Vijayan et al. 2019. *Int. J. Vehicle Structures & Systems*, 11(1), 113-116
ISSN: 0975-3060 (Print), 0975-3540 (Online)
doi: 10.4273/ijvss.11.1.20

International Journal of
Vehicle Structures & Systems
Available online at www.maftree.org/eja

Analysis of Machining Parameters in Turning Operation on Duplex 2205 by using RSM for Vehicle Structure

V. Vijayan[a], B. Sureshkumar, G. Sathishkumar and R. Yokeshwaran

Dept. of Mech. Engg., K. Ramakrishnan College of Tech., Samayapuram, Trichy, Tamil Nadu, India
[a]Corresponding Author, Email: vijayan.me@gmail.com

ABSTRACT:

Turning is the machining process carried out to make cylindrical parts. Since this process is economical and the flexibility of turning operation is high, the process has become highly versatile among the industrial scenario. The design of experiments concept along with response surface methodology is used to analyze the machining parameters such as spindle seed, feed rate and depth of cut, of the turning operation. Three levels of spindle speed, feed rate and depth of cut are used as input parameters and their corresponding responses such as material removal rate (M.R.R), surface roughness, feed force, thrust force and cutting force are considered as the output parameters. The main aim of this experimentation process is to identify the optimal process parameters to get high MRR and low surface roughness. During high spindle speed, the MRR is high and vice versa. Surface roughness is high when its corresponding spindle speed and depth of cut is high. A high spindle speed, the chip formation is continuous whereas in medium speed, discontinuous chip is formed. M.R.R is high when spindle speed, depth of cut and feed rate are high.

KEYWORDS:

Turning; Tungsten carbide; Response surface methodology; ANOVA method

CITATION:

V. Vijayan, B. Sureshkumar, G. Sathishkumar and R. Yokeshwaran. 2019. Analysis of Machining Parameters in Turning Operation on Duplex 2205 by using RSM for Vehicle Structure, *Int. J. Vehicle Structures & Systems*, 11(1), 113-116. doi:10.4273/ijvss.11.1.20.

1. Introduction

Materials are manufactured from casting, forging etc. are required close tolerance to assemble the components in machine tool design. For the reason machining processes were introduced in manufacturing firms. In that lots of machining processes are available to obtain the close tolerance value such as turning, milling, grinding, drilling etc. Turning operation is one of the important process, which is used to remove the excess work piece materials from the cylindrical stock in the form of chips with the aid of cutting tools. Simultaneously, there are huge work piece materials are introduced in aeronautical, automobile and ship building industries for their inherent properties such as low weight high strength property, thermal resistance properties and high hardness properties. In that duplex materials are selected for resistance to corrosion, pitting, erosion, high mechanical strength in different manufacturing firms.

In recent days, modelling and analysis of machining parameters in engineering industries are important. So this work identify the effects of machining parameters by using response surface methodology (RSM) and significant of machining parameters and iteration effects of machining parameters are analyzed with ANOVA. Similarly the empirical models are developed with regression analysis based design of experiment. Abhang et al [1] used the work piece material as EN 31 steel alloy and Tungsten carbide as tool to determine the optimal machining parameters such as spindle speed, feed rate and depth of cut in steel turning operation. The authors used S/N ratio and ANOVA for theoretical analysis and concluded that with higher depth of cuts surface finish is improved if lubricant temperature is lowered. Ashwin et al [2] showed that the work piece material AISI 410 steel to study the effect of main turning parameter such as feed rate, tool nose radius, cutting speed and depth of cut on the surface roughness of the material. The authors has used RSM and concluded that the optimal combination of machining parameters are 255.75 m/min, 0.1 mm/rev, 0.3 mm, 1.2 mm for cutting speed, feed rate, depth of cut and tool nose radius respectively. Sharma et al [3] have identified that using EN 35 as the work piece to resolve the optimal machining parameters such as surface roughness and MRR in turning operation concludes with the results that feed has variable effect on surface roughness using Taguchi method. Varma et al [4] have identified that the work piece material as ASTM A242 TYPE 1 Alloy Steel to optimize the turning parameter such as spindle speed, feed rate and depth of cut for surface roughness of the material.

The authors used Taguchi and ANOVA method for theoretical analysis, and concluded that cutting speed has significant role to play in producing low surface roughness about 57.4% used by feed rate about 16.27%. They have also concluded that depth of cut has lesser role on surface roughness. Rajesh Kumar et al [5] identified that the work piece material as EN24 steel to optimize the MRR. The author’s used Taguchi method for theoretical analysis and also proposed that Taguchi method is a good method for optimization of various machining parameters as it reduces the number of experiments. Lazarevic et al [6] identified that using the work piece material as polyethylene to calculate the optimal turning parameters such as feed rate, depth of cut, nose tool radius for surface roughness in turning operation, Cutting edge of 213.88 m/min, Feed rate-0.049 mm/min, dept of cut-2 mm and nose tool radius-0.8mm were found to be the optimal turning operation parameters. The authors have used Taguchi method and ANOVA.

Suresh et al [7] followed the Taguchi method with AISI-1016 at different cutting condition to get lowest surface roughness in turning operation and the work concluded that the speed, feed and depth of cut are not significant on the response surface finish. Rao et al [8] used work piece material EN24 steel with Tic coated tungsten carbide and aluminium Trioxide and titanium carbide as the tool material to know about the influence of cutting parameters such as feed rate and depth of cut on cutting force and surface finish in turning operation. The authors used Taguchi method and has concluded the result that feed rate of <0.06mm/rev and depth of cut of <0.15mm give the best result for cutting force. Geo et al [9]identified that surface roughness is inversely proportional to surface finish the authors used work piece material as stainless steel and aluminium to calculate the effect of turning parameter such as spindle speed, feed rate and depth of cut on power consumption in EN 24 alloy steel using different cutting tools. The authors followed Box-Behnken design method.

Sahoo [10] showed that the work piece material as AISI 1040 Mild steel to calculate the roughness characteristics of surface profile generated during the turning process and concluded the results that depth of cut, spindle speed and feed rate are independent variables and different roughness parameters like center line average roughness, root mean square roughness and mean line peak spacing as response variables. The author used RSM and ANOVA methods for theoretical analysis. Sharma et al [11] proposed that using the work piece material as EN 16 Steel and Tungsten carbide as tool to optimize the turning parameters such as rpm, feed rate and depth of cut. The author's used RSM and ANOVA methods for theoretical analysis and concluded that rpm and depth of cut as an approximate decreasing trend and the feed rate has the variable on effect on surface roughness.

Gajanan et al [12] have used work piece materials as EN-8 and EN-31 to resolve the surface roughness in turning operation. The authors used Taguchi method and concluded with the result that this method is suitable to solve the stated problems with minimum number of trails as compared with the full factorial design. Thamizmani et al [13] have used the work piece material as SCM 440 Alloy Steel, Aluminium Trioxide and Titanium Carbide gold coated material as cutting tool to know the optimum cutting conditions to get lowest surface roughness in turning operation. The authors used Taguchi Method and concluded with the result that depth of cut 1 to 1.5mm is contributed to get lowest surface roughness. Dinesh et al [14-15] studied about the machining of AISI 4340 steel and attempted to optimize the input parameters using GRA, RSM and Taguchi methods. Krishnan et al [16] presented, classification algorithms ANFIS and random forest are used to classify the test data samples for determining the error rate by comparing its classification response with its corresponding actual response. Based on the literature review it should be noted that many researchers have used Taguchi method, RSM and ANOVA to optimize machining parameters. However, the main effects analysis using multi-parametric nature for turning operation in Duplex 2205 alloy is not witnessed by many. In this work, three levels of significance for spindle speed, feed rate and depth of cut are simulated using design of experiments. The output parameters studied are MRR, surface roughness, feed force, cutting force and thrust force.

2. Experimental investigation

The L27 experimental runs carried out in the machining process are based on levels and ranges of input parameters considered for experiments. The levels and ranges of machining parameters are selected based on machine tool specification and cutting tool manufacturer recommendation. The ranges of input parameters are given in Table 1. The Duplex 2205 as a wok piece material with a dimension of ø 20 x 60 mm length is held on lath chuck. The Tungsten Carbide insert is tightly clamped the tool holder.

Table 1: Experimental values

Input parameter	Level 1	Level 2	Level 3
Spindle speed (rpm)	230	544	830
Feed rate (mm/sec)	0.115	0.129	0.156
Depth of cut (mm)	0.5	1	1.5

3. Results and discussion

The collected experimental data are analysed with statistical technique called RSM, for investigating the input parameter influences on the surface roughness, MRR and cutting forces. Design Expert software has been used for statistical analysis. The ANOVA analysis is used for identification of parameter influences and interaction effects. The regression analysis is carried out for building empirical model. Finally developed empirical models were tested with experimental data. The effects of spindle speed, depth of cut on Surface Roughness is shown in Fig. 1. The graph shows that when depth of cut and spindle speed increases the surface roughness also increases. It can be noted that at spindle speed of 830 rpm and depth of cut 1.5 mm gives high surface response of 1.9 µm. Fig. 2 is drawn to the spindle speed, depth of cut over MRR When depth of cut and spindle speed increases MRR increases. The high spindle speed of 830 rpm and depth of cut of 1.5mm gives the highest material rate of 0.41gms/sec3. Fig. 3 represents that the feed rate has greater effect on the surface response whereas the spindle speed do not have great effect over the surface finish. The combination of spindle speed at 830 rpm and feed rate of 0.16 mm/sec provides high surface roughness of 2.1 µm on the work piece material.

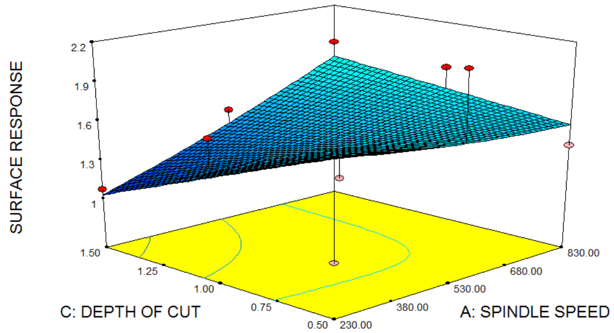

Fig. 1: Depth of cut vs. Spindle speed on surface roughness

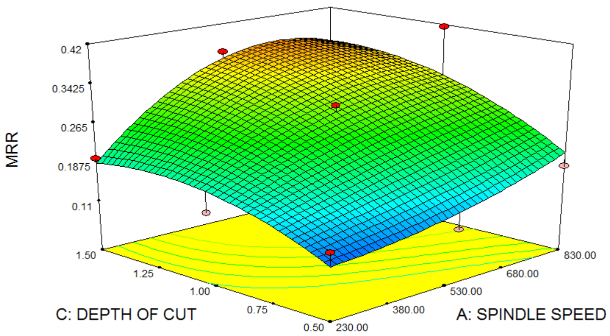

Fig. 2: Depth of cut vs. Spindle speed on MRR

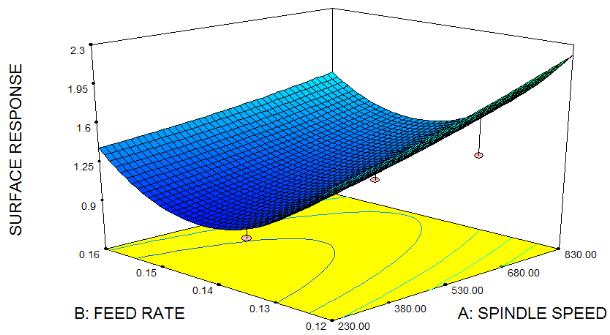

Fig. 3: Feed rate vs. Spindle speed on surface roughness

The effect of surface roughness and depth of cut over feed rate are shown in Fig. 4. The depth of cut has greater effect over the surface roughness whereas feet rate is not a deciding factor in the surface roughness. The combination of feed rate at 0.12 mm/sec and depth of cut of 1.5 mm gives high surface roughness of 2.1µm. The spindle speed has greater effect on the MRR and is the deciding factor compared to feed rate. The spindle speed of 830 rpm and feed rate of 0.16 mm/sec gives the highest MRR of 0.127gms/sec. This phenomenon is graphically depicted below in Fig. 5.

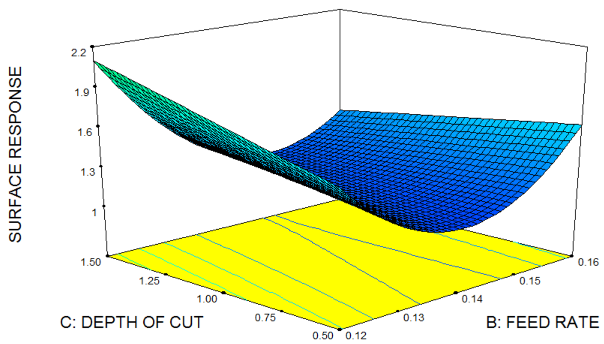

Fig. 4: Depth of cut vs. Feed rate on surface roughness

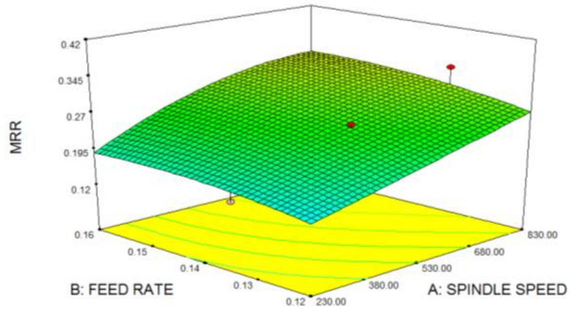

Fig. 5: Feed rate vs. Spindle speed on MRR

Fig. 6 shows that the depth of cut increase gave the MRR increase. Thus depth of cut is an important factor in the MRR. Feed rate do not have an equal effect on the material removal rate as the depth of cut. Feed rate of 0.16 mm/sec and depth of cut of 1.5 mm gave the high MRR of 0.3425 gm/sec. The effect of spindle speed, feed rate over feed force is depicted in Fig. 7. At the low level combination of low spindle speed 230 rpm and low feed rate of 0.12 mm/sec, the lowest force of 11kgf is obtained. At the combination of feed rate 0.135 mm/sec and spindle speed 230 rpm, high feed force of 20 kgf is obtained. Fig. 8 shows the distribution of spindle speed and depth of cut over feed force. The combination of spindle speed 230 rpm and depth of cut 1.5 mm gives maximum feed force of 33 kgf. The combination of spindle speed 830 rpm and depth of cut of 0.5 mm gives feed force of 19 kgf.

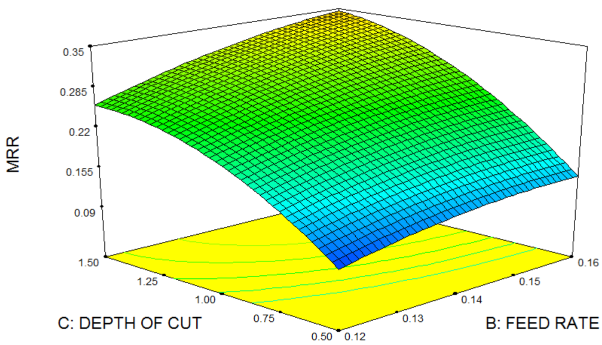

Fig. 6: Depth of cut vs. Feed rate on MRR

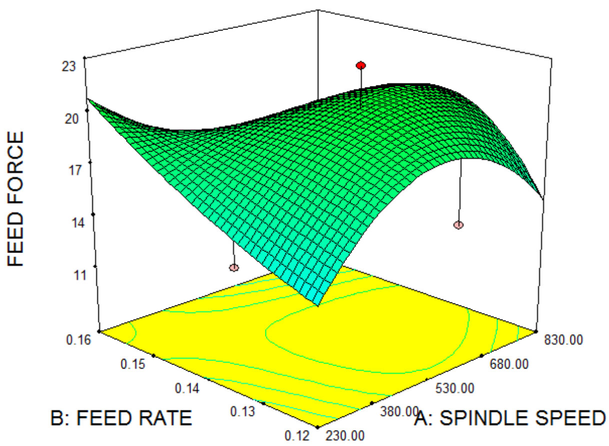

Fig. 7: Feed rate vs. Spindle speed on feed force

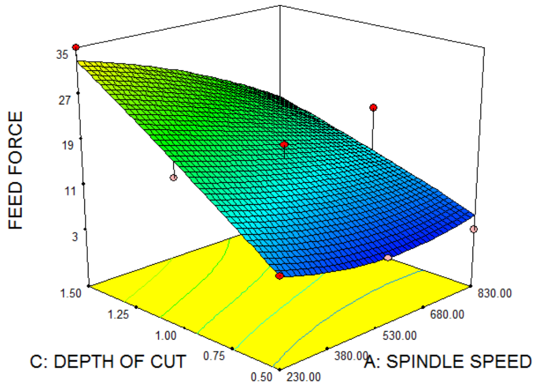

Fig. 8: Depth of cut vs. Spindle speed on feed force

4. Conclusions

The turning of Duplex 2205 with Tungsten Carbide Tool, at various levels of input parameters has lead to the following conclusions:

- Responses such as surface roughness and MRR depends on the machining parameters such as spindle speed, feed rate and depth of cut.
- During machining, tool break has occurred eight times. Four at high speed (830 rpm), three at medium speed (544rpm) and one at minimum speed (230 rpm). Hence, the tool break occurs more in number, when spindle speed is high.
- At high spindle speed, chip formation is discontionous whereas in medium and slow spindle speed, the chip formation is continous.
- MRR is high when the combination of all input parameters is high.
- The combination of minimal values of each input parameters resulted in minimum surface roughness and vice versa as the Feed Force, F_x acting on the tool is minimum when the input paramters are low.
- Cutting Force, F_z acting on the tool is dependent on the spindle speed and depth of cut. For instance, when spindle speed and depth of cut is high, the cutting force is high and vice versa.
- The machining time is low, when the combination of input parameters is high.

REFERENCES:

[1] L.B. Abhang and M. Hameedullah. 2012. Optimization of machining parameters in steel turning operation by Taguchi method, *Int. J. Engg. and Innovative Tech*., 38, 40-48. https://doi.org/10.1016/j.proeng.2012.06.007.

[2] J. Ashvin and J.I. Navanathi. 2013. Optimization of machining parameters of turning operations based on response surface methodology, *Int. J. Industrial Engg. Computations*, 46, 521-1529.

[3] H. Singh, S. Singh, H. Singh and S.K. Sharma. 2014. Optimization of machining parameters of Turning of EN 16 Steel, *Int. J. Current Engg. and Tech*;4(6), 4130-4133.

[4] J. Varma, L. Bajpai and P. Agarwal. 2012. Turning parameter optimization for surface roughness of A242 Type-1 alloy steel by Taguchi method, *Int. J. Advanced Engg. and Tech*;3(1);255-261.

[5] J. Taneja, M. Bector and R. Kumar. 2012. Application to Taguchi method for optimizing turning process by the effects of machining parameters, *Int. J. Engg. and Advanced Tech*;2(1);263-275.

[6] D. Lazarevic, M. Madiac, P. Jankovic and D. Lazarevic. 2012. Cutting parameters optimization for surface roughness in turning operation of polyethylene (PE) using Taguchi method, *Tribology in Industry*, 34(2), 294-297.

[7] K.M. Lavanya, R.K. Suresh, A.S.K. Priya and G. Krishnaiah. 2013. Optimization of process parameters in turning operation of AISI-1016 alloy steels with CBN using artificial neural networks, *Int. J. Engg. Trends and Tech.*, 5(6), 294-297.

[8] C.J. Rao, D.N. Rao and P. Srihari. 2013. Influence of cutting parameters on cutting force and surface finish in turning operation, *Proc. Int. Conf. Design and Manuf.*, 65, 1405-1415. https://doi.org/10.1016/j.proeng.2013.09.222.

[9] R. Geo and J. SherilD'cotha. 2014. Effect of turning parameters on power consumption in EN 24 alloy steel using different cutting tools, *Int. J. Engg Research and general service*, 2(6), 691-702.

[10] P. Sahoo. 2011. Optimization of turning parameters for surface roughness using RSM and GA, *Advances in Production Engg and Management*, 3(2), 197-208.

[11] A.V.N.L. Sharma, K. Venkatasubbaiah and P.S.N. Raju. 2013. Parametric analysis and multi objective optimization of cutting parameters in turning operation of EN353 – with CVD cutting tool using Taguchi method, *Int. J. Engg. and Innovative Tech.*, 2(9), 283-289.

[12] T. DinQuazi and P.G. Moore. 2012. Optimization of turning parameters such as speed rate, feed rate, depth of cut for surface roughness by Taguchi method, *Asian J. Engg. and Tech. innovations*, 2, 05-24.

[13] T. Sivaprakasam, S. Satarudin and S. Hasan. 2007. Analysis of surface roughness by turning process using Taguchi method, *J. Achievements in Materials and Manuf. Engg.*, 20(12), 503-506.

[14] S. Dinesh, M. Prabhakaran, A.G. Antony, K. Rajaguru and V. Vijayan. 2017. Investigation and optimization of machining parameters in processing AISI 4340 alloy steel with electric discharge machining, *Int. J. Pure and Applied Mathematics*, 117(16), 385-391.

[15] S. Dinesh and A.G. Antony, K. Rajaguru and V. Vijayan. 2017. Experimental investigation and optimization of material removal rate and surface roughness in centerless grinding of magnesium alloy using grey relational analysis, *Mechanics and Mech. Engg.*, 21(1), 17-28.

[16] B.R. Krishnan, V. Vijayan and G. Senthilkumar. 2018. Performance analysis of surface roughness modelling using soft computing approaches, *Appl. Math. Inf. Sci*. 12(6), 1209-1217. http://doi10.18576/amis/120616.