Detailed Study on Performance of CNC Machine

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Abstract

In present rapidly changing scenario in production industries, application of predictive techniques is essential for metal cutting industry. It is a challenge for every industry to achieve predefined performance parameter in first trial. Predictive model is very essential in production industry to respond efficiently to severe competitiveness and continuously increasing demand of quality product with minimum cost in the market. Predictive models in metal cutting industries are considered as a vital tool for continuous improvement of product quality as well as minimizing the product cost. Optimization can be carried out with the help of predictive model. Determination of optimum input parameter for predefined performance parameter through cost-effective mathematical model is a very complex task. However, over the years, the predictive techniques have undergone various development and expansion. In this review paper, various predictive techniques like ANN, ANFIS, fuzzy logic, response surface method, taguchi method which are used for prediction of surface roughness has been critically appraised. A comparative study is carried out in tabular form of these predictive models. Surface roughness is taken as performance parameter for this paper.

Keywords: *CNC Machine, Taguchi method, ANN.*

I. Introduction

Metal cutting is the most important and widely used production process in manufacturing industries. In recent time metal cutting operation is performed with the help of computer numeric control machine. The study of metal cutting withdraws attention toward cutting tool material, work piece, input parameters for operation and their responses (output). There is a need of minimization of total cost in development of product due to severe competition in market this days.A significant improvement in product quality can be obtained with the help of predictive model with the same cost. There are a number of input parameters are used in CNC in which spindle speed, feed rate, depth of cut are very important. Many performance parameters are also present in metal cutting industry like MRR, machining time, cost, tool wear, surface roughness, power etc. surface roughness is the most important performance parameter because it affects many factors like precision, frictional consideration, fatigue and notch sensitivity, electrical and thermal contact resistance, subsequent processing, corrosion resistance, appearance and cost.

II. Issues during development of predictive model

There are various issues in the development of predictive model; which are discussed below.

1. Work Piece Materials- there are many materials which are used in the development of predictive models. Those materials are AISI 1060 steel, Ti-6Al-4V (grade 5) alloy, AISI 1045 steel, mild steel, Al 7075-T6, GFRP/Epoxy composite, AISI 4340 steel, Al 6061, GLASS fiber, AA6351, St 50.2 steel, 190 BHN steel, 95MnPb28K etc.

2.Tool Materials-various cutting tool materials are used for the development of predictive models; which are carbide tool, Taegu-TecRCMT10T300, MTT3500, Tungsten carbide, H.S.S tool, SNMG 120408, ISCAR end mill, PCD cutting tool, SNTR carbide tool, CBN grinding tool, AVMT 0903 PER-EMCTT 8020, cemented carbide tool, SECO-DCMY11Y304F7, TPUN160308P10 etc.

3.Input Parameters- There are several input parameters which used for development of predictive model to get performance parameters in machining operation are cutting tool material, tool rake angle, feed rate, cutting speed, depth of cut, cutting fluid, cutting force, cutting velocity, vibration, types of chip formation, work-piece materials and its properties.

4. Performance Parameters–There are many performance parameters in predictive model; which are material removal rate, machining time, total cost, tool wear, vibration, surface roughness.

III. Different Predictive Techniques

There are the different predictive techniques; which were applied by various researchers are given below:

- Artificial Neural Network (ANN)
- Genetic Algorithm (GA)
- Fuzzy Logic
- Taguchi Method
- Response surface method
- ANFIS
- SMO-SMV
- Model tree
- Taguchi-fuzzy
- SVR
- Regression model

IV. Literature Survey

- Girish Kant and Kuldip Singh Sangwan (2015)[1] proposed an alternative method to conventional method for prediction of the optimum value of machining parameters that leads to minimize the surface roughness. They developed a predictive and optimization model by coupling of the two artificial intelligence approaches, one is ANN and another is genetic algorithm (GA). They found predicted result is very closer to the experimental values up to 4.11 percentage mean absolute error that indicates the developed model had good accuracy in predicting of the surface roughness values. They also compared their result by ANN with result obtained by regression and fuzzy logic models. They obtained that ANN models outperforms the regression and fuzzy logic models. They also performed a hypothesis test of which result validate the use of ANN as a prediction model had statically satisfactory to fit from the modelling part of view. They used ANN as prediction model and Genetic algorithm as a optimisation model in a machining process which gives the accuracy of 95.89% and minimum roughness value of 0.099 micrometre.

- Kuldip Singh Sangwan and Sachin Saxena (2015)[2] gave the idea about coupling of two artificial intelligence techniques for better effectiveness and efficiency. In this paper and approach for determining the optimum parameters for machining which leads to minimization of the surface roughness by integrating ANN and GA. They checked the capability of the ANN –GA approach for prediction as well as for optimization by use of real data set which had obtained from real machining experiment. They took Ti-6Al-4V aluminium alloy for turning operation as real machining experiment and developed a feed forward neural network. MATLAB toolbox had been used for training and testing of neural network. They found that expected results and predicted results were almost similar and they used GA technique for optimization of process parameters to minimize surface roughness. This paper shows that integrated ANN-GA technique are well capable to give accurate predicted optimum result. Mean absolute percentage error achieved by this paper is 1.79 compared to 4.30 by rsm model applied by Ramesh et al.

Comparative study of various research works carried out by different researchers

S.N	Paper title	Author and published year	Impleme-ntation	Machining parameters	Model/ Technique	Remarks
1	Novel machine learning based models for estimating minimum surface roughness value in the end milling process	SaroshHashmi et.al. (2014)	CNC end milling machine	a)cutting speed b) feed rate c)radial rake angle	a) Model tree b) SMO-SVM	Predictive model based on model tree gave minimum value of roughness upto 0.182µm.
2	Predictive modelling and optimization of machining parameters to minimize surface roughness using ANN coupled with GA	Girish Kant and Sangwan (2015)	CNC milling machine	a) depth of cut b)cutting speed c) feed rate	a) ANN b) GA	4.11% mean relative error achieved.
3	Predictive modelling for power consumption in machining using AI techniques.	Girish Kant and Sangwan (2015)	CNC milling machine	a) depth of cut b)cutting	a) ANN b) GA	1.79% mean absolute error achieved.
4	Surface roughness prediction using ANN in hard turning of AISI H13 steel with minimal fluid application.	B. Anuja Beatrice et.al. (2014)	CNC lathe machine	a) feed rate b) cutting	ANN	Accuracy achieved upto 95.96%.
5	Prediction of surface roughness in the end milling using ANN.	AzlanMohdZain et.al. (2010)	CNC end milling machine	a) rake angle b) feed rate c) cutting speed	ANN	Predicted result depends upon configuration of neural network and no. of training data set. They found 3-1-1 config. gave best result with 24 data set

6	Optimal selection of process parameters in CNC end milling of AL 7075-T6 aluminium alloy using a Taguchi-Fuzzy approach	Thakur paramjit and R.Rajesh (2014)	CNC end milling machine	a) cutting speed b) depth of cut c) feed rate	Taguchi-Fuzzy	A3B1C3D2 combination gave optimum result with surface roughness 0.14µm.
7	Optimization of machining parameters to minimize surface roughness using integrated ANN-GA approach.	Sachin saxena et.al. (2015)	CNC lathe machine	a) cutting force b) cutting speed c) feed	a) SVR b) ANN	Mean error obtained by SVR is 1.86 where as ANN gave 1.749 mean error.
8	Prediction and control of surface roughness in CNC lathe using ANN.	DurmusKarayel (2009)	CNC lathe machine	a) depth of cut b)cutting speed c)feed	ANN	The predicted result is extremely close to measured result.
9	Neural network process modelling for turning of steel parts using conventional and wiper inserts.	TugrulOzel et.al. (2009)	CNC lathe machine	a)nose radius b)depth of cut c) feed rate d) cutting	ANN	With conventional insert roughness of 0.26µm obtained while from wiper insert 0.22µm roughness obtained.
10	Prediction of surface roughness of freeform surfaces using ANN.	Rajesh.M and R.Manu (2014)	CNC ball end milling machine	a) feed rate b) depth of cut c) step	ANN	Accuracy upto 96.37% achieved.

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