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Geometrical Properties and Machining Process Parameters Optimization on EN 24 by Using VMC

Sikkandar M [a], Jeeva R [b]

[a] *Graduateship / Associate membership , Mechanical Engineering, Indian Institute of Industry Interaction Education and Research*

[b] *Professor / Project Coordinator / Indian Institute of Industry Interaction Education and Research*

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A B S T R A C T

Because of their capacity for production, materials made through casting, forging, and extrusion techniques typically have higher average dimension tolerances. In order to increase product operating efficiencies and achieve tight tolerance assembly, machining procedures were introduced. In response, a variety of machining techniques, including drilling, grinding, milling, and turning, are available nowadays to solve these issues. A crucial part of producing components with excellent accuracy and increased productivity is the milling procedure. The surface of the work material is then planned with an improved surface texture using the face milling procedure.Getting high flatness and low roughness is a key goal of this milling technique.The study sheds light on the factors that affect the flatness, machining timing, Surface Roughness (SR), and Material Removal Rate (MRR) of EN 24 work piece materials. To increase productivity and part quality, face milling parameters including feed rate, depth of cut, and spindle speed must be carefully chosen. In order to improve face milling performances, this work formulates the link between input and response factors. The Taguchi approach was employed to examine the outcomes of the experiment. Speed mostly affected surface roughness, machining timing, and flatness.

1. Introduction

1.1 Milling

The process of milling involves passing work through a spinning multipoint cutter in order to remove metal. Because of the high rotation speed and numerous cutting edges of the cutter, metal is removed quickly during a milling process. Because multipoint cutting edges have more cutting points than single point tools, projects are machined more quickly and have a superior surface polish. A drill or lathe tool operates somewhat differently from a milling cutter. The cutting edge of the cutter is in constant touch with the material being cut during a milling operation. Gradually, the cuts pick. Every tooth produces a chip, and the process to remove it starts with a sliding action when the cutter makes contact with the metal. A crushing action follows shortly after, and the cutting operations occur last Modern manufacturing employs the milling process extensively because of its accuracy and adaptability.

1.2 Cutting Parameters and Responses

MRR, machining time, surface roughness, and tool wear are generally regarded as significant machining responses. The cutting parameters of feed, depth of cut, and cutting speed primarily influence these responses. Additionally, several of the reactions in this work have been examined for different process parameter levels..

1.3 Cutting Speed

The relative motion of the work piece past the cutting edge is cutting speed which is calculated from the following relation

Cutting Speed $v = \pi DN/60$ m/min

Where D-Diameter of the cutter

N-Rpm of the cutter

1.4 Feed

The speed at which the work piece moves under the cutter in a milling machine is called the feed. The distance the work travels in a minute determines the feed per minute. Millimeters per minute are used to express it.

1.5 Depth of cut

The thickness of material removed during a single pass of the piece under the cutter is known as the depth of cut in milling. It is quantified as the perpendicular distance, in millimeters, between the work piece's initial and final surfaces.

1.6 Material Removal Rate

Material removal rate is the volume of the material removed. It is expressed in mm3/min which is calculated by using the formula given below

MRR=BxtxT

Where B- width of the cut in mm

T-Table Travel in mm/min

t-Depth of cut

1.7 Machining Time

It is the amount of time, measured in seconds with a stop watch, needed to finish one cycle of operation.

1.8 Surface Roughness

No matter how the product is made, a perfectly level and smooth surface is impossible to achieve. The machine's components or parts keep the surface imperfections that were left over from manufacture. A part's surface is its exterior or boundary, and its surface imperfections are made up of many small valleys and wedges that diverge from a nominal surface that is fictitious.

2. Work Material Details

Work material – EN 24steel

Work material size–100X 100 mm Square plate 6 mm thickness

3. Chemical Properties

Table :1 Chemical properties

C	**Mn**	**Si**	**S**	**P**	**Cr**	**S**	**Mo**
EN 24	0.2	0.5-1	0.35	0.75-1.25	0.05	0.04	0.35

4. Experimental Setup

L 9 orthogonal array was used as the basis for the studies in relation to the full factorial design. Based on machine tool specifications and tool maker guidelines, the three factors and each of the three levels with two replicates were taken into consideration. The VF 30 CNC machining center from AKSARA was used for the trials.

Figure:1 CNC Vertical Milling Machine

5. Design of Experiment

Table: 2 Process parameters and their levels

Levels	Process Parameters		
	Speed	Feed	DOC
1	1000	1200	0.20
2	1500	1400	0.40
3	2000	1600	0.60

5.1 AN Orthogonal Array L_9 Formation

Table :3 L9 Array formation

Trial	Designation	Speed	Feed	Doc
1	$A_1B_1C_1$	1000	1200	0.20
2	$A_1B_2C_2$	1000	1400	0.40
3	$A_1B_3C_3$	1000	1600	0.60
4	$A_2B_1C_2$	1500	1200	0.40
5	$A_2B_2C_3$	1500	1400	0.60
6	$A_2B_3C_1$	1500	1600	0.20
7	$A_3B_1C_3$	2000	1200	0.60
8	$A_3B_2C_1$	2000	1400	0.20
9	$A_3B_3C_2$	2000	1600	0.40

5.2 Experimental Data

Table : 4 Input parameters and output responses

Trial No.	Speed	Feed	Doc	Mt Min	Ra µm	FLAT
1	1000	1200	0.20	2.41	1.419	0.013
2	1000	1400	0.40	2.38	1.257	0.014
3	1000	1600	0.60	2.34	1.045	0.013
4	1500	1200	0.40	2.25	0.546	0.014
5	1500	1400	0.60	2.21	0.453	0.032
6	1500	1600	0.20	2.29	0.449	0.070
7	2000	1200	0.60	2.18	0.561	0.035
8	2000	1400	0.20	2.22	0.584	0.027
9	2000	1600	0.40	2.19	0.331	0.036

5.6 Machining Time (Analysis of Result)

5.6.1 Machining time and S/N ratios values for the experiments

Table : 5 S.N Ratio value of Machining Timing

TRIAL NO.	DESIGNATION	Speed	Feed	DOC	Machining time	SNRA1
1	$A_1B_1C_1$	1000	1200	0.20	2.41	-7.64034
2	$A_1B_2C_2$	1000	1400	0.40	2.38	-7.53154
3	$A_1B_3C_3$	1000	1600	0.60	2.34	-7.38432
4	$A_2B_1C_2$	1500	1200	0.40	2.25	-7.04365
5	$A_2B_2C_3$	1500	1400	0.60	2.21	-6.88785
6	$A_2B_3C_1$	1500	1600	0.20	2.29	-7.19671
7	$A_3B_1C_3$	2000	1200	0.60	2.18	-6.76913
8	$A_3B_2C_1$	2000	1400	0.20	2.22	-6.92706
9	$A_3B_3C_2$	2000	1600	0.40	2.19	-6.80888

5.6.2 Machining Time and S/N Ratios Values For The Experiments

Table: 6 Response Table for Signal to Noise Ratios-Smaller is better

Level	Speed	Feed	Doc
1	-7.519	-7.151	-7.255
2	-7.043	-7.115	-7.128
3	-6.835	-7.130	-7.014
Delta	0.684	0.036	0.241
Rank	1	3	2

Table :7 Analysis of Variance for MT, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	F	P	% Contribution
SPEED	2	0.051289	0.025644	144.25	0.007	89
FEED	2	0.000156	0.000078	0.44	0.696	10
DOC	2	0.006022	0.003011	16.94	0.056	1
Error	2	0.000356	0.000178			-
Total	8	0.057822				100

Regression Equation

MT = 2.27444 + 0.10222 Speed_1000 - 0.02444 Speed_1500 - 0.07778 Speed_2000

+ 0.00556 Feed_1200 - 0.00444 Feed_1400 - 0.00111 Feed_1600 + 0.03222 DOC_0.2

- 0.00111 DOC_0.4 - 0.03111 DOC_0.6

5.7 Surface Roughness's (Analysis of Result)

5.7.1 Surface roughness and S/N ratios values for the experiments

Table: 8 SN ratios values in surfaces roughness

TRIAL	**DESIGNATION**	**Speed**	**Feed**	**DOC**	**Ra**	**SNRA1**
1	$A_1B_1C_1$	1000	1200	0.20	1.419	-3.03965
2	$A_1B_2C_2$	1000	1400	0.40	1.257	-1.98671
3	$A_1B_3C_3$	1000	1600	0.60	1.045	-0.38233
4	$A_2B_1C_2$	1500	1200	0.40	0.546	5.25615
5	$A_2B_2C_3$	1500	1400	0.60	0.453	6.87804
6	$A_2B_3C_1$	1500	1600	0.20	0.449	6.95507
7	$A_3B_1C_3$	2000	1200	0.60	0.561	5.02074
8	$A_3B_2C_1$	2000	1400	0.20	0.584	4.67174
9	$A_3B_3C_2$	2000	1600	0.40	0.331	9.60344

5.7.2 surface roughness response for each level of the process parameter

Table: 9 Response Table for Signal to Noise Ratios-Smaller is better

Level	**speed**	**feed**	**doc**
1	-1.803	2.412	2.862
2	6.363	3.188	4.291
3	6.432	5.392	3.839
Delta	8.235	2.980	1.429
Rank	1	2	3

Table:10 Analysis of Variance for Ra, using Adjusted SS for Tests

Source	**DF**	**Seq SS**	**Adj SS**	**F**	**P**	**% Of Contribution**
SPEED	2	1.13415	0.567074	764.94	0.001	90
FEED	2	0.08502	0.042510	57.34	0.017	7
DOC	2	0.02902	0.014511	19.57	0.049	3
Error	2	0.00148	0.000741			-
Total	8	1.24967				100

Regression Equation

RA = 0.73833 + 0.5020 Speed_1000 - 0.2557 Speed_1500 - 0.2463 Speed_2000 + 0.1037 Feed_1200

+ 0.0263 Feed_1400 - 0.1300 Feed_1600 + 0.0790 DOC_0.2 - 0.0270 DOC_0.4 - 0.0520 DOC_0.6

5.8 Flatness Error (Analysis of Result)

5.8.1 Flatness and S/N Ratios Values for the Experiments

Table: 11 SN-Ratios Values for Flatness

Trial	**Designation**	**Speed**	**Feed**	**Doc**	**Flat**	**SN-ratio**
1	$A_1B_1C_1$	1000	1200	0.20	0.013	37.7211
2	$A_1B_2C_2$	1000	1400	0.40	0.014	37.0774
3	$A_1B_3C_3$	1000	1600	0.60	0.013	37.7211
4	$A_2B_1C_2$	1500	1200	0.40	0.014	37.0774
5	$A_2B_2C_3$	1500	1400	0.60	0.032	29.8970
6	$A_2B_3C_1$	1500	1600	0.20	0.070	23.0980
7	$A_3B_1C_3$	2000	1200	0.60	0.035	29.1186
8	$A_3B_2C_1$	2000	1400	0.20	0.027	31.3727
9	$A_3B_3C_2$	2000	1600	0.40	0.036	28.8739

5.8.2 Flatness response for each level of the process parameter

Table: 12 Response Table for Signal to Noise Ratios-Smaller is better

Level	**Speed**	**Feed**	**Doc**
1	37.51	34.64	30.73
2	30.02	32.78	34.34
3	29.79	29.90	32.25
Delta	7.72	4.74	3.61
Rank	1	2	3

Table: 13 Analysis of Variance

Source	**DF**	**Seq SS**	**Adj SS**	**F**	**P**	**% Of Contribution**
SPEED	2	0.001052	0.000526	1.48	0.403	37
FEED	2	0.000610	0.000305	0.86	0.538	23
DOC	2	0.000364	0.000182	0.51	0.662	14
Error	2	0.000711	0.000355			26
Total	8	0.002736				100

Regression Equation

FLAERR = 0.02822 - 0.01489 Speed_1000 + 0.01044 Speed_1500 + 0.00444 Speed_2000

- 0.00756 Feed_1200 - 0.00389 Feed_1400 + 0.01144 Feed_1600 + 0.00844 DOC_0.2

- 0.00689 DOC_0.4 - 0.00156 DOC_0.6

6. Conclusion &Result

6.1 Conclusion

In this work, the ideal EN24 milling parameters under dry conditions were determined using the Taguchi approach and ANOVA. The ANOVA method was used to assess the experimental outcomes. One can derive the following conclusion. The Taugchi approach and ANOVA were employed in this work to determine the ideal parameters for milling steel in a wet environment. The Taguchi approach was employed to examine the outcomes of the experiment. Temporal Machining, Surface Roughness, and Flatness were the primary variables impacted by speed. Maximum depth of cut with minimum flatness mistake accomplished at moderate speed. One can derive the following conclusion.

6.2 Result Optimal Control Factor

1. Surface Roughness-A_1 (Speed-1000) B_3 (Feed-1600mm/min) C_2 (DOC-0.40mm)
2. Machining Timing- A_1 (Speed-1000) B_2 (Feed-1400mm/min) C_3 (DOC-0.60mm)
3. Flatness- A_1 (Speed-1000) B_2 (Feed-1400mm/min) C_3 (DOC-0.60mm)

6.3 Percentage of Contribution of Process Parameter

1. Surface Roughness- speed 89%
2. Machining Timing Speed-90%
3. Flatness Error- Speed-37%

REFERENCES

1. **Kishan Dhameliya 1, Jignesh Desai1, Mohit Gandhi1, Divyesh Dave1*** Experimental investigation of process parameters on MRR and Surface roughness in turning operation on CNC Lathe machine for Mild Steel – E250: IS 2062, 1. Dr. Jivraj Mehta a institute of technology, Mogar- 388340, Anand, Gujarat-India, International Journal of Engineering Research & Technology (IJERT)
2. **Abubakar Buhari, Liu Ping (Prof.)**, Study of the Effect of Machining Parameters on Surface Finish in End Milling of Heat Treated Manganese Steel, School of Mechanical Engineering, Tianjin University of Technology and Education (TUTE) Tianjin, P.R. China., International Journal of Engineering Research & Technology (IJERT)
3. **J. Vehmeyera,*, I. Piotrowska-Kurczewskia, F. Bohmermannb, O. Riemerb, P. Maasa**, Least-squares based parameter identification for a function-related surface optimisation in micro ball-end milling., aCenter for Industrial Mathematics (ZeTeM), University of Bremen, 28359 Bremen, Germany bLaboratory for Precision Machining (LFM), University of Bremen, 28359 Bremen, Germany, Procedia CIRP 31 (2015) 276 – 281
4. **Biswajit Das *, S. Roy, R.N. Rai, S.C. Saha**, Application of grey fuzzy logic for the optimization of CNC milling parameters for Al–4.5%Cu–TiC MMCs with multi-performance characteristics, National Institute of Technology, Agartala, Barjala, Jirania, Tripura, Pin-799046, India,, Engineering Science and Technology, an International Journal 19 (2016) 857–865
5. **Nikolaos Tapoglou*, Jörn Mehnen, Jevgenijs Butans, Nicolau Iralal Morar**, Online on-board optimization of cutting parameter for energy efficient CNC milling, EPSRC Centre for Innovative Manufacturing in Through-life Engineering Services, Manufacturing Department, Cranfield University, MK43 0AL, UK
6. **Andris Loginsa, Toms Torimsa**, The Influence of High-Speed Milling Strategies on 3D Surface Roughness Parameters, aRiga Technical University, Faculty of Transport and Mechanical Engineering, Ezermalas St. 6K-105, Riga, LV-1006, 25th DAAAM International Symposium on Intelligent Manufacturing and Automation, DAAAM 2014
7. **chandra nath, zachary brooks and thimas r. Kurfess**, on machinability study and process optimization in face milling of some alloys with indexable copy face mill inserts, school of mechanical engineering, georgia institute of technology, atlanta, georgia, USA
8. **Saurin Sheth a*, P M George b**, Experimental Investigation and Prediction of Flatness and Surface Roughness during Face Milling Operation of WCB Material, a*Associate professor, Mechatronics Engineering Department, G.H. Patel College of Engineering & Tech, VV Nagar, Gujarat, India bProfessor & Head, Mechanical Engineering Department, B V M Engineering College, VV Nagar, Gujarat, India., 3rd International Conference on Innovations in Automation and Mechatronics Engineering, ICIAME 2016
9. **Kannan. S1, Baskar. N*2**, Modeling and Optimization of Face Milling Operation Based on Response Surface Methodology and Genetic Algorithm, #Department of Mechanical Engineering, A. V. C. College of Engineering, Mannampandal, Mayiladuthurai, Tamilnadu, India. Pin: 609 305, Kannan. S. et.al / International Journal of Engineering and Technology (IJET)
10. **Mulugundam Siva Surya1, Sridhar Atla2**, Effect of Approach Angle in Face Milling Using Tungsten Carbide Tool, Assistant Professor, Mechanical Department, GITAM University, Hyderabad, Telangana, International Journal of Recent advances in Mechanical Engineering (IJMECH) Vol.4, No.2, May 2015