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INFLUENCE OF CUTTING CONSTRAINTS AND COATED EFFECTS ON VIBRATION SIGNALS AND SURFACE ROUGHNESS IN CNC MILLING

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A R T I C L E I N F O

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Face milling; feed; vibrations in the tool-work piece system; measurement; milling machine ,Analysis

A B S T R A C T

Vibration affect tool life and machine tool spindle during machining of hardened material. Chatter in machined surfaces that affect the surface quality and dimensional accuracy of product. This paper present way to deal with determines vibration examination on machining of (SS-316 310) material during end milling process. SS-316 310 is a nickel-copper alloy which combines excellent corrosion resistance and added advantages of greater strength and hardness. Typical applications for SS-316 310 products are fasteners, springs, pumps and Values. In this investigation spindle speed, feed and depth of cut selected as an input parameters and Feed acceleration is consider as response parameter. Tool wear rateis also investigated during end milling operation of SS alloy. The vibration test was carried by vibrometer and amplitudes were recorded with different spindle speeds of CNC vertical milling machine. The test were conducted various combinations of spindle speeds. The experimental result shows that spindle speed is the major factor that affects the tool vibrations. Analysis of Variance of feed acceleration was shown to predict vibrations during machining of SS-316 310 by end milling process.

1. Introduction

End milling process is one of the techniques to produce key ways and slots in metal surfaces. Goal of machining operations to achieve good surface finish, dimensional exactness and surface nature of machining surfaces. Milling cutter is a significant factor in metal removal process due to damage of tool and idle time of production. Metal cutting process are metal cutting mechanism which greatly involved between tool and work material. SS well known super material which provides great mechanical properties. SS is mainly used to production of fasteners, cutting tool, petroleum and chemical industrial applications. In end milling process rigidity and tool vibrations are important problems that should be considered. An important characteristics of end milling process such as very less machining area, low tool rigidity, high speed of tool, results it produce more cutting vibrations. Machining chatter is a general vibration phenomena caused by cutting conditions and machine tool. Chatter may be a relative structural excited vibration between cutter and work piece incurred at the cutting zone. Sadettin Orhan et al [2] studied that relationship between the modification of vibration and power wear was investigated throughout End milling process, results vibration amplitude increase with the progression of tool wear. Constantine David et al. [9] analyzed that vibrations caused by cutter run out and have an effect on the chip removal rate. Sukhdev et al. [6] investigated that decrease of surface roughness and power vibration in CNC edge operation and machine vibrations area unit analyzed by response surface response methodology and located feed rate is that the most dominating parameter touching surface end. Nurul Hidayahetal. [8] found that vibration amplitude throughout cutting method will increase with the cutting speed and feed rate will increase with progression of tool wear embedded sensing element within the rotating tool within the End milling process. Lijieetal [10] investigated that modification of spindle speed powerfully affected acceleration vibration and conjointly found that spindle speed is that the most significant parameter that ought to be controlled and reduction of spindle speed will plain decreases the cutting vibrations. Premnarayan viswakarma et al. [12] chosen spindle speed, feed and depth of cut using

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DEFORM 3D software is done on milling operation by varying the parameter of milling cutter and work piece. TaDuyHein [11] deal with investigation on eigen value in stochastic free vibration problem of functionally graded (FG) plates involving uncertain elastic modulus. The main limitation of End milling process is caused by vibrations of machine and work piece. Vibration observation is a vital check to find tool conditions, Surface roughness, dimensional tolerance and chatter throughout machining operations. Commonly vibration analysis is carried out under different machining process parameters and also verifies the difference in milling cutter dimension. This paper investigate the mutual relation of milling cutter wear and vibration signal using vibrometer for the end milling process of SS-316-310 material using coated end mill cutter.

2. Experimental details

End milling operations were carried out in MCV 450 -Vertical milling machine is shown in Fig. 1. A 5 mm coated end mill cutter used to machine SS-316-310 material in different process parameters. Spindle speed, Feed and Depth of cut are the input parameters and feed acceleration is the response parameter of vibrational analysis during end milling operation of SS. The experiments are design by orthogonal array and conducted by 4 levels of milling process parameters. Vibrometer is assist to record Machine vibrations and tool vibration during machining with different spindle speed. The details of chemical and Mechanical properties of SS-316-310 are given in Tables 1 and 2.

3. Result and discussion

Vibration analysis of end milling process

In this Experimental investigation Vibrations are analyzed during End milling process of SS-316 310 material with different factors with 4 levels. The tool wear is measured by Tools maker microscope. The experiments are designed by Taguchi orthogonal array (Table 3). The response parameter is taken as feed acceleration for analyzing vibrations during various process parameters. The end milling process parameters are analyzed through SN Ratio and tool wear. It indicates minimum feed acceleration of end milling of Monel occurs in 2500 rpm, 0.025 mm/rev and 0.4 mm and occur less tool wear (0.18 mm).

Fig 1. CNC – Vertical milling operation.

Table 1
Chemical composition of SS-316 310 .

Ni	9.79 -2010
Cu	0.42-0.085
Al	2.0-NI
Ti	0.8-0.0
C	0.25
Mn	1.98-0.43
Fe	68.51-54.81
Si	0.50-NI

Table 2
Specific mechanical properties of SS-316 310.

Tensile strength (Ksi)	430
Elongation (%)	15%
Hardness (HRc)	34

Table 3
Milling parameters of SS-316 310 for feed acceleration analysis.

Exp. No	Spindle speed (Rpm)	Feed (mm/ rev)	Depth of Cut (mm)	Feed acceleration (mm/sec^2)	S.R Tool (um)
1	2500	0.2	0.5	14.67	0.32
2	2500	0.2	0.5	44.92	0.40
3	2600	0.3	0.7	15.94	0.34
4	2600	0.3	0.7	17.94	0.36
5	2500	0.2	0.5	19.34	0.50
6	2500	0.2	0.5	19.68	0.48
7	2600	0.3	0.7	15.98	0.52
8	2600	0.3	0.7	14.30	0.52
9	2500	0.2	0.5	20.16	0.43
10	2500	0.2	0.5	11.42	0.45
11	2600	0.3	0.7	26.42	0.44
12	2600	0.3	0.7	35.42	0.50
13	3500	0.4	0.4	24.72	0.53
14	3500	0.4	0.3	24.32	0.55
15	3500	0.4	0.2	18.62	0.53
16	3500	0.8	0.1	17.22	0.55

Bian Huameiet al. [7] observed that CNC vertical machine vibration characteristics and achieved vibration signal and source of spindle speed, results tool failure, chatter and vibration developed in low and high levels of end milling process parameters and concludes that hardened steel produce more vibration in low level spindle speed. Fig. 2 shows that main effect plot of Vibration developed during the machining of SS-316-310 in end milling process. It mentioned that third level of spindle speed (2500 rpm) and also indicates spindle of end milling process is a dominating parameter in End milling process.

Table 4 shows that response table for analyzing vibrations during end milling process of SS-316-310 material. It denotes spindle speed (Rank1) is an influencing parameter (smaller is best concept) while achieving the lower vibration and produce good surface finish.

Agus Susantoet al. [3] shows that vibration analysis results using Hilbert-Huang Transform method and represents higher level vibrations are developed by misalignment of milling cutter and machining surface. Spindle speed then feed rate were playan important role for chatter in machining surfaces. Pedrammehr et al. [4] explained about tool vibrations developed by rigidity of tool and milling machine during high spindle speed rotation. The modal is evaluated and correlated with an experimental result by end milling process of CNC vertical milling machine.

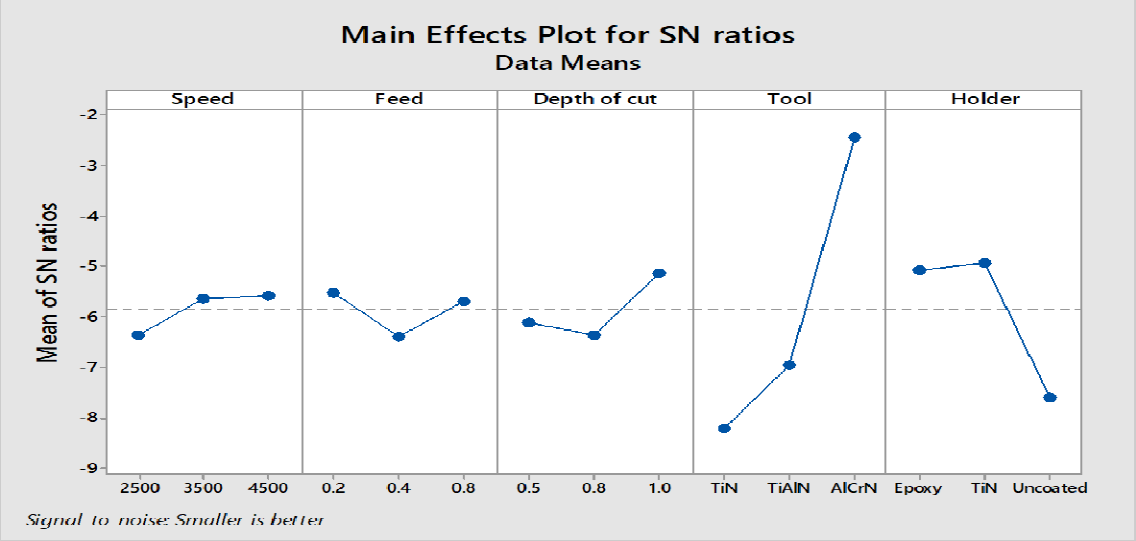


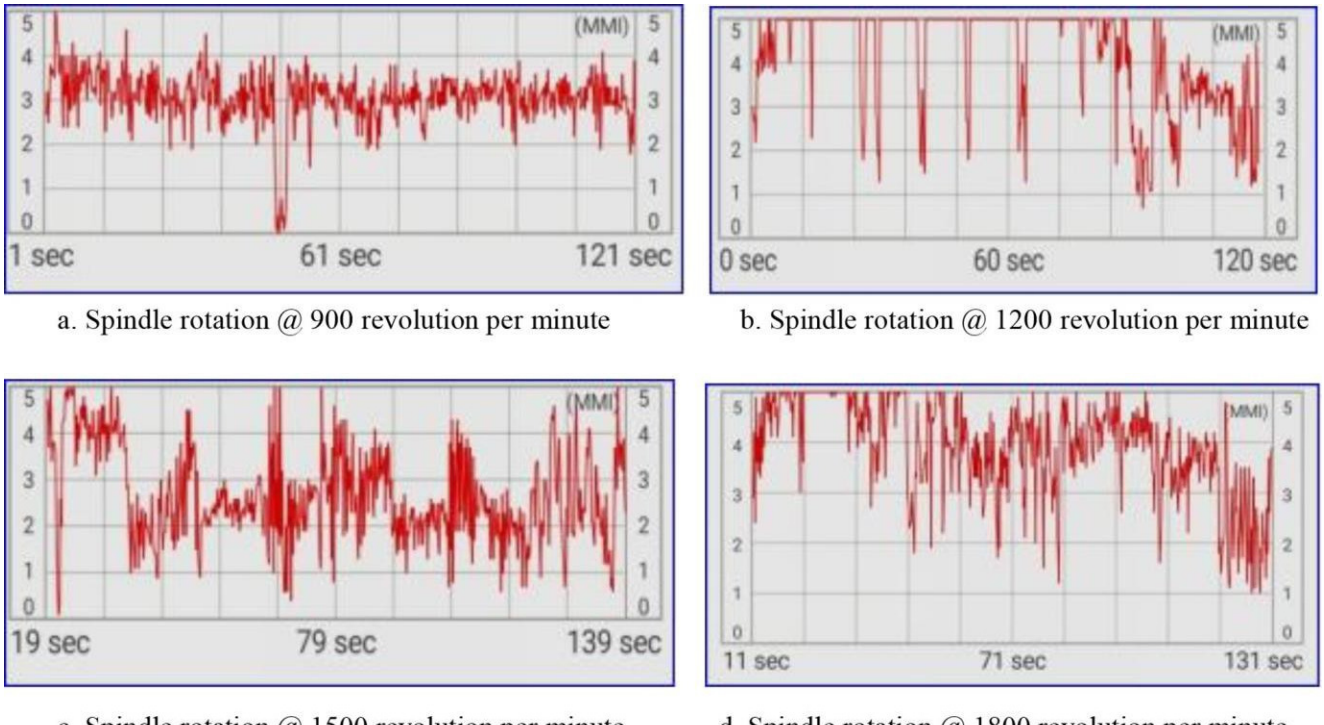
Fig 2. Main effect plot for Vibration during machining of SS-316 310

Table 4
Response table for machining vibrations of SS-316 310 (Smaller is better).

Level	Spindle speed (Rpm)	Feed (mm/rev)	Depth of Cut (mm)
1	—15.16	–22.11	—20.98
2	–22.01	—21.83	–22.83
3	—27.92	–22.79	–22.52
4	—25.82	—24.17	—24.56
Delta	12.76	2.34	3.58
Rank	1	3	2

Table 5
Analysis of variance for feed acceleration during machining SS-316 310.

Source	DOF	Sequence SS	Adjoint SS	Adjoint MS	F Value	P Value
Speed	3	873.23	873.23	291.08	17.88	0.002
Feed	3	38.44	38.44	12.81	0.79	0.544
Depth of cut	3	82.24	82.24	27.41	1.68	0.269
Error	6	97.70	97.70	16.28	–	–
Total	15	1091.61	–	–	–	–



a. Spindle rotation @ 900 revolution per minute

b. Spindle rotation @ 1200 revolution per minute

c. Spindle rotation @ 1500 revolution per minute

d. Spindle rotation @ 1800 revolution per minute

Fig 3. (a,b,c,d) Vibration frequencies in different spindle speed of end milling process.

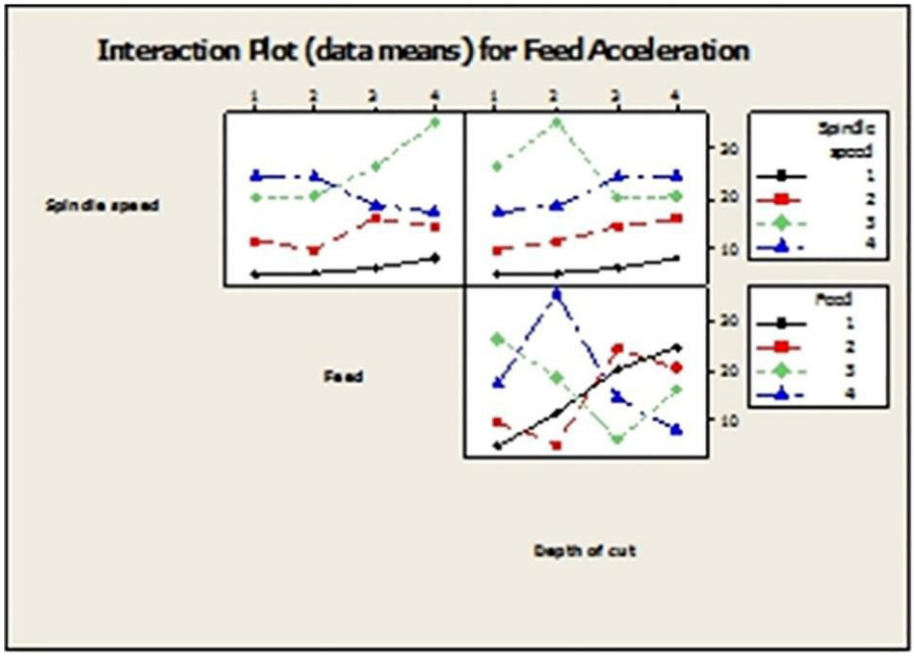


Fig 4. Interaction plot for feed acceleration analysis of milling process.

Fig. 3 denotes the vibration frequency developed by various combination of spindle rotations (2500, 2600, 2500 and 3500 revolutions per minute) were analyzed by using vibrometer which was used to observe whether chatter frequency. The interval of 61 sec, 60 sec, 79 sec, 71 sec (machining of 20 mm length work pieces) was used to obtain this frequency spectrum during End milling process of SS-316 310 material.

According to Fig. 3(a–d) general frequencies appear in the frequency band, from the figure a denotes medium vibrations and produce more chatter, fig b denotes medium vibrations and produce medium chatter, fig c denotes less vibrations and less chatter and fig d denotes less vibrations and medium chatter. The best suitable spindle speed of End milling process is 2500 rpm for achieving less vibration, chatter and tool wear.

To [1] analyzed vibration in high speed milling process and found that vibrations produced in less feed rate and very high depth of cut of process parameters and confirm with Analysis of variance. Table 5 represents Analysis of variance for feed acceleration during end milling process of SS-316 310 material. It indicates higher value of F mention that spindle speed is a dominating parameter in end milling process of SS-316 310 material.

Roshan pateletal [5] conducted dynamic vibration analysis of end milling process and found that more chatter and vibrations are developed in high spindle and low feed rates. It was also mention the spindle speed and feed rate are dependant process parameters of milling process. Fig. 4 denotes interaction plot for feed acceleration analysis of end milling process. It shows that Spindle speed, Feed and depth of cut were dependant process parameter for achieving less feed acceleration and also produce good surface finish and dimensional accuracy.

4. Conclusion

Vibration analysis was conducted during machining of SS-316 310 in End milling process and concludes as follows

- The vibration amplitude of milling machine increases with increases with tool wear
- Tool wear increases with spindle speed of milling machine during machining of SS machining
- Spindle rotational speed is an influencing parameter to achieve lower feed acceleration
- Higher value of F value in Analysis of Variance indicates spindle speed is an influencing parameters for obtain lower feed acceleration
- Depth of cut, Spindle rotational speed and feed rate of End milling process parameters were the dependant parameters to get lower feed acceleration.
- Chatter is occurs in both lower (2500 rpm) and very high spindle speed (3500) during machining of SS-316 310 in end millingprocess. No chatter marks are developed in 2500 RPM.
- FEM modal will serve for further analysis to find out optimum cutting parameter of End milling process of Stainless Steel.

Declaration of Competing Interest

The author declare that there is no conflict of interest.

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