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ENHANCEMENT OF PROCESS PARAMETERS FOR MILLING USING TAGUCHI METHOD

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ABSTRACT

Present work investigates the effect of turning parameters such as rotational speed, feed rate and depth of cut on surface roughness of high carbon steel. Taguchi's method was used for designing the experiments and optimization of turning parameters. Experiments were conducted as per L9orthogonal arraywith three factors having three levels for each factor. The analysis of variance technique is employed to study the significance and contribution of each factor on surface roughness. Results revealed that feed rate has a significant effect on surface roughness and it is the most dominating factor affecting the surface roughness with contribution of 99.58 %. The optimal parameter combination for minimum surface roughness is found to be A1B1C2 i.e., rotational speed of 315 rpm, feed rate of 15 mm/min and depth of cut of 0.8 mm.

Keywords: Milling Machine, Anova and Feed rate.

1. INTRODUCTION

In the conventional varying one factor at a time technique lot of experimental data can be obtained. This way of experimentation not only consumes lot of time but also poses a challenge to the investigator for deriving appropriate conclusion from the huge experimental data. Design of Experiments (DOE) is at our rescue for planning systematic experimentation and arriving at a meaningful conclusion without being inundated in huge set of experimental data. "DOE" is an experimental strategy in which, effects of multiple factors are studied simultaneously by running tests at various levels of factors [1]. In today environment industry want to manufacture low cost, high quality product in short time. The principle of micro-machining is similar to those of conventional cutting operations. The surface of the work- piece is mechanically removed using micro-tools [2]. In micro-machining operations, the rotational speed of spindle should be very high to maintain acceptable productivity since the small tool diameter decrease the chip removal rate. Micro-end milling is emerging as an important micro-machining process and it is widely used in most of the manufacturing industries due to its capability of producing complex geometric surfaces with reasonable accuracy and surface finish [3]. In micro end milling material removal rate is one of the important aspects, which require attention both from industry personnel as well as in Research and development. In modern industry one of the trends is to manufacture low cost product in short time. MRR which indicates

processing time of the work piece and it is an important factor that greatly influences production rate and cost [4]. MRR greatly vary with the change of cutting process parameters. That is why the proper selection of process parameter is essential for maximum MRR in micro-end milling process. Literature review reveals that theresearchers have carried out most of the work on micro- machining processes developments, monitoring and control but very limited work has been reported on optimization of process parameters [5]. In this work, the length of tool, radius and fluids are considered as constant and also tool deflection and tool wear is considered as negligible. This paper focuses the Taguchi technique for the optimization in micro-end milling operation to achieve maximum metal removal rate (MRR) considering the spindle speed, feed rate and depth of cut as the cutting parameters. Material removal rate which indicates processing time of the work piece is important factor that greatly influences production rate and cost. It is necessary to study the material removal rate in micro-end milling process [6]. Because of these, MRR is taken as output response. An orthogonal array, signal-to-noise (S/N) ratio and Pareto analysis of variance (ANOVA) are employed to analyze the effect of these milling parameters. Using Taguchi method for design of experiment (DOE), other significant effectssuch as the interaction among milling parameters are alsoinvestigated.

Experimental Details:Material Used:

- AISI 304 plates
- Mild steel Plate

Process Parameters:

- Spindle Speed
- Feed rate
- Depth of cut

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Table 1: Milling parameters and their levels

S.NO	Control Factors	Units	Factor Levels		
			Level-1	Level-2	Level-3
1	Spindle Speed	rpm	1000	1250	1500
2	Feed Rate	mm/min	100	150	200
3	Depth of Cut	mm	0.25	0.50	0.75

Optimization of Process Parameters for SurfaceRoughness:

Table 2: Parameter Levels and Response of SurfaceRoughness

Trial No	Milling parameter levels and response			
	A	B	C	Surface roughness
1	1	1	1	**3.52**
2	1	2	2	**3.80**
3	1	3	3	**3.50**
4	2	1	3	**3.85**
5	2	2	1	**3.82**
6	2	3	2	**3.21**
7	3	1	2	**3.00**
8	3	2	3	**3.24**
9	3	3	1	**3.25**

Table 3: Influence of each Process Parameter on SurfaceRoughness

S.NO.	Parameters	L_1	L_2	L_3
1	SPINDLE SPEED	3.60	3.62	3.16
2	FEED RATE	3.45	3.64	3.31
3	DEPTH OF CUT	3.54	3.33	3.53

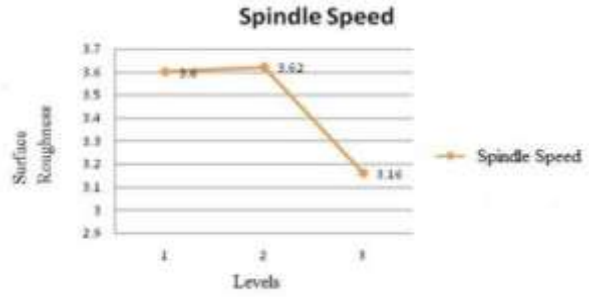

Figure 1: Influence of spindle speed on surfaceroughness

Figure 2: Influence of Feed rate on surface roughness

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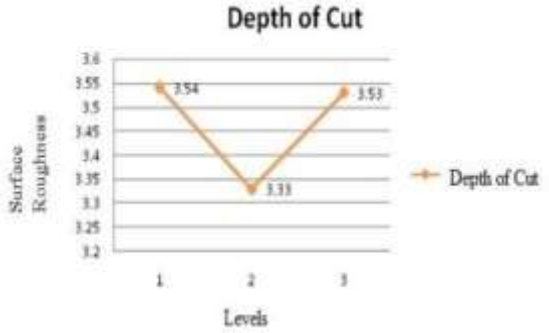

Figure 3: Influence of depth of cut on surface roughness

ANOVA:

Hence, spindle speed and Depth of cut are significant parameter which must be maintained at the levels specified i.e. Depth of cut at level-2 and Spindle speed atlevel-3 other parameter can be maintained at any one of the level values specified based on cost consideration

Table 4: Analysis of Variance (ANOVA) for SurfaceRoughness

Source	DOF	Seqss	Adjms	% contribution
Spindle speed	2	0.4116	0.2058	29.53798459
Feed rate	2	0.1383	0.06915	9.924935054
Depth of cut	2	0.748	0.37378	53.64775451
Error	2	0.096	0.048	6.889325851
Total	**8**	**1.39**		**100**

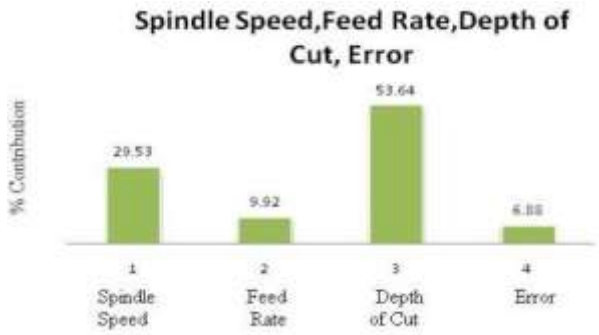

Figure 4: Percentage Contribution of each factor onSurface Roughness

Optimization of Process Parameters for MaterialRemoval Rate:

Table 5: Parameter Levels and Response of MaterialRemoval Rate

Trial No	Milling parameter levels and response			
	A	B	C	Material removal rate
1	1	1	1	0.98
2	1	2	2	0.93
3	1	3	3	0.86
4	2	1	3	0.89
5	2	2	1	0.90
6	2	3	2	0.83
7	3	1	2	0.85
8	3	2	3	0.97
9	3	3	1	0.90

Table 6: Influence of each Process Parameter on MaterialRemoval Rate

Parameters	L_1	L_2	L_3
SPINDLE SPEED	2.77	2.62	2.72
FEED RATE	2.72	2.83	2.62
DEPTH OF CUT	2.78	2.61	2.72

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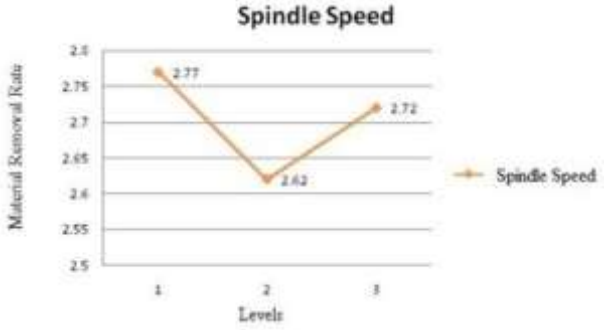

Figure 5: Influence of Spindle speed on MaterialRemoval Rate

Figure 6: Influence of Spindle speed on MaterialRemoval Rate

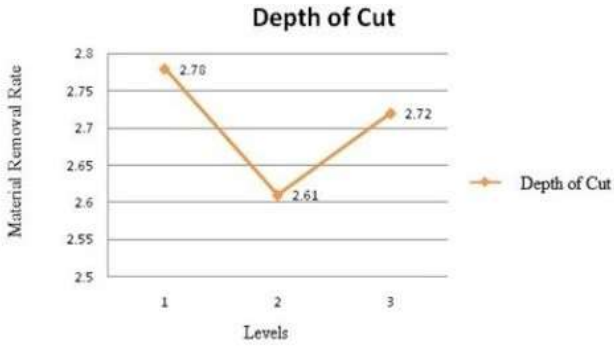

Figure 7: Influence of depth of cut on Material RemovalRate

Analysis of Variance (ANOVA) for Material RemovalRate:

Table 7: Analysis of anova for material removal rate

Source	DOF	Seqss	Adjms	% contribution
Spindle speed	2	3.89E-03	0.001944	19.47
Feed rate	2	9.62E-03	0.004811	48.19
Depth of cut	2	4.96E-03	0.002478	24.81
Error	2	0.0015	0.00075	7.51
Total	**8**	2.00E-02		**100**

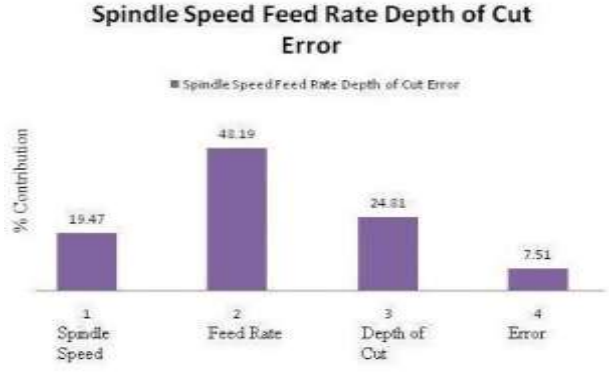

Figure 8: Percentage Contribution of each factor onMaterial removal rate

2. CONCLUSIONS

As per L9 orthogonal array, we have 3^3=27 combinations. Instead of 27 experiments, nine numbersof trials were conducted. The optimum value for surface roughness and material removal rate is not available in the nine numbers of experiments. The optimum values ofsurface roughness, combinations of parameters and their levels are also predicted by Taguchi method.

By the experiment results it was found that the surface roughness quality characteristic is smaller the better but the experimental value is 3.00mm i.e., at parameters S_3, F_1, D_2 and for material removal rate quality characteristicis bigger the better but experimental value is i.e., 0.98 at S_1, F_1, D_1.

After applying Taguchi techniques the predicted values are 2.82mm and material removal rate is 5.97mm. The values obtaining after applying Taguchi technique is more effective than the experimental values.

By ANOVA techniques, influence of each milling parameter is studied and the prediction of the surface roughness and material removal rate is done.

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