International Conference on Recent Trends in Mechanical Engineering
International Journal of Scientific Research inScience,
Engineering and Technology
Print ISSN: 2395-1990 | Online ISSN : 2394-4099 (www.ijsrset.com)

Optimization of MRR for CNC Turning of Steel

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ABSTRACT

Stainless steel is mainly used for manufacturing of different parts like bio-implants, milk and food containers drink cans, surgical tools and structural components. It possesses excellent chemical and mechanical properties. Turning of this steel with digital control lathe enhance the material removal rate as well other desired quality characteristics than conventional lathe. Therefore in the present study digitally control lathe that is computer numerical control (CNC) lathe used to machine stainless steel. Turning on work material conducted using orthogonal array twenty seven by varying control factors speed, feed and depth of cut. Significant factor is evaluated using analysis of variance method. Depth of cut is found as significant control factor followed by feed and speed.

Keywords: steel, CNC turning, orthogonal array, coated carbide tool, Taguchi method

I. INTRODUCTION

Computer numerical control (CNC) lathe digitally control the distinct control parameters that affects the quality characteristics. However these parameters can be control manually in conventional lathe. Evaluation of optimum turning parameters for different materials may have a reference values for emerging industries. Therefore researchers have reported their work based on turning of different hard materials. Later suggested optimum values of process parameters obtained from different statistical methods [1-6]. Akhtar et al. conduct turning on aluminium alloy using orthogonal array and revealed optimum values of parameters [7]. Rizvi and Ali analysed the surface and material characteristics of CNC turned steel using hybrid approach [8]. Qinge et al. [9] had done turning to optimize turning parameters. They used hybrid method i.e. fuzzy logic and data mining for optimization of power consumption during turning. Their experimental and simulation finding were superimposed. Riadh et al. [10] studied parametric effects on surface roughness and material removal rate for turning of cobalt alloy. Tamizharasan et al. [11] used Taguchi methodology for investigation of chip thickness ratio during CNC turning of metal matrix composite. They reported that cutting speed has more effect on chip thickness ratio. Palanisamy et al. [12] used orthogonal array during turning of nickel based super alloy. Surface roughness, micro-hardness and material characteristics of work material have investigated. Ngoc et al. [13] used Taguchi-adaptive neuro-fuzzy inference system-teaching learning based model to find the optimum values of process parameters for carbon steel turning. Surface finish of analysed by varying control factors feed, speed and depth of cut for turning of steel [14-15]. Accuracy of developed techniques found robust. From the short literature review, author unable to find CNC turning of hard steel (AISI 304) using CNC Turn 250 (Model Manufacturer: EMCO Concept) with coated carbide cutting tool made of ceratizit. Orthogonal arrays (L27) are used for conduct the experiment. The main aim of present study is to obtain the optimum value of CNC lathe control factors (i.e. spindle speed, feed and depth of cut) for material removal rate. Values of optimum control factors have been obtained using Taguchi and analysis of variance methods. In this analysis it is found that the depth of cut is most significant.

II. MATERIALS AND METHODS

The Stainless steel (AISI304) is elected because it has wide applications like bio-implants, milk and food containers drink cans, surgical tools and structural components, textile equipments, cryogenic vessels and coal hopper etc. Chemical composition of work material is shown in Table I. The work piece tensile strength (MPa) = 124, experimentally calculated density (Kg/m3) = 7964, thermal conductivity (W/m-k) = 116 and melting temperature (^{0}C) = 885. Coated carbide cutting tool made of ceratizit used for cutting (turning) and CNC Turn 250 made of EMCO Concept lathe (Figure 1) used for turning. Control factors spindle speed (rpm), feed (mm/rev) and depth of cut (mm) and their associated levels are selected based on preliminary literature review and catalogue provided by cutting tool manufacturer for machining of AISI 304 stainless steel. The levels of turning process parameters are shown in Table II. Material removal rate is calculated by the weight difference of the work piece before and after machining using weighing machine then divide by the machining time multiply with the density of the selected material. Material removal rate is measured in term of (mm^3/min). To determine the MRR in term of signal to noise ratio (SNR) equation (1) is used.

TABLE I CHEMICAL COMPOSITION OF WORK PIECE (IN PERCENTAGE)

Fe	Si	Mn	P	S	Cr	Ni	N	C
66-74	1.0	2.0	0.045	0.03	18-20	8-11	0.10	0.08

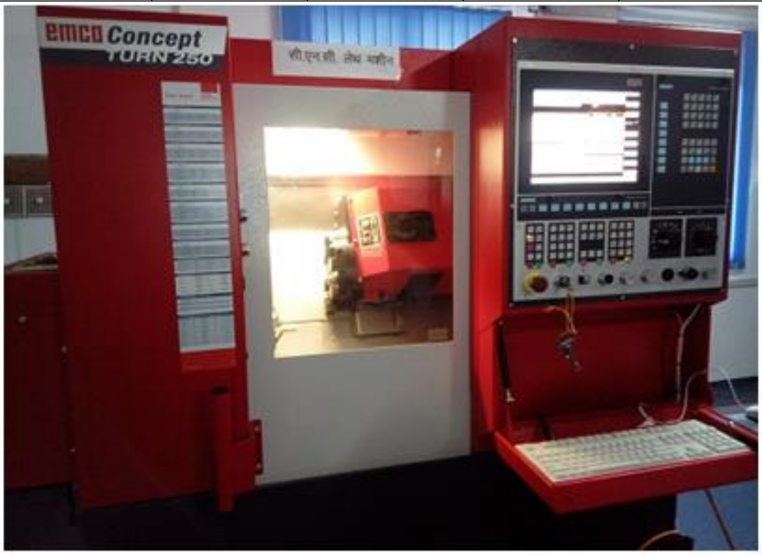

Figure 1: Photograph of EMCO Concept Turn 250 machine tool used for turning.

Table II Levels of control factors

Factors	Units	Levels		
		i	ii	iii
Spindle Speed (SS)	RPM	1400	1600	1800
Feed	mm/rev	0.08	0.14	0.2
Depth of Cut (DOC)	mm	0.4	0.8	1.2

Signal-to-Noise Ratio for MRR:

$$\left[\frac{S}{N} = -10log\left(\frac{\left(\Sigma\frac{1}{Y_i^2}\right)}{n}\right) \atop Larger - The - Better\right] \quad (1)$$

III. RESULTS AND DISCUSSION

Turning operation performed on work material using CNC lathe with coated carbide cutting tools. Material removal rate is calculated by the weight difference of the work piece before and after turning using weighing machine then divide by the machining time multiply with the density of the selected material. The experimental values of MRR are present in Table III.

TABLE III ORTHOGONAL ARRAY LAYOUT (L_{27}) AND CORRESPONDING VALUE OF MRR

Exp. No.	Input parameters			MRR	
	SS	Feed	DOC	Experimental values (mm³/min)	Signal to noise ratio (dB)
1	1400	0.08	0.4	1711.991	64.6700
2	1400	0.08	0.8	3358.02	70.5217
3	1400	0.08	1.2	5087.312	74.1298
4	1400	0.14	0.4	2674.663	68.5454
5	1400	0.14	0.8	6588.058	76.3751
6	1400	0.14	1.2	9660.706	79.7002
7	1400	0.20	0.4	4158.724	72.3792
8	1400	0.20	0.8	8566.931	78.6565
9	1400	0.20	1.2	13432.547	82.5632
10	1600	0.08	0.4	2154.555	66.6672
11	1600	0.08	0.8	5004.753	73.9877
12	1600	0.08	1.2	54175.257	94.6760
13	1600	0.14	0.4	5129.8157	74.2020

14	1600	0.14	0.8	10146.888	80.1267
15	1600	0.14	1.2	11329.797	81.0844
16	1600	0.20	0.4	6134.568	75.7557
17	1600	0.20	0.8	12022.136	81.5996
18	1600	0.20	1.2	18293.522	85.2459
19	1800	0.08	0.4	2719.479	68.6897
20	1800	0.08	0.8	5569.003	74.9155
21	1800	0.08	1.2	7774.587	77.8135
22	1800	0.14	0.4	4988.176	73.9588
23	1800	0.14	0.8	8768.331	78.8583
24	1800	0.14	1.2	12614.619	82.0175
25	1800	0.20	0.4	6717.615	76.5443
26	1800	0.20	0.8	12144.053	81.6873
27	1800	0.20	1.2	12905.436	82.2155

Analysis of Variance (ANOVA) method was introduced by Sir Ronald Fisher to evaluate different statistical components like sums of squares, degrees of freedom, error variance and F-values. Maximum material removal rate is always desired on CNC turned work part. Therefore higher is better type quality characteristic used to evaluate the signal to noise (S/N) ratio as shown in Table III. Rank of control factors evaluated by Taguchi method that is shown in Table IV. The ANOVA test performed at the significance level of 5% and confidence level of 95% [16]. From Table V, depth of cut found high than other control factors. It means depth of cut is more responsible for high material removal rate. This validates the results obtained using Taguchi method based optimization. The Figure 2 depicts the effect of control factors.

TABLE IV EVALUATION OF SIGNIFICANT CONTROL FACTORS

Levels	SS	Feed	DOC
i	74.17	74.01	71.27
ii	79.26	77.21	77.41
iii	77.41	79.63	82.16
Difference of maximum and minimum	5.09	5.62	10.89
Rank	3	2	1

Table V ANOVA TEST RESULT

Factors	DOF			
		SS	MS	F-value
SS	2	283727854	141863927	1.75
Feed	2	29506189	14753095	3.18

DOC	2	684455765	342227882	4.22
SS*Feed	4	269312890	67328223	0.83
Feed*DOC	4	242266043	60566511	0.75
SS*DOC	4	368326042	92081510	1.13
Error	8	649193073	81149134	
Total	26	252678785		
S = 9008.28	R-Sq = 74.31%	R-Sq (adj) = 16.50%		

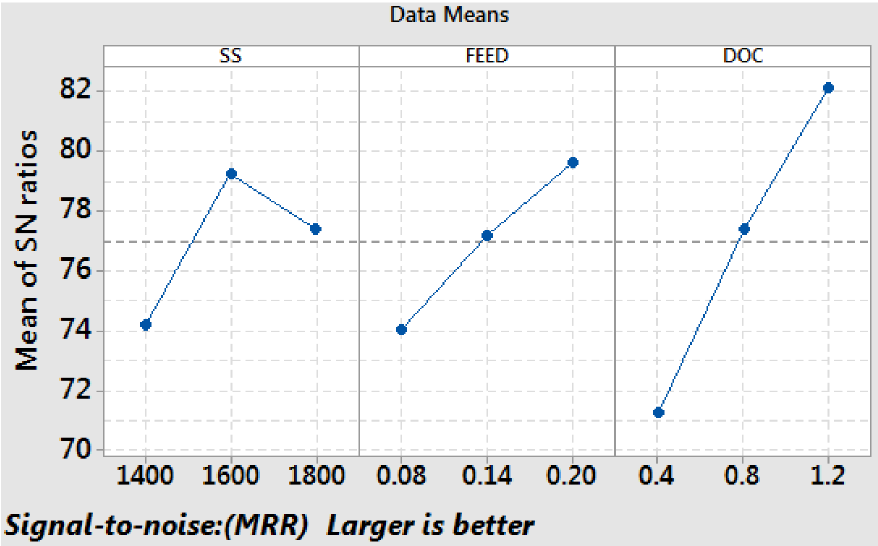

Figure 4: Main effect of SNR versus control factors

IV. CONCLUSION

Turning on stainless steel (grade AISI304) conducted using computer numerical control turn machine. Material removal rate of work material has analyzed using Taguchi and analysis of variance methods. Following observations are found from present study.

a. Orthogonal array design used for turning on work material.
b. Analysis of variance test done on 95% of confidence level.
c. Depth of cut is found significant parameter.

V. REFERENCES

[1]. Saini S. K., Pradhan S. K., Soft Computing Techniques for the Optimization of Machining Parameter in CNC Turning Operation, International Journal of Emerging Technology and Advanced Engineering, 4 (2014) 117-124.

[2]. Joshi V, Kumar H. Optimization of CNC Lathe Turning: A Review of Technique, Parameter and Outcome. Advances in Manufacturing and Industrial Engineering 73 (2021) 963.

[3]. Natarajan C., Muthu S., Karuppuswamy P., Prediction and analysis of surface roughness characteristics of a non-ferrous material using ANN in CNC turning, International Journal of Advance Manufacturing Technology 57 (2011) 1043-1051.

[4]. Saini S. K. and Pradhan S. K., Optimization of multi-objective response during CNC turning using taguchi-fuzzy application. Procedia Engineering 97 (2014) 141-149.

[5]. Saini S. K. and Pradhan S. K., Optimization of machining parameters for CNC turning of different materials. Journal of Applied Mechanics and Materials 592-594 (2014) 605-609.

[6]. Pradhan S. K. and Saini S. K., Multi-objective optimization of CNC turning machining parameters. Journal of Advanced Materials Research 1016 (2014) 172-176.

[7]. Akhtar MN, Sathish T, Mohanavel V, Afzal A, Arul K, Ravichandran M, Rahim IA, Alhady SS, Bakar EA, Saleh B. Optimization of Process Parameters in CNC Turning of Aluminum 7075 Alloy Using L27 Array-Based Taguchi Method. Materials 14 (2021) 4470.

[8]. Rizvi SA, Ali W. Analysis of surface roughness and material removal rate in machining of AISI 1040 steel using CNC turning process. International Journal of Innovation in Engineering 3 (2021) 8-19.

[9]. Qinge X., Congbo Li, Ying T., Lingling Li, Li Li, A knowledge-driven method of adaptively optimizing process parameters for energy efficient turning, Energy 166 (2019) 142-156.

[10]. Riadh S., Brahim B. F., Tarek M., Salim B., Mohamed A. Y., Modeling and optimization of the turning parameters of cobalt alloy (Stellite 6) based on RSM and desirability function. The International Journal of Advanced Manufacturing Technology 100 (2019) 2945-2968.

[11]. Tamizharasan T., Senthilkumar N., Selvakumar V., Dinesh S. Taguchi's methodology of optimizing turning parameters over chip thickness ratio in machining P/M AMMC, SN Applied Physics 1-160 (2019).

[12]. Palanisamy A., Selvaraj T., Sivasankaran S., Optimization of turning parameters of machining incoloy 800h superalloy using cryogenically treated multilayer cvd-coated tool. Arabian Journal for Science and Engineering 43 (2018) 4977-4990.

[13]. Ngoc L. C., Minh-Quan N., Thanh-Phong D., Shyh-Chour H., Te-Ching H., Du D., Van A. D., An effective approach of adaptive neuro-fuzzy inference system-integrated teaching learning-based optimization for use in machining optimization of S45C CNC turning. Optimization and Engineering 20 (2019) 811–832.

[14]. Saini S. K. and Kumar P., CNC turning process parameters optimization for stainless steel. Applications of Advanced Computing in Systems pp 59-64. https://doi.org/10.1007/978-981-33-4862-2_6.

[15]. Pradhan S K, Saini S. K., Multi-Objective Optimization of CNC Turning Machining Parameters. AMR 2014;1016:172–6. https://doi.org/10.4028/www.scientific.net/amr.1016.172.

[16]. Saini S. K. and Dubey A. K., Study of material characteristics in laser trepan drilling of ZTA. Journal of Manufacturing Processes 44 (2019) 349-358.