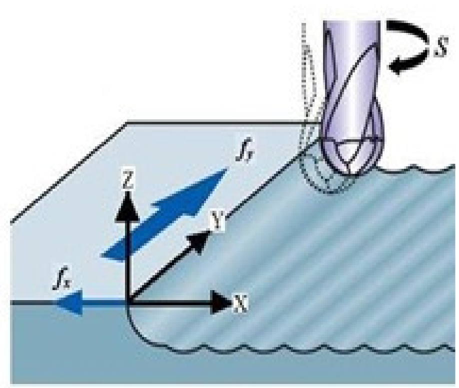


Fig. 3: Ball end milling cutter

4. Neural Network

a. Neural Network Modeling

Neural network is a highly flexible modelling tool with the ability to learn the mapping between input and output parameters. An artificial neural network (ANN) is capable of learning from an experimental data set to describe the nonlinear and interaction effects more effectively. The network consists of an input layer used to present data, output layer to produce ANN's response, and one or more hidden layers in between. The network is characterized by their topology, weight vectors, and activation function that are used in hidden and output layers of the network. Networks with biases, a sigmoid layer, and a linear output layer are capable of approximating any function with a finite number of discontinuities. Before applying the neural network for modelling the architecture of the network has to be decided; i.e. the number of hidden layers and the number of neurons in each layer and transfer function for each layer. As there are 3 inputs to produce one output, the number of neurons in the input and output layer has to be set to 3 and 1 respectively. Considering one hidden layer the number of neurons in the hidden layer is optimized.

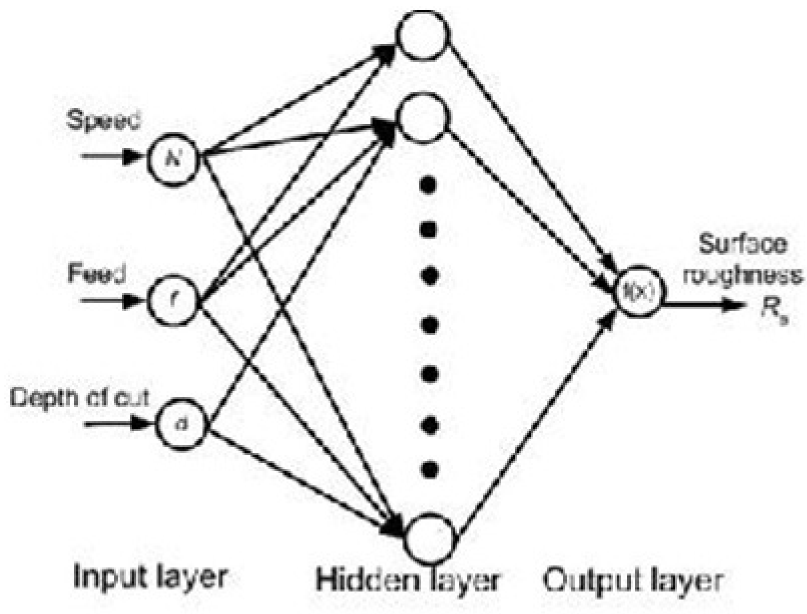


Fig. 4: Neural Network

b. The Back Propagation Algorithm

As our approach is "narrow and intensive", we have selected back propagation algorithm for training and building an expert system. Most people would consider the Back Propagation Network to be the Quintessential Neural Net. Actually, Back Propagation 1, 2, 3 is the training or learning algorithm rather than the network itself. A Back Propagation Network learns by example. You give the algorithm examples of what you want the network to do and it changes the network's weights so that, when training is finished, it will give you the required output for a particular input. Back Propagation Networks are ideal for simple Pattern Recognition and Mapping Tasks. As just mentioned, to train the network you need to give it examples of what you want – the output you want (called the Target) for a particular input. In the following figure (Fig. 5), 2 inputs, 3

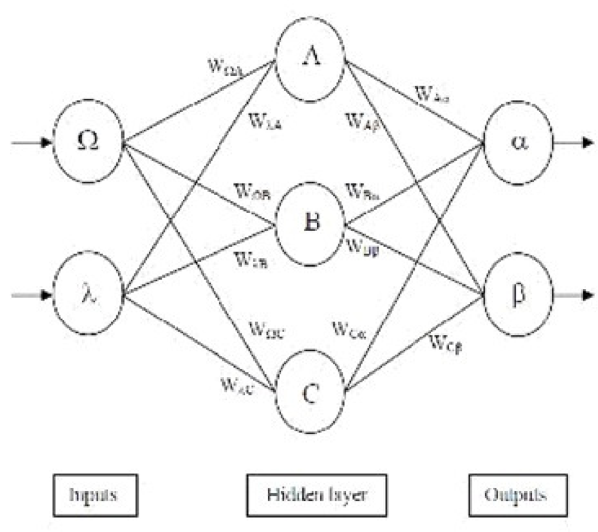


Fig. 5: Back Propagation Network

hidden layer neurons and 2 outputs are forming a back propagation neural network.

A Back Propagation consists of at least three layers of units: one input, one intermediate hidden layer and an output layer. Typically, units are connected in a feed forward fashion with input units fully connected to units in the hidden layer and hidden units fully connected to units in the output layers. The back propagation method for training multilayer feed forward network is conducted in two phases. There is first a feed forward phase in which input patterns are presented and the network computes output values, producing an error value for each pattern at each output unit. This is followed by a feed backward phase in which error derivatives at each unit are computed and weight are adjusted to reduce errors.

c. *Implementation of Back Propagation Algorithm in Two Phases*

Phase I: Propagation

Each propagation involves the following steps:

1. Forward propagation of a training pattern's input through the neural network in order to generate the propagation's output activations.
2. Backward propagation of the propagation's output activations through the neural network using the training pattern target in order to generate the deltas of all output and hidden neurons.

Phase II: Weight Update

For each weight-synapse follow the following steps:

1. Multiply its output delta and input activation to get the gradient of the weight.
2. Subtract a ratio (percentage) of the gradient from the weight.

This ratio (percentage) influences the speed and quality of learning; it is called the learning rate. The greater the ratio, the faster the neuron trains; the lower the ratio, the more accurate the training is. The sign of the gradient of a weight indicates where the error is increasing.

5. Conclusion

From the above literature survey it is found that most effected parameters to cutting condition are cutting speed, feed rate and depth of cut and they are easily controlled by operator at the machine at same time. All milling operations will be performed on CNC milling machine. In which input parameters are cutting speed, feed rate and depth of cut and the response parameters are surface roughness and material removal rate. Many researchers had used the back propagation algorithm to develop the expert system to predict surface roughness value and ANN as an optimization tool. This research work will also include RMS (root mean square), kurtosis as response parameters. Acoustic signals will be captured during CNC machining and RMS and kurtosis values will be found using Lab View software.

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