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Process Parametric Optimization of CNC Vertical Milling Machine Using ANOVA Method in EN24

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Abstract: ***Materials are manufactured from casting, forging and extrusion processes have higher typical dimension tolerances due to its producing ability. So, machining processes were introduced for close tolerance assembly and improve the product working efficiencies. In response, now a day's lots of machining processes are available such as turning, milling, drilling and grinding to overcome these problems. Milling operation is playing vital role on making the components with high accuracy and higher productivity. Subsequently, face milling operation is utilized for planning the surface of work material with improved surface texture. It is one of the important milling processes to achieve high flatness and low roughness. The work enlights the parameters influence on Surface Roughness (SR). As seen in this study, the Taguchi method provides a systematic and efficient methodology for the minimum surface roughness with far less effect that would be required for most optimization techniques. Based on the S/N ratio, the optimal parameters for the minimum surface roughness are the feed rate at level 1 (80 mm/min), the cutting speed at level 3 (1000 rpm), face mill diameter at level 3 (12 mm-E24) and the depth of cut at level 2 (2 mm). The tool diameter influences the surface roughness next to the feed rate.***
Keywords: EN24, MRR Face milling, Ra, DOE, Taguchi design

I. INTRODUCTION

A. Milling

Milling is the process of removing metal by feeding the work past a rotating multipoint cutter. In milling operation, the rate of metal removal is rapid as the cutter rotates at a high speed and has many cutting edges. Thus, the jobs are machined at a faster rate than with single point tools and the surface finish is also better due to multipoint cutting edges. The action of the milling cutter is vastly different from that of a drill or lathe tool. In milling operation, the cutting edge of the cutter is kept continuously in contact with the material being cut. The cuts pick gradually. The cycle of operation to remove the chip produced by each tooth is first a sliding action at the beginning, the cutter meets the metal and then crushing action takes place just after it is leading finally to the cutting actions. The versatility and accuracy of the milling process causes it to be widely used in modern manufacturing.

B. Face Milling

Face milling is a widely used machining operation to produce plane surfaces with defined properties. One important application of face-milled surfaces is their use as seal faces. Here, the surface quality and the edge shape of the workpiece are essential for its functionality. Non-compliance with one of the quality requirements mentioned above can lead to malfunction of a component in operation. In addition to its importance for functionality of part, an unsatisfactory edge shape complicates the manageability of the and can lead to injuries while handling the work pieces.

C. Improved Productivity

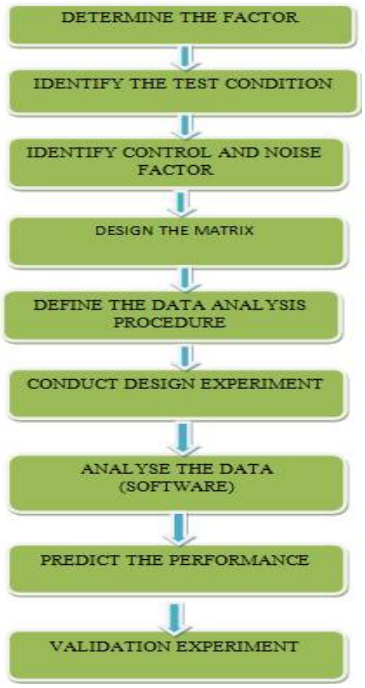
It is a very complex problem in machining and depends on the machining methods as well as machining factors employed each time. The following factors have significant impact in cutting processes,

1) Cutting conditions (cutting speed, feed rate, depth of cut)
2) Process kinematics
3) Cutting tool form and material
4) Mechanical properties of processed material
5) Vibrations in the machine tool system

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D. Experimental Plan

The proposed work approach and methodology has been elaborately shown in the flow chart.



II. CNC MILLING OVERVIEW & INPUT PARAMETER



Fig: 1vertical Milling Machine

Computer Numerical Control (CNC) Milling is the most common form of CNC. CNC mills can perform the functions of drilling and often turning. CNC Mills are classified according to the number of axes that they possess. Axes are labeled as x and y for horizontal movement, and z for vertical movement, as shown in this view of a manual mill table. A standard manual light-duty mill (such as a Bridgeport™) is typically assumed to have four axes: Table x.

1) Table y.
2) Table z.
3) Milling Head z.

The number of axes of a milling machine is a common subject of casual "shop talk" and is often interpreted in varying ways. We present here what we have seen typically presented by manufacturers. A five-axis CNC milling machine has an extra axis in the form of a horizontal pivot for the milling head, as shown below.

This allows extra flexibility for machining with the end mill at an angle with respect to the table. A six-axis CNC milling machine would have another horizontal pivot for the milling head, this time perpendicular to the fifth axis.

CNC milling machines are traditionally programmed using a set of commands known as G-codes. G-codes represent specific CNC functions in alphanumeric format.

A. Experimental Setup

The experiments were conducted based on L9 orthogonal array with respect to full factorial design. The three factors and each three levels with two replicates were considered based on machine tool specifications and tool manufacturer recommendations.

B. Machine Specifications

The experiments were conducted on BATLIBOI CHETAK-75MC-VMC fourth axis machining center

C. Tool and Insert

The tool diameter is a key factor while calculating the material removal rate. The diameter of tool is considered as 30 mm for this experiment. Tungsten carbide inserts are used for this experimental work

III.MACHINING PARAMETER

A. Taguchi Approach

Basically, experimental design methods were developed original fisher. However experimental design methods are too complex and not easy to use. Furthermore, many experiments must be carried out when the number of the process parameters increases, to solve this problem, the Taguchi method uses a special design of orthogonal arrays to study the entire parameter space with a small number of experiments only. The experimental results are then transformed into a signal – to – noise (S/N) ratio to measure the quality characteristics deviating from the desired values. Usually, there are three categories of quality characteristics in the analysis of the S/N ratio, i.e., the – lower – better, the – higher – better, and the – nominal – better. The S/N ratio for each level of process parameter is compared based on the S/N analysis.

B. Design of Experiment

TABLE I
PROCESS PARAMETERS AND THEIR LEVELS

Levels	Process Parameters			
	Diameter mm	Spindle Speed (*N*) (RPM)	DOC mm	Feed Rate (mm/min)
1	8	400	1.5	80
2	10	700	2	110
3	12	1000	2.5	130

C. Experimental Data Analysis and Optimization

TABLE III
EXPERIMENTAL DATA ANALYSIS

Sl. No	Diameter mm	Speed (N) (RPM)	DOC mm	Feed Rate (mm/min)	Ra (Mean) micron
1	8	400	1.5	80	3.489
2	8	700	2	110	5.308
3	8	1000	2.5	130	7.208
4	10	400	2	130	6.321
5	10	700	2.5	80	3.487
6	10	1000	1.5	110	5.51
7	12	400	2.5	110	4.826
8	12	700	1.5	130	6.421
9	12	1000	2	80	2.299

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D. S/N Ratios Values for the Experiments

TABLE IIIII
S/N RATIOS VALUES FOR THE EXPERIMENTS

Sl. No	Diameter mm	Speed (N) (RPM)	DOC mm	Feed Rate (mm/min)	Ra (Mean) SN-Ratio
1	8	400	1.5	80	-10.854
2	8	700	2	110	-14.498
3	8	1000	2.5	130	-17.156
4	10	400	2	130	-16.015
5	10	700	2.5	80	-10.849
6	10	1000	1.5	110	-14.823
7	12	400	2.5	110	-13.671
8	12	700	1.5	130	-14.790
9	12	1000	2	80	-8.59

E. Surface Roughness (Analysis of Variance)

TABLE VI
RESPONSE TABLE FOR SIGNAL TO NOISE RATIOS-SMALLER IS BETTER

Level	Diameter mm	Speed (N) (RPM)	DOC mm	Feed Rate (mm/min)
1	-14.170	-13.514	-13.943	-9.645
2	-13.896	-13.833	-12.582	-14.331
3	-12.352	-13.070	-13.892	-16.441
Delta	1.818	0.763	1.361	6.797
Rank	2	4	3	1

TABLE V
ANALYSIS OF VARIANCE FOR RA, USING ADJUSTED SS FOR TESTS

Source	Df	Seq Ss	Adj SS	Adj SS	F	P	% of Contribution
Diameter	2	5.7657	5.7657	5.7657	0	0	7
Speed	2	0.8814	0.8814	0.8814	0	0	1
Doc	2	3.5736	3.5736	3.5736	0	0	4
Feed	2	72.6122	72.6122	72.6122	0	0	88
Residual Error	0	0	0	0			0
Total	8	82.8329					100

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F. Confirmation Test

Once the optimal level of the design parameters has been selected, the final step is to predict and verify the improvement of the quality characteristic using the optimal level of the design parameters. The estimated S/N ratio using the optimal level of the design parameters can be calculated as:

$$\hat{\eta} = \eta_m + \sum_{i=1}^{m} \left(\tilde{\eta} - \eta_m \right)$$

Where η_m is the total mean S/N ratio, $\tilde{\eta}$ the mean S/N ratio at the optimal level, and m is the number of the main design parameters that affect the quality characteristic. The estimated S/N ratio using the optimal cutting parameters for tool life can then be obtained as follows:

TABLE VI
ESTIMATED S/N RATIO USING THE OPTIMUM LEVEL

Optimum parameter	η	η_m	$\eta - \eta_m$
Tool diameter (8mm)	-12.352	-13.052	-0.7
Speed (400rpm)	-13.896	-13.833	-0.063
Depth of cut (1.5mm)	-14.170	-13.514	-0.656
Feed rate (80mm/min)	-12.808	-10.404	-2.404
		Total	3.823

Estimated S/N ratio = -12.352+3.823 = -8.529
S/N ratio at optimum level i.e., experiment number `9' in Table 4 = -8.529
From above calculations, it is observed that estimated S/N ratio and mean S/N ratio at optimal level are almost same which indicates that our experimental and predicted results validate.

IV. RESULT & CONCLUISON

The various parameters have to be selected for CNC milling machining. The work piece will be planned with various parameters like DOC, speed; feed angle. In order to achieve to high degree surface finish swells minimum cycle timing.
As seen in this study, the Taguchi method provides a systematic and efficient methodology for the minimum surface roughness with far less effect that would be required for most optimization techniques. Based on the S/N ratio, the optimal parameters for the minimum surface roughness are the feed rate at level 1 (80 mm/min), the cutting speed at level 3 (1000 rpm), face mill diameter at level 3 (12 mm-E24) and the depth of cut at level 2 (2 mm). The tool diameter influences the surface roughness next to the feed rate. Therefore e, the tool diameter seems to be the most critical parameter and should be selected carefully in order to reduce all kinds of damages. Conceptual S/N ratio and ANOVA approaches for data analysis draw almost similar Conclusions. The confirmation experiments were conducted to verify the predicted optimal parameters with the experimental results. The comparison of the predicted and experimental values of Surface roughness using the optimal cutting parameters, showed a good agreement between the predicted and experimental results of order of 98.61%.

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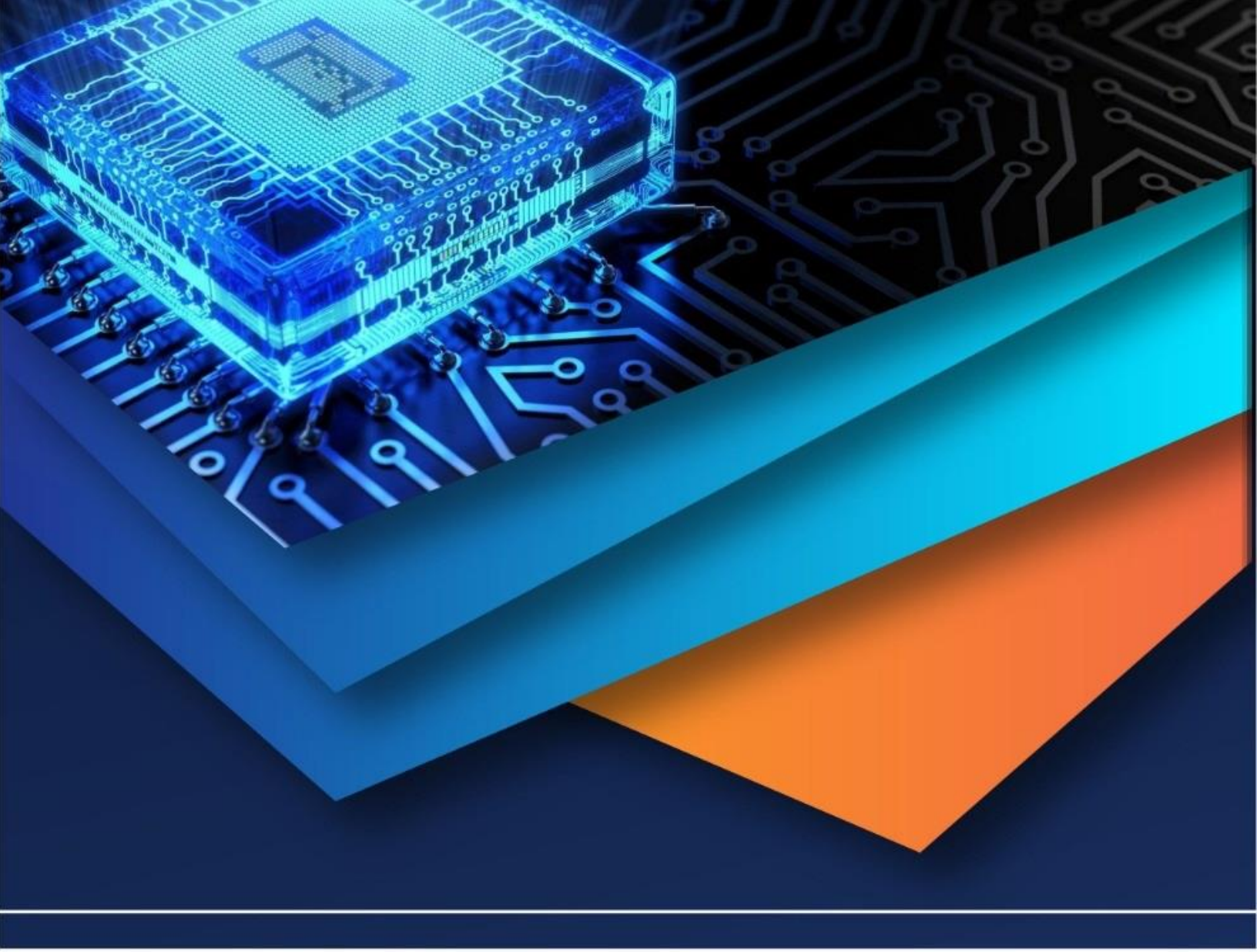
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