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Effectiveness of Milling Parameter in Horizontal Milling Machine Using EN24 Steel as a Specimen

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Abstract

In this modern era where precision and efficiency play a vital role in the field of production. Undesired vibration can create issues like bad surface finish, low competence, decrease in output and it can also impede the tool's life. New technologies are being developed day by day to tackle these problems and barriers that come across during the time of production. So to decrease the quiver on a horizontal milling machine composite material (PVC plates) was being used between the workpiece (EN24 steel) and the slotted table. This paper describes the influence of machining variables and the number of plates of PVC plates on EN24 based on the Taguchi (L27) method. Analysis of variance indicated that a better surface finish was obtained at 240 rpm and a higher number of plates gives a better surface finish.

Keywords: Milling machine, Surface finish, Taguchi method, Composite material, EN24 steel, PVC plate.

Introduction

Machines are just names that we give to those creations that make our lives easy and comfortable. They have become an important part of our life. From simple machine tools to the most complicated artificial intelligence systems all are considered as machines. The machine has countless uses in various fields. Some common fields are Manufacturing, Health care, finance, transportation, communication, agriculture, energy sector, education, entertainment, construction, research and development. In the field of manufacturing, machines play an important role, from milling machines to lathe machines they contribute their way to increasing the efficiency of production. Metal shearing is one of the most common manufacturing processes. This can be defined as the process of withdrawing material from the job to create a desired measurement.

Machining variables can have a huge impact on the effectiveness of machining activity. Some common variables are cutting speed, feed rate, depth of cut, tool geometry, coolant, and many more. The main purpose of this work was to interpret the productivity of milling variables on surface roughness. Using EN24 steel as the work item on a horizontal miller. Taguchi's (L27) method was used to design the experiment. Several PVC plates were introduced below the work piece and the worktable to observe the influence of different variables on the surface roughness of the job piece using MINITAB 18 analysis software. The ANOVA method was used to find the optimized parameter for a better surface finish.

Literature Review

In this chapter, the main aim is to review the research paper on how different parameters affect the surface roughness of a milling machine. The literature review addresses Taguchi's optimization technique that can be used to minimize surface roughness on EN-24.

Satyanarayana et al. worked on how cutting speed, feed rate, and depth of cut affected material removal rate. The experiment was conducted on a meticulous CNC milling setup using an HSS milling cutter. The choice was made to use the Taguchi method with an L9 orthogonal array. They verified that the Taguchi method gave optimal machining parameters. The optimal surface roughness was achieved at level 3 cutting speed, level 1 of feed rate, level 1 of depth of cut, and level 3 of tool corner radius. [1]

Sharma et al. examined the impact of preparing parameters on surface wrap up and fabric expulsion rate on EN31 steel. L16 orthogonal array design was chosen to examine the process parameter. The result states that for material removal rate depth of cut is most important. For minimum surface finish number of passes was the important parameter. [2]

Sahare et al. experimented with wet and minimum quantity lubrication and the outcomes of this situation were compared with each other. Taguchi L27 orthogonal array was chosen for the testing and comparing of data on Al20204. It was concluded that for wet lubrication depth of the cut affects the surface roughness and for minimum quantity lubrication depth of the cut is the highest factor that affects the surface finish. [3]

Chamble et al found that in a conducted experiment on a conventional milling machine with AI6082 alloy and index-able carbide inserts, it was observed that machining tool vibration, particularly tangential and axial vibrations, is significantly influenced by the feed rate, while spindle speed has a notable impact on radial vibration. Additionally, the surface roughness is affected by the spindle speed, with the identified ideal parameters being 710 rpm, 40 mm/min feed rate, and a 0.3 mm depth of cut. [4]

Jangid et al. carried out an experiment on EN-24 in the MAXMILL MTAB drilling machine was used to experiment. The depth of cut was an important drilling machining parameter. Two sections were planned: one for the Taguchi method, and the other one was optimized using a desirability function. The optimum values, including a feed rate of 13 mm/min, a spindle speed of 1100 rpm, and a depth of cut of 1 mm, were obtained. [5]

Sudianto et al. found that there is a way to predict the surface roughness by observing several cutting parameters. They studied various papers and research work. They found the advantages of the model such as regression, ANN, Fuzzy logic, Gaussian Taguchi, and ANFIS. The formulation of this surface roughness predicting model would contribute to the development of a smart milling machine. [6]

Liu et al. analyzed how the tool path can affect the roughness of the surface in the milling process. The series of simulations was done in a Master CAM. They kept all the parameters the same and only varied the tool path. it was found that the path parallel to the z-x axis can give us the best surface finish and the waste is also very minimal. [7]

Luiz et al. determined the optimal machining parameter of AISI D2 steel by using PVD-TiAlN coated with a WC. In a turning process keeping the dry machining condition. The main aim of the experiment was to minimize the surface finish and reduce the flank wear. The ANOVA method was used to find the result. According to the outcomes it was determined that the depth of cut is the most significant parameter for surface finish whereas the feed rate is responsible for flank wear. [8]

Kang et al. concluded that out of all the three parameters, the influence of feed rate is highest on MRR and surface roughness followed by cutting speed than depth of cut. For better machining, the important parameters are cutting speed and feed rate. It was also found that Taguchi grey relational analysis is very effective as it does not have any complicated theory or calculation. [9]

Lee et al. conducted an experiment with two different work piece materials One is metal and the other one is alloy. The roughness testing machine Kosaka SE-3500 was used for the experiment purpose. it was observed that the work piece material that has high tensile strength shows a better value of surface roughness in the testing machine. [10]

Tseng et al. have used two different approaches one is the design of the experiment to find the factors and then fuzzy logic was used to predict the surface roughness. A 63-role model of fuzzy was developed to predict the surface roughness for the given set of parameters. Its accuracy in predicting was 95% when the work piece was an aluminum block. [11]

Problem identification

From the available literature, we can observe that research has been done on the effects of machining variables on surface finish, and no work has been done on using an additional material between the workpiece and the milling machine bed. Therefore we should make an effort to use additional material in between the workpiece and bed to achieve the high surface finish.

Objective of the research work

The main purpose of this research work is to observe the surface roughness when we use EN24 steel attached to a diverse layer of PVC plates as a workpiece in a horizontal milling machine. We also observe the effect of different machining variables on the workpiece.

Experimental Details

Table 1: Attributes of composite material

Name of the Material	Material Type	Profile (mm)
Polyvinyl chloride (PVC)	Thermoplastic	205x205x10

Table 2: Machining variables and their level

Control Variables					
Variables	Symbol	Level			Unit
		1	2	3	
Feed rate	F	15.00	20.00	25.00	mm/min
Cutting speed	S	200	240	280	RPM
Depth of cut	d	0.010	0.020	0.030	mm
No. of plate	n	1	3	5	

The test was designed keeping Taguchi's method in Minitab software. L27 orthogonal array was chosen for the test. As there are three factors, each factor has three levels. Table 3 below shows us the test result.

Table 3 Test result

Sl no.	F (mm/min)	S (RPM)	d (mm)	No. of plates	(Ra)
1	15.00	200	0.020	3	0.81
2	25.00	200	0.020	3	1.22
3	15.00	280	0.020	3	2.03
4	25.00	280	0.020	3	1.62

5	20.00	240	0.010	1	1.40
6	20.00	240	0.030	1	1.74
7	20.00	240	0.010	5	1.66
8	20.00	240	0.030	5	1.92
9	15.00	240	0.020	1	1.73
10	25.00	240	0.020	1	1.49
11	15.00	240	0.020	5	1.53
12	25.00	240	0.020	5	1.79
13	20.00	200	0.010	3	1.84
14	20.00	280	0.010	3	2.22
15	20.00	200	0.030	3	1.21
16	20.00	280	0.030	3	2.01
17	15.00	240	0.010	3	1.66
18	25.00	240	0.010	3	1.22
19	15.00	240	0.030	3	1.86
20	25.00	240	0.030	3	1.98
21	20.00	200	0.020	1	1.81
22	20.00	280	0.020	1	1.86
23	20.00	200	0.020	5	1.03
24	20.00	280	0.020	5	1.46
25	20.00	240	0.020	3	1.70
26	20.00	240	0.020	3	1.26
27	20.00	240	0.020	3	0.80

Result and Discussion

The impact of the machining variables S(cutting speed), F(feed rate),d(depth of cut), and n(number of plates) on the response parameter selected are judged for three supplementary bed materials. Then the outcomes are fed into the Minitab 18 software for additional examination on surface roughness. From figure 1, figure 2, and figure 3 the graph indicates that when the feed rate increases from 15 to 20 the surface roughness also increases but gradually we can see after 20 mm/min the surface roughness starts to decline. The best feed rate is 240 rpm in this case. Here as the depth of cut is not varied very significantly its has not huge impact on surface roughness. As the number of plates starts increasing the surface finish also increases so these two are directly proportional to each other. In figure 4 we can see clearly that standard residues lie between 2 and -2. The parallel line to the x-axis in versus fit indicates that the variance is fixed. From the histogram, we conclude that the data are not outliers. Residuals versus order of the data indicate that there are systematic goods in the information due to time or data collection order.

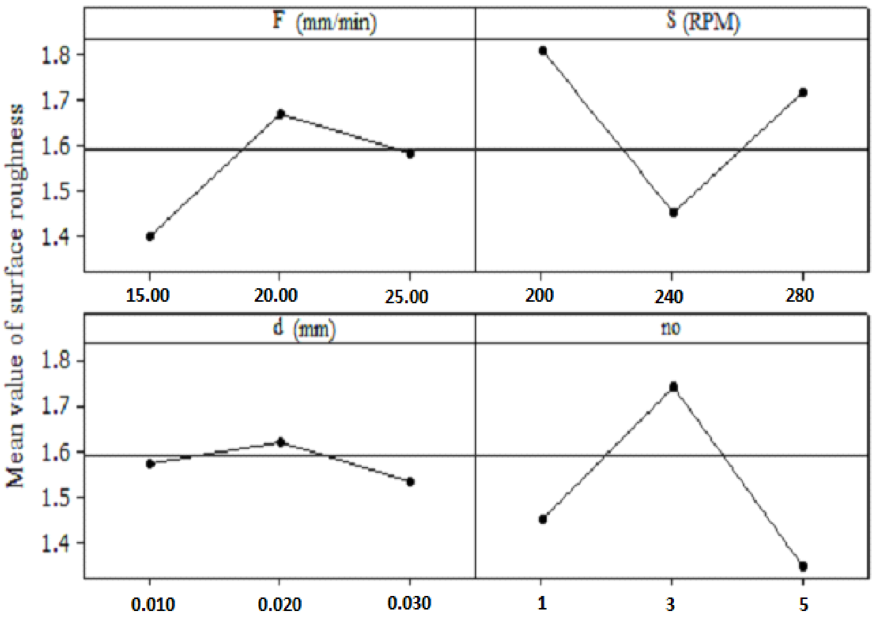

Figure 1: Main effect plot for surface roughness

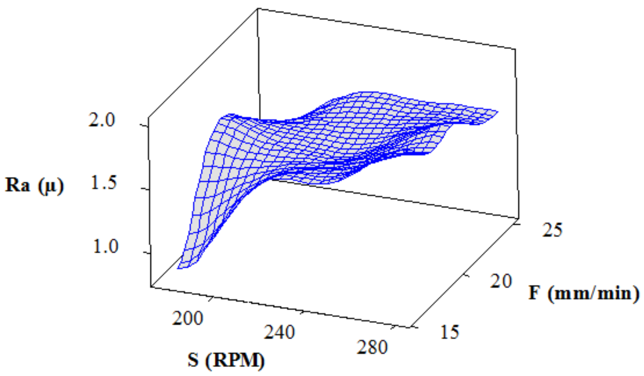

Figure 2: surface plot Ra vs. S, F

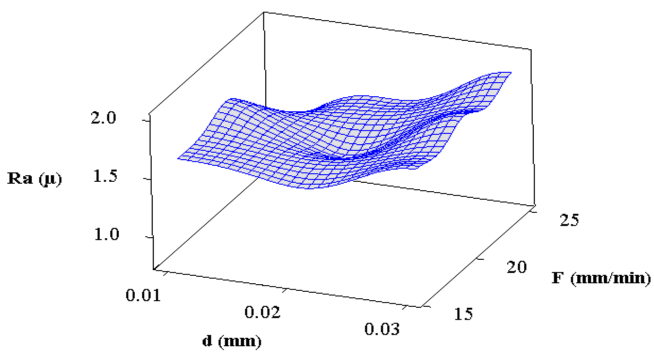

Figure 3 surface plot Ra vs. f, d

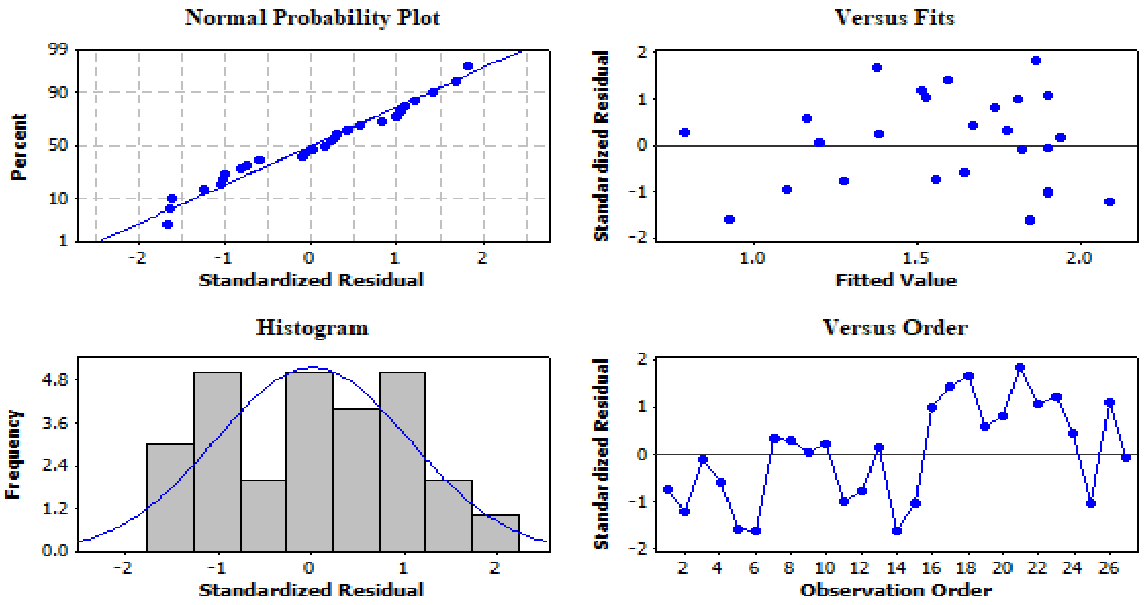

Figure 4: Residual plot for surface roughness

Conclusions

Based on the exploratory comes about, the ensuing conclusions are regularly drawn:

• Response face methodology is set up to be a successful procedure to perform analysis of face roughness in milling operations regarding diverse combinations of design variables (cutting speed, feed rate, depth of cut, and figures of plates).

• The upper value of the feed rate gives the great outer layer finish.

• Speed is increased within the face roughness value is shrinking up to maximum position also they start to increase. The optimum value of the speed is 240 rpm permanent face finish.

• The quantum of the plate is to the face roughness value dwindling. So, it's frequently shown that the quantum of the compound plate adds to the face finish. 2nd order response model for Ra is more precise significant results during machining activity.

References

[1] Kosaraju Satyanarayana, Vadla Tharun Kumar, Ravi Rathod, Md Shafi, Shankara Chary, Ahmed Alkhayyat, Manisha Khanduja - "Optimization Of Machining Parameters Of CNC Milling Operation For Material Removal Rate And Surface Roughness On En-24 Steel Using Taguchi Method". E3s Web Of Conferences (2023) 391.

[2] Vishal Sharma, Ganesh Kantak, Md. Mukhtar Alam, Kunal Yadav.- “Evaluation Of Surface Grinding Response Parameters Of En31 Alloy Steel” IOP Conference Series: Material And Science Engineering (2022) 1224.

[3] Shipa B Sahare, Sachin P Utawale, Prashant D Kamble, Ss Chaudhari, Trupati Balvir – “Experimental Investigation Of Milling Process Under Optimum Lubricant Use” Journal Of Physics Conference (2021)

[4] Parmesh Chamble, M.R Bharath, K Lokesha, S Christoper Ezil Singh – “Machine Tool Vibration On Dimensional Accuracy And Surface Roughness During Milling Operation Of Al6082 With Indexable Carbide Insert” Journal Of Applied Research And Technology 18 (2020) 69-76

[5] Yogesh Kumar Jangid, Ashish Goyal, Manish Dadhich -”, Investigation of Cutting Time and Tool Wear Rate on Rn-24 Steel Alloy By the Drilling Process." Engineering Review (2020).

[6] A.Sudianto, Z Jamaludin, A.Azwan Abdul Rahman. – “Prediction of Surface Roughness for Development of Smart Milling Machine” Journal of Physics Conference (2019) 1201.

[7] Bai Liu, Jixuan Yvan, Zhenjiu Zhang. – "Simulation Analysis Of Surface Roughness For Milling Process" Natural Science, Volume 11, Number 5 (2019)

[8] N. López-Luiz, O. Jiménez Alemán, F. Alvarado Hernández, M. Montoya Dávila, V. H. Baltazar-Hernández "Experimentation on Tool wear and surface roughness in AiSi D2 steel turning with Wc insert" Modern Mechanical Engineering Volume – 8, Number – 3 (2018)

[9] Amardeep S Kang, Gurmeet S Cheema, Varun Gandhi- “Optimization Of Surface Roughness And Metal Removal Rate In End Milling Using Taguchi Grey Relationship Analysis" Indian Journal Of Science And Technology Volume-10 (2017) 31.

[10] Joon-Seong Lee "Evaluation Of Surface Roughness Of Metal And Alloy Material" Journal Of Material Science And Chemical Engineering Volume-4, Number-1(2016)

[11] Tzu-Liang Tseng, Uday Varun Konada, Yongjin Kwon – “A Novel Approach To Predict Surface Roughness In Machining Operation Using Fuzzy Set Theory” Journal Of Computational Design And Engineering Volume-3 Issue-1 (2016) 1-13.