Prediction Of CNC Machining Parameters For Teak Wood By Using Svm Method

K.Ajay, A.Nagaraju, Koona.Ramji

Abstract: Surface quality plays an important role in the process planning of any manufacturing industry including furniture industry.The objective of the paper is to develop a mathematical model to predict surface roughness of Teak wood material lusing CNC machining parameters. Experiments are conducted by varying Speed, feed rate and depth of cut first. The machined teak wood work pieces are analysed for surface roughness using Surftest SJ-210. The results are further evaluated using SVM method there by predicting surface roughness against machining parameters. Results proved the close relation between MRR and Surface roughness. Developed model is able to predict the surface roughness with an average error less than 8% proving its fitness for Teak wood material.

Keywords: S**urface roughness, SVM, Teak wood**

I. INTRODUCTION TO FACE MILLING

Facing is usually the first and an essential process on CNC machining centre. Milling is an operation of removing excess material by rotating cutter onto a stationary work piece on CNC milling machine [1].Surface roughness plays a major role in evaluating and measuring the surface quality of the machining a products in today's manufacturing industry. Surface roughness greatly affects the functional attributes of products which are friction, fatigue, lubricant, light reflection, and coating. Surface roughness is not only a quality indicator .But is also the final stage in controlling the machining performance and the operation cost [2]. These require a program written in terms of G-Codes. Computer numerical controlled (CNC) machine tools has been implemented to utilization full automation in milling operations and they provide degree of improvements in productivity, increase the quality of the machined parts and also its requires less operator input .[5]

A. Principle of Milling Operation

The work piece is holding on the work table. The router movement controls the feed of work piece against the rotating cutter.

Fig.1. Milling Operation

The cutter is mounted on a spindle or arbour is revolves at high speed [6]. As the work piece advances the cutter remove the materials from the surface of the work piece and the desired shape is produced. There many operations produced. There are many operations are involved in milling are end milling, chamfer milling, face milling, drilling, etc [8].

B. Importance of Teak Materials

Teak is a hardwood tree species places in flowering plant family lamiaceae. Some forms of teak are Burmese teak, Central province. Teak has leather, like smell when it is freshly milled and is particularly valued for its durability and water resistance.

Fig.2. Teak Wood

The Teak was used for prepare the boat building, exterior construction, veneer, furniture, curving, turnings, and other small wood projects. Teak has high oil content; high tensile strength and tight grain. Due to these properties, it particularly suitable where water resistance is desired [6]. The very major drawback of teak wood is very expensive. The reason for this is the declining natural resources over the years [1].

II.PROBLEM DESCRIPTION

The optimization of CNC machining parameters are important part in face milling operation. Then selection of exact process parameters is one of the most important factors are to be considered for the effective machining [5]. From these literatures survey further more scopes exists to improve the machining by using suitable tool path. Hence the tool travel length, MRR and surface finish are the major machining parameters to achieve an effective machining on

Teak wood is chose for experiment and HSS (High Speed Steel) is selected as tool material [7].

1. Machining conditions like Speed, feed rate, depth of cut are considered.
2. Machining allowance like cutter radius compensation, tool offset are essential for parameter optimization.
3. Tool size selection was taken into consideration.
4. Machining economy in terms of above parameters also has considered.

The scope of these works is to predict the CNC milling parameters of milling operation with maximum material remove rate and enhanced surface finish.

III.EXPERIMENTAL SETUP

For this experiment the whole work is carried out on CNC router machine is a cutting machine which is controlled by inputs from a computer. The CNC router gets input in the form of G/M-codes from the computer [4].

Fig 3 CNC milling machine

The specifications of CNC router:
Type = Automatic
Length of bed = 8 feet
Breadth of the bed = 4 feet
Maximum spindle speed = 18000 rpm
Power = 4.5 KW

The work piece is fastened to the bed using clamps with T-bolts. These clamping is done to ensure that the work piece does not change its orientation during machining and is held rigidly. The tool used for machining is set and is fastened using collect chuck. The maximum diameter of the tool that can be accommodated is 12.5mm [9].

A. Cutting Tool Material:

Fig 4 Ball nose milling cutter

Cutter Type Ball nose milling Cutter
Tool Material High Speed Steel
Tool Diameter 6 mm

A. Material Selection

Fig 5 Mounting of workpiece

A teak wood specimen of dimensions 75 x 140 x 25 mm is used for the present study. The work piece material is mounted onto the machine table keeping the base edges parallel to the table edgesand perpendicular to the machine's spindle head.

B. Design Variables

Input parameters:

N Speed (rpm)
f Feed rate (m/min)
d Depth of cut (mm)

Output parameter:

MRR Material remove rate
Ra Surface Roughness
% MRR Error Percentage of MRR
% Ra Error Percentage of Ra

C. Process parameters Used in Experimentation

Parameter	Units	Perform 1	Perform 2	Perform 3
Speed	Rpm	9000	12000	15000
Feed rate	m/min	2, 5, 8	2, 5, 8	2, 5, 8
Depth of cut	mm	2, 4, 6	2, 4, 6	2, 4, 6

Table 1 Process variables

D. EXPERIMENTAL WORKS

The objective of this work is to optimize the output parameters with appropriate speed, feed rate, depth of cut for achieving maximum material remove rate and maximum surface roughness. The SVM method was used to create machining inputs and to evaluate the performance of variables such as Material remove rate and Surface roughness's based on experimental results.

Fig 6 Machining Specimen

The experiments were conducted with face milling operation by applying the input variables like speed, feed rate, and depth of cut. The CNC milling machine was used for machining as per the drawing. Before machining the simulation of machining is carried out as per the generate program.

F. Evaluation of Output Parameters

1. Material remove rate (MRR)

The material MRR is defined as the ratio of the product of feed, radial depth of cut and axial depth of cut.

MRR = RDOC x ADOC x f

Where

RDOC - Radial depth of cut

ADOC - Axial depth of cut

f - Feed rate

2. Surface Roughness

Surface roughness test has done for 27 jobs were taken by using the portable surface roughness tester.

Fig 7 Portable Surface Roughness tester

G. SVM METHOD:

Support Vector Machine (SVM) is a supervised machine learning algorithm which can be used for either classification or regression challenges. SVM when your data has exactly two classes. An SVM classifies data by finding the best hyper-plane that separates data points of one class from the other class. The best hyper plane for an SVM means the one with the largest margin between the two classes. SVM algorithms use a set of mathematical functions that are defined as the kernel. The function of kernel is to take data as input and transform it into the required form. Different SVM algorithms use different types of functions like**linear, nonlinear, polynomial, radial basis function (rbf), and sigmoid.** Introduce kernel functions for sequence data, graphs, text, images, as well as vectors. The most used type of kernel function is **RBF.**Ithas localized, and finite response along the entire x-axis. The kernel functions return the inner product between two points in suitable feature space. The Prediction of MRR and Surface roughness to vary the certain parameters in SVM kernel rbf function.

test res = svroutput(x, test ip, ker, Beta, bias)

er_ test = abs(test_op-test_ip)

per_er = ((er_test/test op) *100)

A. SVM model development for Surface Roughness

Radial Basis function (RBF) is used to develop the model for surface roughness using input variables of spindle speed, feed rate and axial depth of cut and output parameter is Surface roughness. The Model development of Surface Roughness using RBF kernel function change variable like Bias function and P1,Tol, espi, Par, C are the constant in the RBF function. In order to identify the influence of these RBF variables, their values are changed individually as mentioned in the table 1 and error percentage is planned to calculate accordingly.

RBF kernel functions change variables	
P1	0.5, 1, 1.5
C	75, 100, 125
Epsi	1, 1.5, 2
Par	0.05, 0.1, 0.15
Tol	0.41, 0.51, 0.61
Bias	5, 7.5, 10, 12.5, 15

Table:2 Change variables in RBF function

IV. EVALUATION

The design of experiment was used to create a model of output parameters. The speed, feed, radial depth of cut and axial depth of cut are chosen as process variables as shown in below table (1). The significance of the parameter was found and it is developed for percentage error of MRR, Percentage error of Surface roughness and Surface roughness. By using of SVM method the performance of the experimental results were evaluated and optimized.

V. RESULTS AND DISCUSSION

From the above results of SVM with variation of its 6 kernel function parameters of RBF model, It is identified that 'Bias' parameter is able to predict the surface roughness more closely compared to the remaining 5 parameters with the least average percentage error at a Bias value of 12.5. This final SVM model is able to predict surface roughness with an average percentage error of **7.94** and with a standard deviation of **5.25**

VI. CONCLUSION

Teak (Tectona grandis) wood is one of the widely accepted hard woods especially for artistic works especially in South & Southeast Asian countries. Also, machinists are using CNC machines to carve models over teakwood material. So, an attempt is made to understand the influence of machining parameters (Spindle speed, Feed rate & Axial depth of cut) after face milling operation over surface quality of Teakwood in the present research. Keeping all other machining parameters same, 27 experiments of face milling operations are conducted over similar teak wood samples with different combinations of Spindle speed (9000, 12000 & 15000), Feed Rate (2, 5 & 8 m/min) & Axial depth of cut (2, 4 & 6 mm). Machined work pieces are analysed for surface roughness using Surftest SJ-210 Model. Six kernal function parameters of RBF model are evaluated for their influence over percentage error independently to predict surface roughness. It is identified that 'Bias' parameter is able to predict the surface roughness successfully compared to the remaining 5 parameters and the percentage error is least at a Bias value of 12.5.

Developed SVM model is able to predict surface roughness with an average percentage error of 7.94 and standard deviation of 5.25

Speed (RPM)	Feed (m/ min)	Radial Depth of Cut (mm)	Axial Depth of Cut (mm)	Ra	Percentage error in Ra				
					Bias= 5	Bias= 7.5	Bias= 10	Bias= 12.5	Bias= 15
9000	2	2	0.48	12.64	60.443	40.6646	20.8861	1.1076	1.6709
9000	2	4	0.48	15.04	66.7553	50.133	33.5106	16.8883	0.266
9000	2	6	0.48	14.02	64.3367	46.505	28.6733	10.8417	6.99
9000	5	2	0.48	12.24	59.1503	38.7255	1.3007	2.1242	22.549
9000	5	4	0.48	13.36	62.5749	43.3623	25.1497	6.4371	12.2754
9000	5	6	0.48	12.91	61.2703	41.9055	22.5407	3.1758	16.189
9000	8	2	0.48	13.125	61.9048	42.8571	23.8095	4.7619	14.2857
9000	8	4	0.48	12.09	58.6435	37.9653	17.287	3.3912	24.0695
9000	8	6	0.48	13.31	62.4343	43.6514	24.8685	6.0856	12.6972
12000	2	2	0.48	16.855	70.3352	55.502	40.6704	1.285	25.838
12000	2	4	0.48	14.3	65.035	47.5524	30.0699	12.5874	4.8951
12000	2	6	0.48	11.01	54.5867	31.8801	9.1735	13.5332	36.2398
12000	5	2	0.48	11.94	58.124	37.1859	16.2479	4.6901	25.6281
12000	5	4	0.48	12.065	58.5578	37.8367	17.1156	19.3317	24.3266
12000	5	6	0.48	14.15	64.6643	46.9965	29.3286	11.6608	6.0071
12000	8	2	0.48	12.935	61.3452	42.0178	22.6904	3.363	15.9644
12000	8	4	0.48	11.09	54.9143	32.3715	9.8287	12.7142	35.257
12000	8	6	0.48	11.74	57.4106	36.1158	14.8211	6.4736	27.7683
15000	2	2	0.48	12.195	58.9996	38.4994	17.9992	2.561	23.0012
15000	2	4	0.48	10.875	54.023	31.0345	8.046	14.9425	37.931
15000	2	6	0.48	11.22	55.4367	33.1551	10.8734	11.4082	33.6898
15000	5	2	0.48	13.26	62.2926	43.4389	24.5852	5.7315	13.1222
15000	5	4	0.48	14.16	64.9893	42.0339	29.3785	11.7232	5.9322
15000	5	6	0.48	12.985	61.494	42.241	22.9881	3.7357	15.5779
15000	8	2	0.48	12.48	59.9359	39.9038	19.8718	0.1603	20.1922
15000	8	4	0.48	14.015	64.3259	46.4859	28.6479	10.8098	7.0282
15000	8	6	0.48	14.33	65.102	47.6682	30.2163	12.7704	4.6755
				Avg	**61.07723**	**41.39589**	**21.50291**	**7.936852**	**17.55805**
				Std Dev (σ)	**3.904 3.904**	**5.736 5.736**	**8.704 8.704**	**5.25 5.25**	**10.859 10.859**

Table.3 Model development of Ra for change the Bias parameters

VIII. REFERENCES

[1] Kantheti Venkata Murali Krishnam Raju, "Optimization of Cutting Conditions for Surface Roughness in CNC End Milling", International Journal of Precision Engineering And Manufacturing Vol. 12, No. 3, Pp. 383-391.

[2] Z.Bouaziz a and A.Zghals, "Optimization and selection of cutters for 3D pocket machining". International journal of computer Integrated manufacturing. Vol-21 No.1. January-February2008, 73-88

[3] B.C.Routara and A. Bandyopadhyay and P.Sahoo, "Roughness modeling and Optimization in CNC end milling using response surface method (RSM) effect of work piece material variation" Int. J Adv Manufacturing Technology (2009)40: 1166-1180.

[4] Azlan Mohd Zain a, Habibollah Haron a, Safian Sharif b, "Application of GA to optimize cutting conditions for minimizing surface roughness in end milling machining process". Int J expert Systems with Applications 37(2010), 4650-4659.

[5] Ender Hazir, K.Hiiseyin Koc, "Determination of wood cutting parameters using Taguchi method". International journal of Scientific Research Engineering and Technology Vol-5

[6] R.Ramanathan, S,Syed Abuthanir, Dr.P.Ranjitkumar," Analysis of CNC milling Parameters for Aluminum AA6063 By using Taguchi method" International Journal of Advanced Research in Biology, Ecology, Science and Technology. Vol-1

[7] H.Oktem "An Integrated study of surface roughness for modeling and optimization of cutting parameters during end milling operation" Int J Adv Manufacturing Technology (2009)43:852-861

[8] Ender Hazir, K.Hiiseyin Koc, "Optimization of wood surface machining parameters in CNC routers, Response Surface Methodology (RSM) approach, International Journal of Scientific Research Engineering and Technology. ISSN 2278-0882, Vol-5(10), Pp: 494-50
[9] A.A.Krimpensis, N.A.Fountas, T.Mantziouras and N.M.Vaxevanidis, "Optimizing CNC wood milling operations with the use of genetic algorithms on CAM Software" Wood material Science and Engineering Vol-11, Issue 2, Pp: 102-115
[10] Priscila Roel De Deus, Manoel Cleber de Sampaio Alves, Fabio Henrique Antunes Vieria "The quality of MDF work machined in CNC milling machine in cutting speeds, feed rates and depth of cut" Meccanica (2015)50: 2899-2906. DOI 10.1007/s 11012-015-0187-z
[11] Naveen Bansal, Gyanender Ghanghas "Optimization Techniques for Surface roughness of CNC milling". IJEEMF, Vol.08, Issue 01 July 2013, ISSN: 22278-3989.
[12] Elssawi Yahya, Guofu Ding and Shengfeng Qin," Prediction of cutting force and surface roughness using Taguchi technique for aluminium alloy AA6061" Austalian Journal of Mechanical Engineering, Issue 21 July 2014, ISSn:1448-4846.
[13] S. Ozcan, A. Ozcifci, S. Hiziroglu, H. Toker, Effect of heat treatment and surface roughness on bonding strength, Constr. Build. 33 (2012)7–13.