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Prediction of vibration effect on Surface Roughness of Poly methyl methacrylate (PMMA) by using ANN

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Abstract: *Poly methyl methacrylate (PMMA) is the material used in various optical industries having high degree of surface finish. In this paper, experimental and simulation study has been carried out on CNC machine to obtain fine surface finish on the component. During the actual experimentation it was observed that the cutting parameters along with vibration affecting the surface finish. For the analysis experimental parameters were considered such as feed rate, depth of cut and speed. The response parameters are surface roughness and acceleration in Z-direction. In ANN, with the help of MATLAB the training of Neural Network has been done to gain the optimum solution. The predicted results of ANN for surface roughness are almost matching with experimental results whereas the predicted results of acceleration in Z-direction vary with very small margin from experimental values.*

Keywords –*acceleration in Z-direction , ANN ,CNC, Diamond Turning, Surface Roughness*

I. Introduction

Diamond Turning was initially introduced in 1960. Till 1980s, its commercialization began as a mature cost-efficient manufacturing technology for generating optical surfaces. Presently, it has gradually developed into a fast and high flexible technique for shaping complex free-form and optical surfaces. With readily achievable sub-micrometric form error and nanometric surface roughness, it has been found widespread applications to the fabrication of high precision components, such as prisms or micro-lens arrays. The surface roughness and form error is largely determined by cutting conditions, tool geometry, relative error motions, material factors [1]. The cost involved in the diamond turning machining is high and the components required some pre machining with high surface finish. The cutting parameters are very critical in pre-machining and in diamond turning process. In order to reduce the machining time and cost some predictions require either by simulation or by some predictive models. This builds confidence in researcher's mind about planning the experiments.In this work one method is explained as a predictive model is developed for pre-machining of PMMA to identify Surface Roughness and magnitude of acceleration on CNC lathe machine. Initially experiments were conducted and correlated with the predicted results. It helps in selecting the cutting parameters and their effects on roughness and vibration in terms of acceleration.

1. Artificial Neuron Network

Artificial Neural Network (ANN) is a systematic computing system whose core theme is borrowed from the similarity of biological neural networks. ANN's are also named as "artificial neural systems," or "parallel distributed processing systems," or "connectionist systems." ANN acquires a large collection of units that are interconnected in some pattern to allow communication between the units. These units, also referred to as nodes, are simple processors which operate in parallel. There is a connection link which connects each neuron with other neuron. Artificial neural network is formed as a non-linear mapping system that works like human brain wherein a total of three layers are interconnected and each layer has one or more neurons. First layer of ANN model is input layer, receives numerical value as input to the model. Herein, one neuron is assigned by one variable. Second layer, i.e. hidden layer, receives the information from the input layer and processes further. Output layer is connected with second layer by synaptic weights, provides the output(s). The type of configuration, training algorithm, different functions, and weights and biases influence the accuracy of the ANN model. Predictive models have proved their worth as beneficial tools in the machining processes where the effect of input parameters is required to be investigated on output(s) of the process [2]. ANNs are one of the most well known predictive models that are able to estimate output(s) of the machining processes in the range of investigated input parameters. ANNs have been successfully used for modeling of turning process by several researchers. K. Sangwana *et.al* [3] has studied an method for determining the optimum machining parameters for achieving minimum surface roughness by integrating Artificial Neural Network Model (ANN) and Genetic Algorithm (GA). M. Hanief *et.al* [4] study has aimed to investigate the effects of cutting parameters (speed, depth of cut and feed rate) on the cutting forces during the turning operation of red brass (C23000) using high speed steel (HSS) tool by developing a model. L. Monostoria *et.al* [5] has investigated that the One of the main goals of the research to be reported here was to find a general model for a set of assignments, which can satisfy accuracy requirements. K.A.Mahajan *et.al* [6] has done experimental investigation of Tool Vibration effect on the surface roughness of PMMA material and found that cutting speed is highly influencing for vibration.

In present study, Matlab is used for the formulation of artificial neural network. Several models were made, designed and tested to determine the optimal model, the best training model is shown in Fig.1. The initial step in ANN is training of neurons. An input is provided to the ANN model alongside with the outputs to be targeted and the weights are initially set randomly. ANN has many learning methods for adjusting the weights of neurons, satisfactory method is back propagation algorithm that adjust weight in backward manner i.e. output to input. The optimum solution is achieved by minimizing the global error using back propagation algorithm. The training of the network is stopped when the most optimum solution is achieved [4]. In order to develop ANN model, the network was trained by using a set of experimental values. After successful training the network was used to predict the roughness and z- direction acceleration for validation and testing. Less training makes the ANNs inefficient and may leads to inaccurate prediction of results. Therefore, a network structure 3-10-2 is selected for Surface Roughness and acceleration predictions.

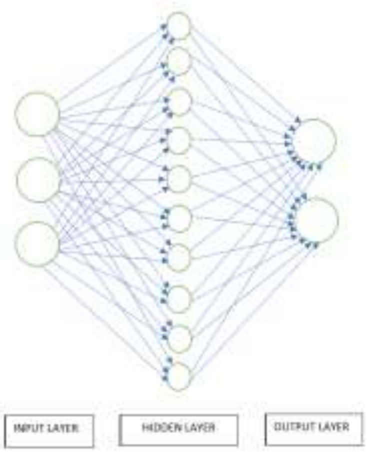

Fig. 1. Architecture of ANN (3-10-2)

II. Experimental Set Up And Procedure

The experimental setup consists of CNC lathe machine, tool holder, insert and Talysurf tri axial accelerometer, signal convertor, computer. The experimental setup is shown in Fig. 2. DX 150 two axis CNC machine made by Jyoti Machine Tool was used.

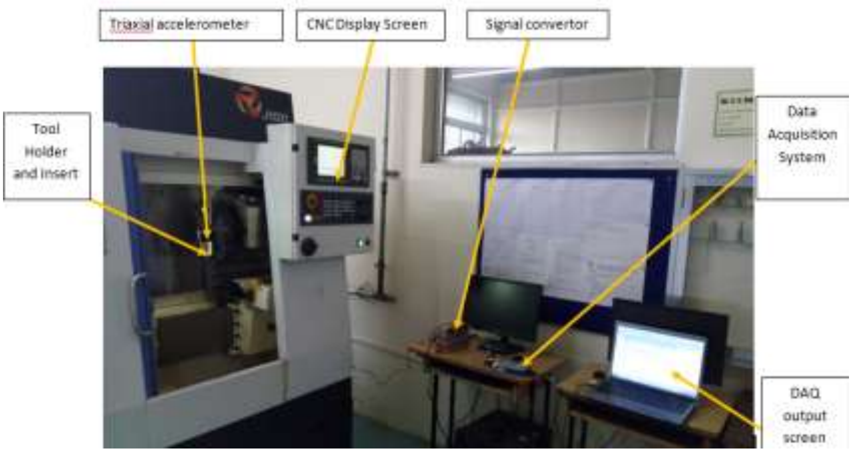

Fig. 2. Experimental setup

Tool holder used is MTJNL 2020 WIDAX K16. A tungsten carbide insert is used for the facing operations of the PMMA material. The insert has nomenclature of TNMG 160404-HMAs mentioned earlier, there are 3 layers mainly input, hidden, output layer. In this study three inputs namely Velocity(m/min), Feed(mm/rev), Depth of Cut(mm) and the output is Roughness and acceleration. First Roughness was found out experimentally then it was analyzed by ANN.The aim of study is to understand the effect of vibration on PMMA material, the theory states that the metal cutting process should be studied by considering the turning operation. The facing operation is not relevant for vibration study on CNC lathe as the cutting speed is varying from outside towards centre of work piece. However when the cutting speed is changing with respect to diameter maintaining the spindle speed constant which results in less vibration.In this study the cutting speed was kept constant so that the spindle speed variation may generate the tool tip – work piece interaction which produces the vibration. Another purpose of selecting the facing operation is that the work piece is further machined on Diamond Turning Machine (DTM). The DTM is generally used to face the components. So the conventional fundamentals were not considered in the study.

2.Experimental Dataset

The dataset for this analysis is taken from conduction of experimental to analyze the surface finish and acceleration. The experiments were conducted using Taguchi's L 27 orthogonal array with 3 levels, as shown in Table I. The surface finish measured on the Mitutoyo Talysurf and the acceleration in the NI DAQ for real time acceleration. The experimental data is as shown in Table I.

Table 1: Experimental Data [6]

Run Order	Cutting Velocity (m/min.)	Feed Rate (mm/rev)	Depth of Cut (mm)	Surface Roughness R_a (micron)	Acceleration in Z direction (m/s^2)
1	157.08	0.01	0.05	0.108	1.93
2	157.08	0.01	0.1	0.08	1.44
3	157.08	0.01	0.15	0.09	1.42
4	157.08	0.05	0.05	0.24	1.61
5	157.08	0.05	0.1	0.18	2.9
6	157.08	0.05	0.15	0.27	3.72
7	157.08	0.1	0.05	0.24	3.43
8	157.08	0.1	0.1	0.243	2.93
9	157.08	0.1	0.15	0.223	3
10	235.62	0.01	0.05	0.07	2.95
11	235.62	0.01	0.1	0.06	3.17
12	235.62	0.01	0.15	0.065	3.42
13	235.62	0.05	0.05	0.133	3.58
14	235.62	0.05	0.1	0.193	3.31
15	235.62	0.05	0.15	0.2	3.26
16	235.62	0.1	0.05	0.25	3.7
17	235.62	0.1	0.1	0.2	3.54
18	235.62	0.1	0.15	0.18	3.56
19	274.89	0.01	0.05	0.05	2.162
20	274.89	0.01	0.1	0.05	2.03
21	274.89	0.01	0.15	0.08	1.65
22	274.89	0.05	0.05	0.1	2.51
23	274.89	0.05	0.1	0.09	2.22
24	274.89	0.05	0.15	0.23	1.93
25	274.89	0.1	0.05	0.22	1.79
26	274.89	0.1	0.1	0.233	2.29
27	274.89	0.1	0.15	0.22	2.04

I. Optimization of Turning Process through ANN

The Software used for ANN is MATLAB. The function used is nn-tool. Several Networks were designed with trial and error methods to validate the results.3-10-2 model gave the most optimum solution. The Levenberg-Marquadt (LM) algorithm was used to train the neuron network. Tansig (Hyperbolic Tangent Sigmoid) transfer function has been used as it gives the best result by activating function in output and hidden layer as shown in Fig. 3.

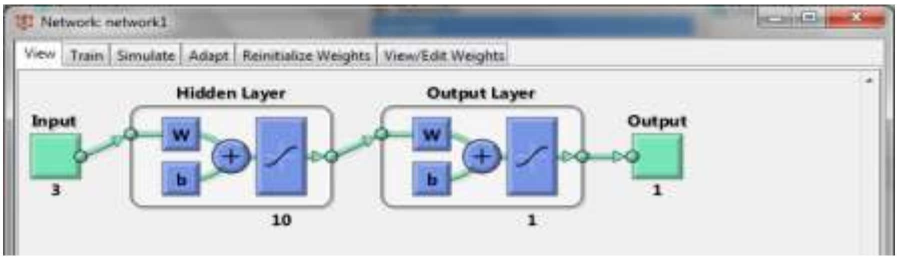

Fig. 3. ANN model

III. Results And Discussion

The accuracy of the ANN model is based on the number of layers and the process of trainning. The experimental data is validated by simulation with multiple training of hidden layers. The tested layers started from the range 2-10 and found that layer 8 and layer 10 is in the range of experimental outcome as shown in Table II . The percentage error of the layer 10 is comparatively less than the other layers. The variation of experimental value and the predicted is as shown in Fig.4. and Fig.5. for surface roughness and z-direction acceleration respectively. This model indicates the close agreement with desired results from experimentation so that it can be used for any parameter to obtain the Surface roughness and acceleration data.

Table 2 : Result of ANN Prediction model

Run Order	Cutting Velocity (m/min.)	Feed Rate (mm/rev)	Depth of Cut (mm)	Surface Roughness R_a (micron)	Predicted Ra (micron)	% error of Ra	Acceleration in Z direction (m/s^2)	Predicted Acceleration(m/s^2)	% of Acceleration in Z Direction
1	157.08	0.01	0.05	0.108	0.12116	10.86167	1.93	1.7436	-10.6905
2	157.08	0.01	0.1	0.08	0.089685	10.79891	1.44	1.7713	18.70378
3	157.08	0.01	0.15	0.09	0.084459	-6.56058	1.42	1.7563	19.14821
4	157.08	0.05	0.05	0.24	0.20041	-19.7545	1.61	1.8353	12.27592
5	157.08	0.05	0.1	0.18	0.18625	3.355705	2.9	2.84	-2.11268
6	157.08	0.05	0.15	0.27	0.26265	-2.7984	3.72	3.2803	-13.4043
7	157.08	0.1	0.05	0.24	0.23992	-0.03334	3.43	3.3411	-2.6608
8	157.08	0.1	0.1	0.243	0.23296	-4.30975	2.93	3.144	6.806616
9	157.08	0.1	0.15	0.223	0.24884	10.38418	3	3.305	9.228442
10	235.62	0.01	0.05	0.07	0.055197	-26.8185	2.95	2.5016	-17.9245
11	235.62	0.01	0.1	0.06	0.062311	3.708815	3.17	3.1274	-1.36215
12	235.62	0.01	0.15	0.065	0.065064	0.098365	3.42	3.2857	-4.08741
13	235.62	0.05	0.05	0.133	0.13003	-2.28409	3.58	3.4103	-4.9761
14	235.62	0.05	0.1	0.193	0.19167	-0.6939	3.31	3.0923	-7.04007
15	235.62	0.05	0.15	0.2	0.21238	5.829174	3.26	3.0845	-5.68974
16	235.62	0.1	0.05	0.25	0.25199	0.789714	3.7	3.3158	-11.5869
17	235.62	0.1	0.1	0.2	0.25233	20.73872	3.54	2.7941	-26.6955
18	235.62	0.1	0.15	0.18	0.18173	0.951962	3.56	2.5638	-38.8564
19	274.89	0.01	0.05	0.05	0.054167	7.692876	2.162	2.225	2.831461
20	274.89	0.01	0.1	0.05	0.053777	7.023449	2.03	1.9754	-2.764
21	274.89	0.01	0.15	0.08	0.061637	-29.7922	1.65	2.2955	28.12024
22	274.89	0.05	0.05	0.1	0.098248	-1.78324	2.51	2.7017	7.095532
23	274.89	0.05	0.1	0.09	0.091789	1.949035	2.22	2.1485	-3.3279
24	274.89	0.05	0.15	0.23	0.23191	0.823595	1.93	2.0765	7.055141
25	274.89	0.1	0.05	0.22	0.21472	-2.45902	1.79	3.1548	43.26106
26	274.89	0.1	0.1	0.233	0.22245	-4.74264	2.29	2.7818	17.6792
27	274.89	0.1	0.15	0.22	0.22074	0.335236	2.04	2.4785	17.69215

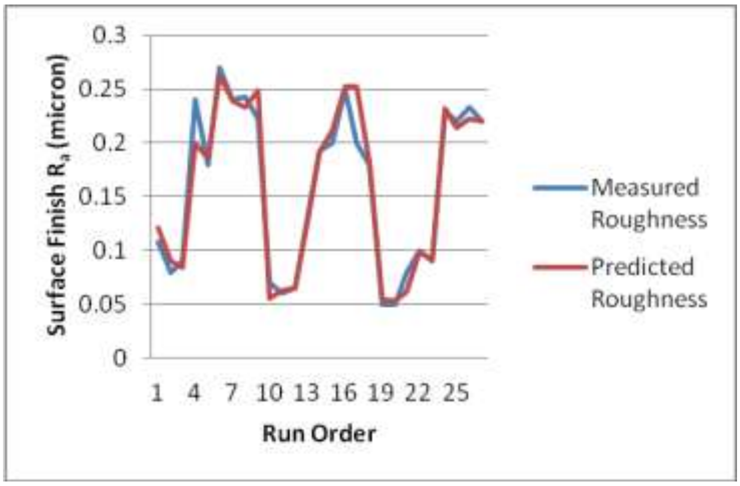

Fig. 4. Measured and predicted surface roughness

The above Fig.4 shows slight difference between measured and predicted value of Surface Roughness and it is dependant on the machining parameters that can be controlled. The average Percentage error for Surface Roughness is 0.61%

Fig. 5. Measured and predicted acceleration

The above Fig.5 show large difference between measured and predicted value by ANN as it is uncertain parameter,but it follows the same trend that is followed by actual measured value. The Average Percentage Error for Acceleration in Z-Direction is 1.35%

IV. Conclusion

The predicted results are useful for extensive experimetation and for selection and optimisation of machining parameters. These parameters play important role in generating the minimun surface finish in pre-machining of components. Also it reduces the machining time of diamond turnining as number of cuts can be reduced to achieve the desired surface quality. The present study has indicated that that

- The surface roughness is almost matching with the experimental results and it means that for the desired surface roughness the cutting parametrs can be identified by using ANN model. The average percentage error for Surface Roughness are seen between 0-5%,while the average percentage error for acceleration in Z-direction are seen between 10-20%
- This approach will reduce the experimentation time and cost of machining.
- The vibration is playing important role in getting the better surface finish and it can also be predicted. It is observed that increase in acceleration, the roughness also increases. In order to maintain the lower roughness , vibration should be minimized.

Conflict of interest The authors declare that there is no conflict of interests regarding the publication of this paper.

References

[1]. S. Zhang, J. Yu, S. To, Z. Xiong, "A theoretical and experimental study of spindle imbalance induced forced vibration and its effect on surface generation in diamond turning" , International Journal of Machine Tools and Manufacture,133(2018)61-71.

[2]. Djavanroodi F., Omranpour B., SedighiM., " Artificial neural network modeling of ECAP process", Materials and Manufacturing Processes, 2013, 28, 276–281.

[3]. Kuldip Singh Sangwana,* ,Sachin Saxena, Girish Kant, " Optimization of Machining Parameters to Minimize Surface Roughness using Integrated ANN-GA Approach", Procedia CIRP,29,(2010),305-310.

[4]. M. Hanief, M.F. Wani, M.S. Charoo, "Modeling and prediction of cutting forces during the turning of red brass(C23000) using ANN and regression analysis", Engineering Science and technology, an international journal, 20, 3, (2017), 1220-1226

[5]. L. Monostoria, Zs.J. Viharosa, S. Markosba, "Satisfying various requirements in different levels and stages of machining using one general ANN-based process model", Journal of Materials Processing Technology, 22,(2000), 228-235

[6]. K.A.Mahajan, P.K.Brahmakar , R.Balasunramanium, M.R.Dhakad, "Experimental Investigation of Tool Vibration Effect on the Surface Roughness in Facing Operation of PMMA Material", International Review of Mechanical Engineering(IREME), Vol.11 ,N.10 October 2017