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OPTIMIZATION OF MILLING PARAMETERS IN VERTICAL MILLING MACHINE USING EN24 STEEL AS SPECIMEN

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ABSTRACT:

The surface roughness and Material Removal Rate analysis are dependent on various parameters, specific to input parameters are feed, speed, and percentage of water in Coolant. The combination of these parameters is designed by MINITAB using L_9 orthogonal array. On the basis of Design of Experiment, the milling operations are performed in order to evaluate surface roughness and material removal rate. The authors performed the experiment on Vertical Milling Machine using for cutting Alloy material with end mill tools. Experiment wise investigation of the EN24 plates is fixed as work-piece specimen milling operation is carried out. The experiment is performs on different sets of EN24 plates as per design of experiment by MINITAB. The best setting among the feed, speed, and percentage of water in Coolant for low surface roughness and high MRR has been evaluated. Moreover, Grey Relation Method is used to convert Surface roughness and Material Removal into single responses. In each case, the best setting among the feed, speed, and percentage of water in Coolant for low surface roughness and high MRR and both is found by S/N ratio curve. The results are shown in conclusion section.

Keywords: ***Milling machine, Surface roughness, MRR.***

1. INTRODUCTION

Metal cutting is one of the most significant manufacturing processes in the area of material removal. Metal cutting can be define as the removal of metal from a work piece in the form of chip in order to obtain a finished product with desired attributes of size, shape and surface roughness. In production, metal machining is an important process. In manufacturing engineering the quality of surface finish is an important requirement. Machining condition play a very important role in estimating the performance of machining operation. The machining condition such as cutting speed, feed rate, depth of cut, percentage of water in coolant affect the operation in great extent. These parameter must be taken to optimize the machining operation. Researches have been done to improve, tool geometry, cutting tool material, cutting parameter such as feed rate, depth of cut, cutting speed to optimize the machining process.

2. LITERATURE REVIEW:

Kulbhushan Bhagat et al. [1] performed an experiment on AISI 52100 steel (D3 type) in milling machine. They studied the effectiveness of milling parameter on surface roughness (Ra) and metal removal rate (MRR). **Paulo Davim [2]** used Taguchi method in research development. The cutting condition such as feed rate, depth of cut and speed influence the surface finish. **Suresh et al. [3]** performed an experiment, Die steel (D3 type) used for work piece material and machining performed in this work piece. Tin coated tungsten carbide (CNMG) was used for cutting tool. **Nisarg M. Trivedi et al. [4]** In this Research work, the slotted table horizontal milling machine have been used for machining purpose and the work piece material is mild steel plate. **Om Wankhede et al. [5]** in this research, the experiment performed on slotted table horizontal milling machine. **G Harii Krishna rao et al. [6]** In this research, an attempt has been made to study the effect of cutting parameters such as depth of cut, speed, feed rate that influence the quality of surface roughness. **G Akhyar et al. [7]** in this research Taguchi method is used to optimize the cutting parameters in turning operation. **Kopac et al. [8]** in this research various flank milling parameter designed to optimize the milling surface roughness, cutting force, material removal rate in the machining of an alloy casting plate. **Ghani J.A et al. [9]** the objective of this research is to optimized the cutting parameters such as cutting speed, feed rate and depth of cut in end milling process milling machine used to machining the hardened steel AISI H13 with Tin coated P10 carbide insert tool. **Rishi kumar et al. [10]** in this research determine the best optimal cutting parameter leading to maximum metal removal rate (MRR) and minimum roughness by Multi-Objective Genetic Algorithm (MOGA) with integrating response surface methodology (RSM) in face milling of Al 6061 alloy.

Balinder singh et al. [11] this study evaluates the machining performance of EN24 steel. The machining operation perform by CNC machine with carbide end mill cutting tool Taguchi design of experiment use for experimental purpose and study the response variables such as MRR and surface roughness.

3. PROBLEM STATEMENT

The determination of optimal cutting condition for specified surface roughness and accuracy of the product are the key factor in the selection of machining process. To reduce the problem of vibration and ensure that the desired shape and tolerance are achieved, extra care must be taken with production planning and in the preparation for the machining of a work piece. Researchers have been done to improve cutting tool material, tool geometry and cutting parameter such as cutting speed, feed rate and depth of cut are the most important factor has to be considering in milling operation. The wrong selection of the combination cutting parameter will lead to the bad cutting condition e.g. vibration in tool, that effect, the poor surface finish. Different work piece material with different property and micro structure give different effect to the cutting tool performance. In milling operation, the performance of cutting tools is depending on a few cutting condition and parameters. The proper selection of fed rate has direct effect to the product surface roughness. Milling process by maximizing cutting speed and depth of cut will optimize the cutting process and minimize the production cost. The tool life, machined surface integrity and cutting force are directly dependent on cutting tool performance. The study of surface roughness form will resolve the characteristic and phenomena happing during the machining process.

4. OBJECTIVE OF RESEARCH WORK:

The study was carried out to evaluate the effects of different cutting parameters such as feed rate, cutting speed, percentage of water in coolant at constant depth of cut on work piece for surface profile and metal removal rate with milling operation and to find out the optimum cutting condition by analyzing the different cutting parameter value to get the lowest surface roughness and high metal removal rate in milling a EN 24 steel. Objective of this research study are following:

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- To evaluate the effect of different process parameter on surface roughness
- Find out the optimal value of speed, feed rate, percentage of water in coolant to give lowest surface roughness and MRR

5. EXPERIMENT PERFORMANCE:

Machining Parameters

A EN24 steel plate, thickness 10 mm placed on the bed of vertical milling machine. Machining parameter and their level is shown in Table.1. Fig. 1 shows the Vertical Milling Machine.

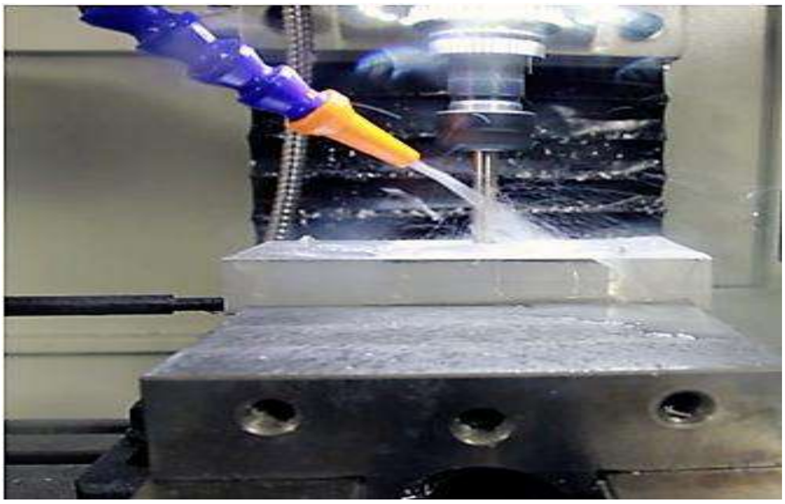

Fig. 1 Vertical Milling Machine

Table. 1 Machining parameter and their level

Control Parameter					
Parameter	Symbol	Level			Unit
		1	2	3	
Feed	F	150	200	250	mm/min
Speed	S	1800	2000	2200	RPM
Coolant Mixture	M	15	20	25	% of Water
Depth of Cut		10			Mm

Design of Experiments by Taguchi Approach in Minitab Software:

L_9 basic types of standard orthogonal arrays (OA) used for the experiment of Taguchi parameter design. Since three factors are taken in the experiment, three level of each factor are considered. Therefore, an array L9 is selected for the experiment. Table 2 shown design of experiment by Taguchi Method.

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Table. 2 Design Of Experiment by Taguchi Method

S. No.	Feed (F)	Speed (S)	Water % in Coolant (M)
1	150	1800	15
2	150	2000	20
3	150	2200	25
4	200	1800	20
5	200	2000	25
6	200	2200	15
7	250	1800	25
8	250	2000	15
9	250	2200	20

6. EXPERIMENTAL RESULTS

The surface roughness is direct measured by surface roughness testers. Surface Roughness for four sides and their average is shown in table. (Unit - µm)

6.1 ANALYSIS OF SURFACE ROUGHNESS (Ra)

(1) Calculation of S/N ratio for Ra

The S/N ratio is obtained using Taguchi methodology. Here the term "signal" represents the desirable value (mean) and the term "noise" represent the undesirable value (standard deviation). Thus, the S/N ratio represents the amount of variation presents in performance characteristics. Here the desirable objective is to optimize the response variables R_a . The Table 3 Experimental data of surface roughness is depicted by Table. 3. Hence smaller the better type S/N ratio was applied for transforming the raw data for surface roughness as smaller values of R_a as desirable the values of S/N ratio corresponding to different runs have been tabulated in Table 4.

Table. 3 Experimental data of Surface Roughness

S. No.	Feed Rate (F)	Speed (S)	Water % in coolant (M)	Roughness of side 1 (R1)	Roughness of side 2 (R2)	Roughness of side 3 (R3)	Roughness of side 4 (R4)	Average Roughness (Ra)
1	150	1800	15	1.11	1.31	1.16	1.27	1.2125
2	150	2000	20	1.45	1.59	.96	1.48	1.37

3	150	2200	25	1.10	1.19	1.15	1.02	1.115
4	200	1800	20	0.70	0.61	0.66	0.66	0.6575
5	200	2000	25	0.96	0.89	0.82	1.00	0.9175
6	200	2200	15	1.48	1.34	1.10	1.39	1.3275
7	250	1800	25	0.87	0.83	1.02	1.03	0.9375
8	250	2000	15	0.85	0.89	1.26	0.87	0.9675
9	250	2200	20	0.94	0.78	0.82	0.90	0.86

Table. 4. Signal to Noise Ratio for Surface Roughness

S. No.	Feed Rate (F)	Speed (S)	Water % in coolant (M)	Signal to noise ratio (S / N)
1	150	1800	15	-1.67363
2	150	2000	20	-2.73441
3	150	2200	25	-0.94550
4	200	1800	20	3.64208
5	200	2000	25	0.74788
6	200	2200	15	-2.46069
7	250	1800	25	0.56057
8	250	2000	15	0.28698
9	250	2200	20	1.31003

From the main effect plots for means the optimal solution for surface roughness is evident at combination of “ F3 S1 M2 ” i.e. feed rate of 250 mm/min, speed of 1800 rpm, percentage of water in coolant of 20.

6.2 ANALYSIS OF MATERIAL REMOVAL RATE (MRR)

(1) Calculation of S/N ratio for MRR:

The desirable objective is to optimize the response variable MRR. Hence, larger the better type S/N ratio was applied for transforming the raw data for material removal rate as larger values of MRR as desirable. The value of S/N ratio corresponding to different experimental runs have been tabulated in Table 5.

Table. 5 Signal to Noise Ratio for Material Removal Rate

S. No.	Feed Rate (F)	Speed (S)	Water % in coolant (M)	Signal to noise ratio (S / N)
1	150	1800	15	47.1587
2	150	2000	20	50.5009
3	150	2200	25	52.5678
4	200	1800	20	42.6708
5	200	2000	25	44.6599
6	200	2200	15	50.0212
7	250	1800	25	46.0639
8	250	2000	15	47.9588
9	250	2200	20	51.1019

7. GREY RELATION ANALYSIS

The grey relation method is a very effective method to optimize the values and analyze the input parameters to give effective response. In this method three input parameters are taken and two response factors are optimized. MS to apply compute GRG. The below Table.6 is showing the experimental output vs average surface roughness. excel is used for grey relation analysis. The authors have followed the paper **(Kopac and Krajnik [8**].

Table: 6. the experimental outputs vs average surface roughness

S. No.	Feed (F)	Speed (S)	Water % in Coolant (M)	Roughness (Ra)	Material Removal Rate (MRR)
1	150	1800	15	1.2125	228
2	150	2000	20	1.37	335
3	150	2200	25	1.115	425
4	200	1800	20	0.6575	136
5	200	2000	25	0.9175	171
6	200	2200	15	1.3275	317
7	250	1800	25	0.9375	201
8	250	2000	15	0.9675	250
9	250	2200	20	0.86	359

7.1. ANALYSIS OF GREY RELATION GRADE

***(1) Calculation of S/N ratio for GRG**:*

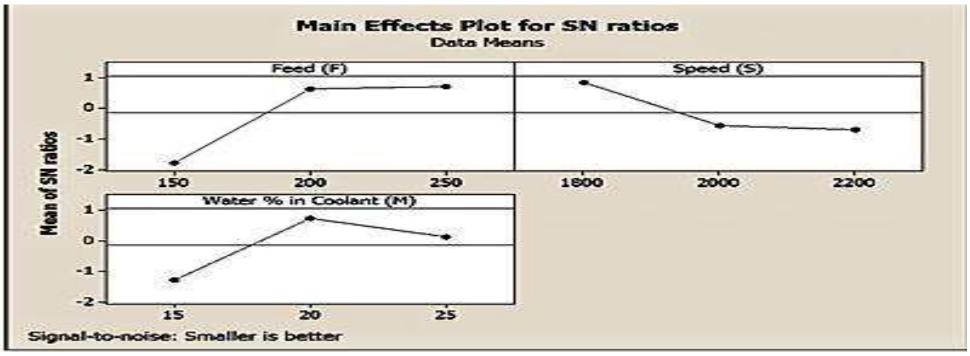
Table. 7 Signal to Noise ratio for GRG

S. No.	Feed Rate (F)	Speed (S)	Water % in coolant (M)	Signal to noise ratio (S / N)
1	150	1800	15	-7.80811
2	150	2000	20	-6.46979
3	150	2200	25	-2.86663

4	200	1800	20	-3.52139
5	200	2000	25	-6.55065
6	200	2200	15	-6.75051
7	250	1800	25	-6.44786
8	250	2000	15	-6.13426
9	250	2200	20	-3.58284

CONCLUSIONS:

1) Design of Experiment is found to be a successful technique to perform trend analysis of surface roughness and MRR on milling operation considering the combinations of design variables (feed rate, cutting speed and Water % in coolant). Taguchi method was used to design the experiments.
2) The Main effect plot of S/N ratios and means for Surface Roughness (Ra) is plotted graphically using Minitab 15 (Graph 2 & 3) both the Graph indicate the influence of various factor on the surface roughness.
3) The Main effect plot of S/N ratios and means for Material Removal Rate (MRR) is plotted graphically using Minitab 15 (Graph 4 & 5) both the Graph indicate the influence of various factor on the Material removal rate.
4) Grey relation method helped to convert the two response factor into single to exhibit the combined effects on quality of work part.
5) The main effect plots (Graph 6 & 7 for means the optimal solution for Surface Roughness and Material Removal Rate is evident at combination of " F3 S3 M2 " i.e. feed rate of 250 mm/min, speed of 2200 rpm, percentage of water in coolant of 20 %.
6) The optimal solution for minimizing the surface roughness value and maximizing the MRR is " F3 S3 M2 " i.e. feed rate of 250 mm/min, speed of 2200 rpm, percentage of water in coolant of 20 %.



Graph 2 SN Ratio for surface roughness

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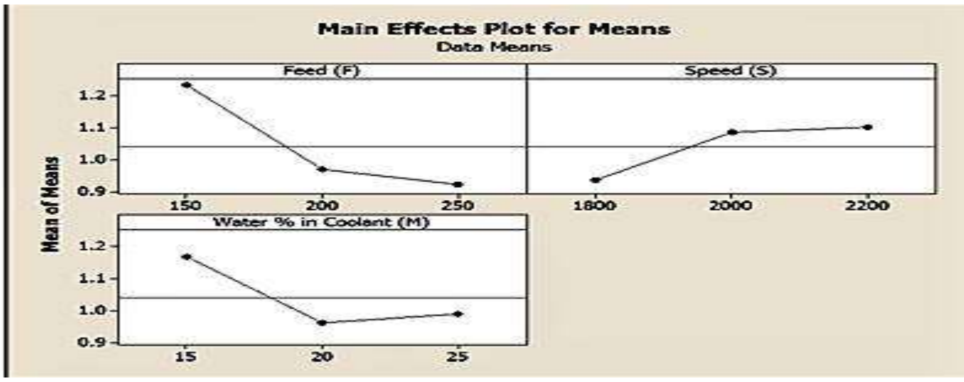
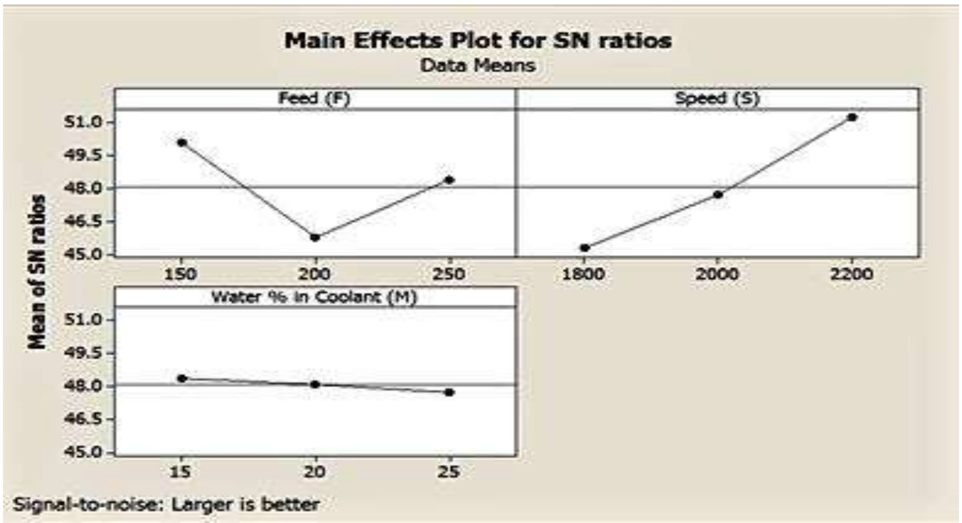
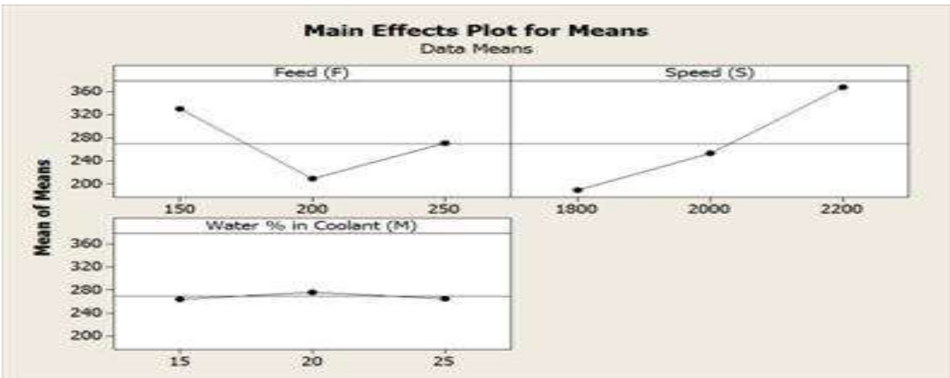


Graph 3 Mean for Surface roughness



Graph 4 SN Ratio for Material Removal Rate



Graph 5 Mean for Material Removal Rate

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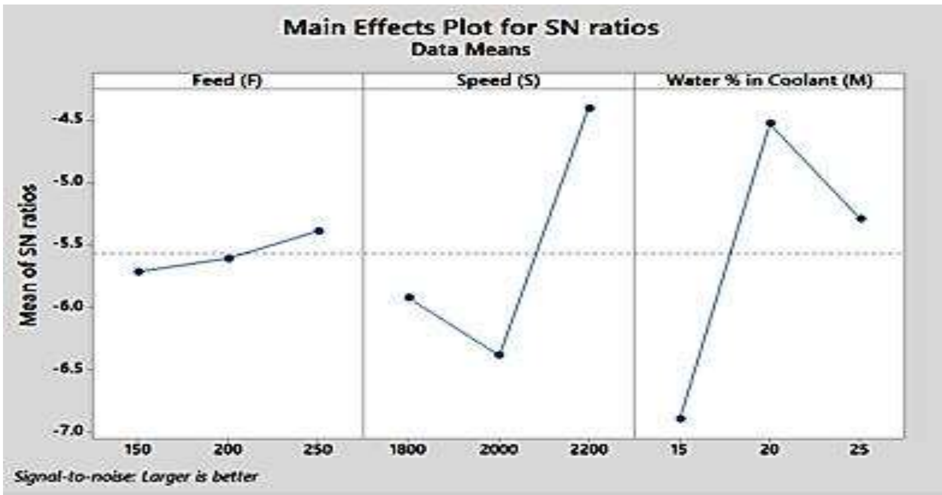
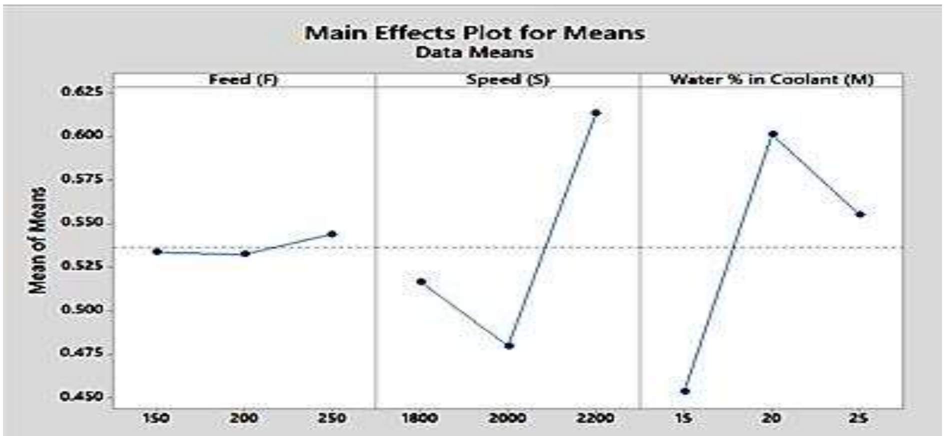


Graph 6 Signal to Noise ratio for GRG



Graph 7 Mean for GRG

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