IOSR Journal of Engineering (IOSRJEN) www.iosrjen.org
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 07, Issue 10 (October. 2017), ||V2|| PP 36-43

Prediction of Surface Roughness in Hard Turning Using Artificial Neural Networks

Ch. Prem Chaitanya [1]*, B Chandra Shekar[2], V Ravi Kumar[3]
[1] PG Scholar, ASRCE, AP, India.
[2, 3]Assistant Professor, ASRCE, AP, India
Corresponding Author: Ch. Prem Chaitanya

Abstract: At the present-day development of engineering, it is crucial to finish a product with reduced sub steps and at the similar period excellent surface finishing levels are to be attained throughout turning process. Hard turning process is beneficial over conventional grinding process. Grinding process is an additional process for accompanying the surface finish after the whole manufacturing process is completed, which consequences in the manner of increasing of overall cost of the manufacturing. In a related way hard turning would work for the similar persistence. This present work is directed for exploring the influence of spindle speed (n) and depth of cut (h) on the cutting forces and surface roughness (Ra) and also catches the breaking point of tool tip KC5525 in the hard turning process of EN8 material. Finally, artificial neural network (ANN) models are established for feed forces and surface roughness (Ra) in hard turning process of EN8 material using KC5525 cutting tool. The input parameters are selected as spindle speed (n) and depth of cut and outputs are feed forces and surface roughness. The predicted feed forces and surface roughness by employed models have been compared with the experimental data which shows the best fit to experimental results and producing better outputs with a regression coefficient of 0.9.

Keywords: Hard Turning, Surface Finish, Prediction, ANN.

Date of Submission: 22-08-2017 Date of acceptance: 09-11-2017

I. INTRODUCTION

Manufacturers of machined components and manufactured goods are repeatedly challenged to decrease cost, improve quality and condense setup times in order to persist competitive. Habitually the solution originates with innovative technology solutions. Such is the case with grinding where the traditional operations involve expensive machinery and generally have long manufacturing cycles, costly support equipment, and lengthy setup times. However, the grinding process itself may require several machine tools and several setups to finish all component surfaces. Because grinding can be a slow process with low material-removal rates, there has been a determined search for replacement processes.

The newer solution is a hard turning process, which is best performed with appropriately configured turning centers or lathes. Hard turning really started to develop at the beginning of the nineties. The reason for this was the availability of new tool materials and the capability of designing a turning machine that was rigid, stable and accurate enough to successfully finish hard turn. The result of these developments have made finish hard turning a viable alternative to grinding, as an accurate finishing operation.

II. HARD TURNING

Manufacturers around the world constantly strive for lower cost solutions in order to maintain their competitiveness, on machined components and manufactured goods. Globally, part quality has been found to be at acceptable levels and it continues to improve, while the pressure for part piece cost is enormous and is constantly being influenced downward by competition and buyer strategies. The trend is toward higher quality, lower cost and smaller batch sizes. In order to compete against producing countries with low wage structures, it is necessary to seek out appropriate new technological solutions that can help to level the business playing field.

Technology has played an enormous role in advancing the metal working industry and creating opportunities to reduce costs and improve quality. Consider the role technology has played in transforming routine metal cutting operations. At one time machining was very much an operator dependent, skill critical process. Today, CNC machine tools, which operate with mature technology and provide both consistency and reliability, have now become the biggest contributor to part quality and cost. Technology-based tools such as 3- D CAD systems, computer programming, and simulation packages, are now commonplace in many shops and in most countries of the world. A rapid adoption of these newer and more cost effective manufacturing techniques will be constantly required if manufacturing operations are to remain competitive. In a much smaller way, but no less significant, we begin to see a technology evolution occurring in the area of hard turning.

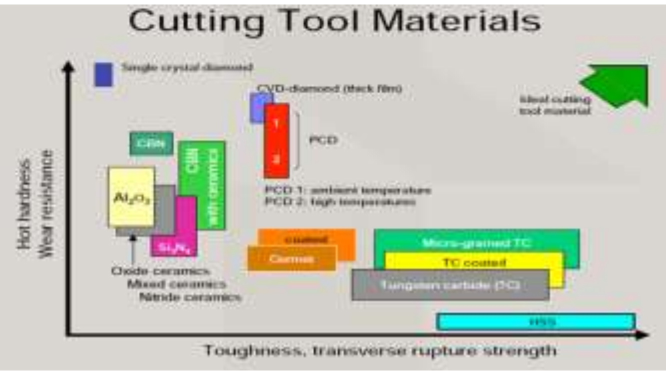

Fig 1 A graphical comparison of various cutting tool materials

Hard turning is defined as the process of single point cutting of part pieces that have hardness values over 45 RC but more typically are in the 58- 68 RC range.

From an applications standpoint, hard turning is very much a part specific process. It excels at cutting complex geometries intricate arcs, angles, and blended radii. Instead of having to buy a form wheel for the grinder that contain, you can program the lathe's single point much faster and cheaper.

Hard turning can eliminate several types of grinding, as well as lapping and other finishing operations. Not only is removing steps from the process money in the bank, but, for some, it can also mean bringing outsourced work back under their roofs and under their own control. Hard turning is a way to achieve high machining efficiency in an environmentally-acceptable manner and a new technology to machine hardened parts processed by forging or casting. Compared with grinding, hard turning can machine some complex work pieces in one step. The machining cycle time of hard turning can be up to three times faster than grinding. Hard turning also consumes about one-tenth of the energy per unit volume of metal removed than grinding and is more environmental friendly

Hard turning yields very little scrap and minimizes rejected parts. Because it uses the same coolant as soft turning, adding another coolant and its associated waste stream is unnecessary. Better still, hard turning can make cutting dry an option, letting you avoid the expense and waste products of coolant altogether. Hard turning also eliminates annoying grinding slag-and the labor-intensive, cost-laden tasks of recycling and disposing of it.

Hard turning is a developing technology that offers many potential benefits compared to grinding, which remains the standard finishing process for critical hardened steel surfaces. To increase the implementation of this technology, questions about the ability of this process to produce surfaces that meet surface finish and integrity requirements must be answered. Additionally, the economics of the process must be justified, which requires a better understanding of tool wear patterns and tool life predictions.

Hard turning is best accomplished with cutting inserts made from either CBN (Cubic Boron Nitride), Cermet or Ceramic. Since hard turning is single point cutting, a significant benefit of this process is the capability to produce contours and to generate complex forms with the inherent motion capability of modern machine tools. High quality hard turning applications do require a properly configured machine tool and the appropriate tooling. For many applications, CBN tooling will be the most dominant choice. However, Ceramic and Cermet also have roles with this process.

Hard turning is a developing technology that offers many potential benefits compared to grinding, which remains the standard finishing process for critical hardened steel surfaces. To increase the implementation of this technology, questions about the ability of this process to produce surfaces that meet surface finish and integrity requirements must be answered. Additionally, the economics of the process must be justified, which requires a better understanding of tool wear patterns and tool life predictions.

III. LITERATURE REVIEW

K Muniswaran A et al.,[1] had made a study on hard turning and in his report titled " Experimental Study On Hard Turning Of Hardened Tool Steel With Coated Carbide Cutting Tools" shows that the results obtained from the experiment involving KC 5010 cutting tool indicate that the feed factor is the most significant factor affecting the radial cutting force whereby. Increase in cutting speed will lower the radial force, because the increase in cutting speed will raise cutting temperature and reduce friction coefficient, furthermore the metal being cut off cannot be completely deformed in such a short time, both deformation and frictional force will be reduced; these combine to make the cutting force decrease.

Milton c.shaw et al.,[2] metal cutting principals by c.shaw is most useful for found mathematical relation used in calculation of cutting forces and shear stress.

Mehdi Tajdari et al.,[3] had made Surface roughness modeling in hard turning operation of AISI 4140 using CBN cutting tool ,he has to develop Ann model for surface roughness in hard turning process by input parameters like hardness of tool tip and feed rate and also developing reverse network to find the input parameters like hardness of tool tip and feed. In this case he is using different number of tool having different hardness values.

K.manikyakanthi et al.,[4] have developed a neural network model for prediction of bead height. Back propagation algorithm with learning rate of 0.6 and momentum 0.9 was used for training the network and the number of samples used for training and testing the results were 54 and 9 respectively. It is mostly helpful for developing NN models.

BerendDenkena et al.,[5] has an experimental investigation was conducted to determine the effects of cutting conditions and tool geometry on the surface roughness in the finish hard turning of the bearing steel (AISI 52100). Mixed ceramic inserts made up of aluminum oxide and titanium carbonitride (SNGA), having angles, were used as the cutting tools different nose radius and different effective rake. This study shows that the feed is the dominant factor determining the surface finish followed by nose radius and cutting velocity.

DilbagSingh . P. Venkateswara Rao [6] An experimental investigation was conducted to determine the effects of cutting conditions and tool geometry on the surface roughness in the finish hard turning of the bearing steel (AISI 52100). This study shows that the feed is the dominant factor determining the surface finish followed by nose radius and cutting velocity.

Derek Korn,[7], According to his experimental work hard turning process is less economical than conventional grinding process for obtaining good surface finish, reduces tool inventory and also reduces overall machining time.

IV. ARTIFICIAL NEURAL NETWORKS

Artificial neural networks (ANN) are modeled closely following the brain. Some neural network structures are not closely associated with the brain and some does not have a biological counterpart. However, neural networks have a strong similarity to the biological brain and therefore a great deal of terminology is borrowed from neuroscience. ANN is an information-processing paradigm that is inspired by the way biological nervous systems, such as brain, process information. ANN consists of multiple layers of simple processing elements called neurons.

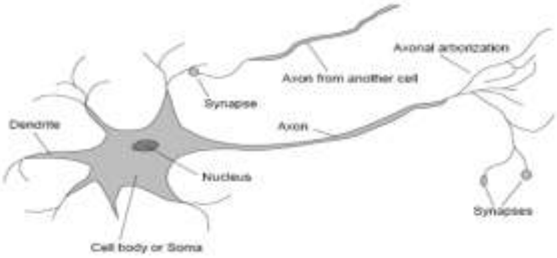

Fig 2 Biological inspiration

Structure of Artificial Neural network is composed of different layers, minimum number of layers being two; one layer consists of neurons to receive inputs, called input layer, which receive data from outside the neural network the other, viz. output layer, which send data out of neural network. Depending on the application and complexity of problem, number of layers of neurons can be increased. Layers other than input and output layers are known as hidden layers, whose input and output signals remain within the neural network.

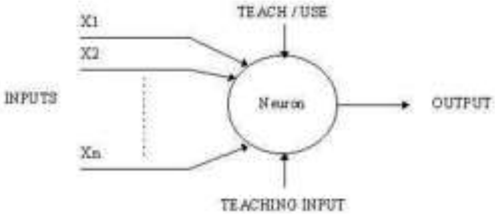

Fig 3: Artificial Neural network

V. EXPERIMENTAL PROCEDURE

5.1 Experimentation:

Cutting tests are conducted on a lathe to obtain data for training neural networks and to validate the details obtained from various techniques. Constant cutting conditions are selected for turning work piece. The present chapter provides a brief description of apparatus used and metrology followed throughout the experiments.

Fig. 4: Machining set-up on the lathe

Machining is performed on a lathe with a specifications mentioned above. EN-8 steel is selected as a work piece and KC-5525 tool is used for machining. Depth of cut is varied for constant spindle speeds. Cutting conditions mentioned below:

Spindle speeds: 256,351,494,654,937 and 1282 rpm
Depth of cut: 0.5, 1, 1.5 and 2 mm

Feed forces are measured using a lathe tool dynamometer are tabulated in table 1.

Table 1: Experimental Results for various parameters

S.No	h mm	N RPM	t sec	l nn	Fp (N)	Fq (N)	Fr (N)	Ra µm
1	0.5	256	36	7.5	49.0	107.9	78.5	1.81
2	1	256	33	6.6	88.3	205.9	98.1	2.18
3	1.5	256	47	9.0	107.9	235.4	107.9	2.04
4	2	256	30	6.0	156.9	313.8	235.4	1.92
5	0.5	351	30	9.8	58.8	117.7	88.3	2.05
6	1	351	30	8.4	98.1	196.1	107.9	1.56
7	1.5	351	30	8.1	137.3	274.6	117.7	1.73
8	2	351	30	8.9	176.5	372.7	245.2	1.67
9	0.5	494	30	11.6	68.7	127.5	98.1	1.06
10	1	494	29	11.1	117.7	215.8	117.7	2.09
11	1.5	494	28	11.3	176.5	323.6	137.3	1.09
12	2	494	30	11.8	205.9	402.1	274.6	1.09
13	0.5	654	30	13.6	98.1	264.8	98.1	1.86
14	1	654	30	14.6	107.9	205.9	107.9	2.01
15	1.5	654	30	14.4	176.5	333.4	215.8	2.2
16	2	654	26	13.7	225.6	451.1	304.0	1.74
17	0.5	937	31	20.8	68.7	98.1	225.6	1.31
18	1	937	29	21.2	137.3	274.6	245.2	1.23
19	1.5	937	30	20.4	186.3	421.7	235.4	1.54
20	2	937	30	21.3	225.6	510.0	235.4	2.07
21	0.5	1282	30	28.6	98.1	176.5	127.5	1.23
22	1	1282	30	28.5	137.3	313.8	176.5	1
23	1.5	1282	30	28.4	147.0	402.1	225.6	1.1

From the experimental data the values of various influencing parameters are calculated from the following equations.

Feed Rate $b = \frac{l}{t.n}$ (1)

Chip thickness Ratio $r = \frac{t_0}{t_1}$ (2)

Chip Reduction Coefficient $\Delta h = 1/(r)$ (3)

Shear Angle $\emptyset = \tan^{-1}\left(\frac{\cos \alpha}{\Delta - \sin \alpha}\right)$ (4)

and$\mu = \frac{(F_q + F_p \tan \alpha)}{(F_q - F_p \tan \alpha)}$, Friction angle $\beta = \tan^{-1} \mu$ (5)

Shear Force $F_s = F_p \cos \emptyset - F_Q \sin \emptyset$ (6)

Shear Area $A_s = \frac{b.h}{\sin \emptyset}$ (7)

Shear Stress $\tau_s = \frac{F_s}{A_s}$ (8)

$$K_{fc} = \frac{t_s \sin(\beta - \alpha)}{\sin\varphi . \cos(\varphi + \beta - \alpha)} \qquad (9)$$

$$K_{tc} = \frac{t_s \cos(\beta - \alpha)}{\sin\varphi . \cos(\varphi + \beta - \alpha)} \qquad (10)$$

$$F_c = K_{tc}.b.h \qquad (11)$$

$$Nc = Ktc.\ b.h \qquad (12)$$

Resultant Force R= $\sqrt{}$ (Fc2+Nc^2) (13)

Where b is feed rate, h is depth of cut, Ø is shear angle and Kfc ,Ktc are cutting constants.Fc is feed cutting force, Nc tangential cutting force.

5.2 Model Development:

The input process parameters , spindle speed(n) and depth of cut(h) are used in the presence study to predict four output parameters , the feed force(F p) ,tangential feed force (Fq), radial feed force (Fr) and surface roughness (Ra). The experimental data is used to build ANN model. A neural network model was developed using 20 samples for training and 3 experimental values for testing.

Neural network is composed of many nonlinear computational elements operating in parallel. Learning in a neural network means finding an appropriate set of weights that are connection strengths from the elements to the other layer elements. In this study, the back-propagation algorithm of neural network, which is one of various learning modes, is employed and four models are created to find feed forces and surface roughness.

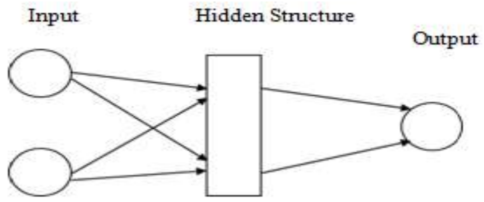

Fig 5: Schematic diagram of ANN used for prediction

The neural network in this study is employed a back propagation rule with Traingdm as learning algorithm .The input layer has 2 neurons and the output layer has 1neuron.Tan-sigmoid transfer function was used for both input and output layers. With a learning rate of 0.01 and a momentum term of 0.9 and the network was trained with above 1000 epochs.

VI. RESULTS AND DISCUSSIONS

Cutting tests are carried out on lathe using En-8 steel as work piece material and carbide tool bit. Feed force signals from the cutting tool are measured using a lathe tool dynamometer. The experiments are conduct with different values of spindle speeds and depth of cuts.

Experiments are conducted by varying depth of cuts at constant spindle speed. During the experiments, feed forces are measured using tool dynamometer. Increase in depth of cut results in feed force to increase. This Results more act on the cutting, it is also effect on the chip removal rate. Compared to remaining feed forces tangential feed force more affects the tool damage.

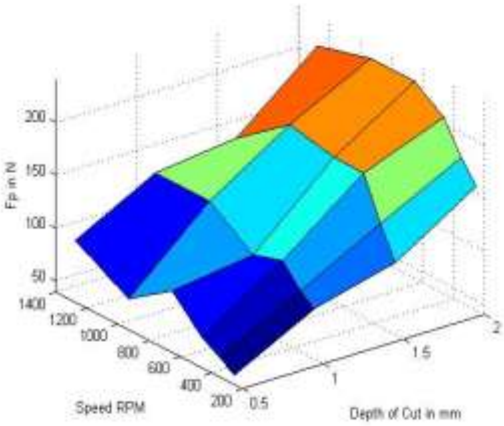

Fig6: Surface plot for Feed force Fp vs Speed and Depth of cut

If depth of cut increases, both cutting forces are also increases gradually. But at a speed of 654 rpm cutting feed cutting force first decreases up to 1mm depth of cut and then increases.

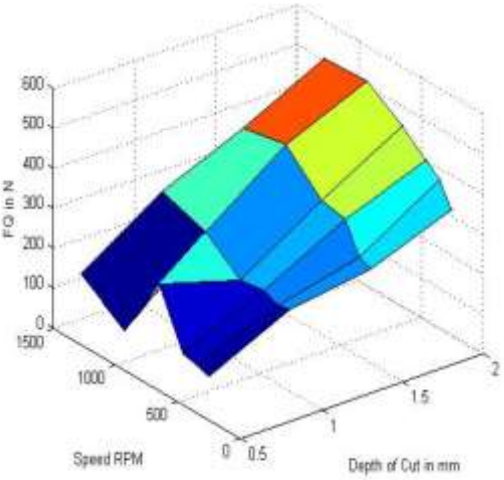

Fig 7: Surface plot for Tangential feed force Fq vs Speed and Depth of cut

The value of surface roughness varies with the depth of cut. At low speeds and high spindle speeds the surface roughness decreases upto a depth of cut 1mm and increases later above 1mm. But for medium spindle speeds, the surface roughness has a maximum value at 1 mm depth of cut and later it decreases.

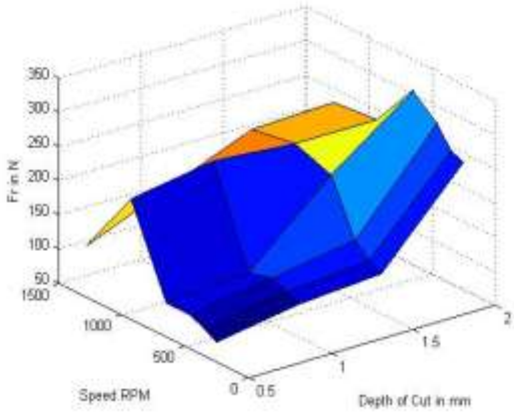

Fig 8: Surface plot for Radial feed force Fr vs Speed and Depth of cut

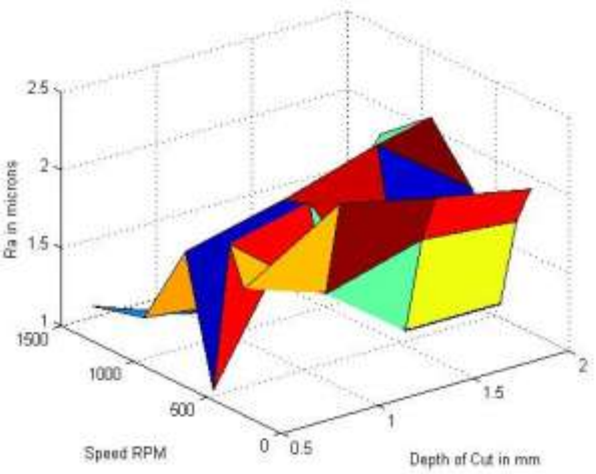

Fig 9: Surface plot for surface roughness Ra vs Speed and Depth of cut

Breaking points of cutting tool is depends on different parameters like machine condition, work piece holding devices, material composition and also depends on cutting parameters. According to my machine capability breaking point of tool occur at 1282 rpm spindle speed and at 2mm depth of cut.

Four different neural network models are developed in this work to predict feed forces and surface roughness. A correlation coefficient is calculated to measure the relationship between experimentally measured output and the output predicted by neural network model. A regression analysis was performed on the network to draw the line of best fit shown in fig for the predicted points and a correlation coefficient of 0.999 is obtained for training samples of NN tool.

VII. CONCLUSION

- It is observed that during the experimentation time, the breaking point of the tool is depending upon the input parameters, like spindle speed and depth of cut.
- In these two parameters depth of cut mostly affects the breaking of the tool tip, because the metal removal rate is increased by increasing depth of cut. Due to this reason the resistance acting on the tool tip is more. This will cause in the breaking the tool tip at the high depth of cuts at high speeds. The point obtained at spindle speed 1282 rpm and depth of cut 2mm.
- Surface finish is most important parameter for identification of quality of quality of part in the manufacturing. This surface finish is also affected by the depth of cut.
- Different neural network models are developed to predict the feed force, tangential feed force, radial feed force and surface roughness and these are found that the ANN models predicts the output with very high accuracy with percentage error ranging in between 0% to 1% for most of the samples while training and within 6% while testing.

VIII. FUTURE SCOPE

ANN models are developed for hard turning process for predicting feed forces and surface roughness. The future work based on present project can be developing a single model for performing hard turning process to evaluate the same.

NOMENCLATURE:

b	Feed Rate
l	Machine Length
t	Machine Time
r	Chip Thickness Ratio
Δ_(h)	Chip reduction Coefficient
∝	Rake Angle
Ø	Shear Angle
μ	Friction Factor
β	Friction Angle
Fp	Feed Force
Fq	Tangential Feed Force
Fr	Radial Feed Force

Ts	Shear Stress
Fs	Shear Force
As	Shear Area
Kfc ,Ktc	Cutting Constance
Fc	Feed Cutting Force
Nc	Tangential Cutting Force
R	Resultant Force

REFERENCES:

[1]. K.MUNISWARAN A/L K.SEVEEN: Experimental Study On Hard Turning Process of Hardened Tool Steel; july 2007. With Coated Carbide Cutting Tools.

[2]. Metal cutting principles by Milton c.shaw; professor Emeritus of engineering.

[3]. Saeed ZareChavoshi and Mehdi Tajdari(2010) Surface roughness modeling in hard turning operation of AISI 4140 using CBN cutting tool ; Received: 14 Springer/ESAFORM

[4]. K.Manikyakanti: Prediction of bead geometry in pulsed GMA welding using artificial neural network.

[5]. BerendDenkena: Influence of the tool corner radius on the tool wear and process forces during hard turning: Received: 24 January 2011 / Accepted: 9 June 2011 # Springer-Verlag London Limited 2011.

[6]. DilbagSingh . P. VenkateswaraRaoA surface roughness prediction model for hard turning process.

[7]. Using Hard Turning To Reduce Grinding Time’, Article from: Modern Machine Shop, Derek Korn, Senior Editor.

[8]. Metal cutting principle by P.N.RAO.

[9]. Kummer precision hard turning: the key for success, Kummer machinery online article.

Ch. Prem Chaitanya Prediction of Surface Roughness in Hard Turning Using Artificial Neural Networks.” IOSR Journal of Engineering (IOSRJEN) , vol. 7, no. 10, 2017, pp. 36-43.