International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 06 | June -2017 www.irjet.net p-ISSN: 2395-0072

COMPARISON STUDY OF OPTIMIZATION OF SURFACE ROUGHNESS PARAMETERS IN TURNING EN1A STEEL ON A CNC LATHE WITH COOLANT AND WITHOUT COOLANT

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Abstract - *This paper presents the comparison study optimization of surface roughness parameters in turning EN1A steel on a CNC lathe with coolant and without coolant. The optimization of machining processes is essential for the achievement of high responsiveness of production, which provides a preliminary basis for survival in today's dynamic market conditions. The quantitative determination of Surface Roughness is of vital importance in the field of precision engineering. Machinability can be based on the measure of Surface Roughness. Surface Roughness depends on the factors such as Speed, Feed and Depth of Cut. In this work, the Taguchi methods, a powerful statistical tool to design of experiments for quality, is used to find the optimal cutting parameters for turning operations. Analysis of Variance has been used to determine the influencing parameters on the output responses. Using Taguchi technique, we have reduced number of experiments from 27 to 9 there by the total cost of the project is reduced by 66.66%. The results obtained are encouraging and the concluding remarks are helpful for the manufacturing industries.*

Key Words: surface roughness, Taguchi method, with coolant, parameters.

1.INTRODUCTION

The machinability of metal is defined as the ease with which a given material may be machined with a specific cutting tool. In other words the most machinable metal is one which will permit the fastest removal of the largest amount of material per cut of a tool with satisfactory finish. The operational characteristics of a cutting tool are generally described by its machinability which has 3 main aspects, tool life, surface finish and power required to cut. The quantitative determination of Surface Roughness is of vital importance in the field of precision engineering. Machinability can be based on the measure of Surface Roughness. Surface Roughness depends on the factors such as Speed, Feed and Depth of Cut. Other factors include cutting tool material, cutting tool geometry, machine condition, work piece material, cutting tool clamping and depend on operation carried out. The presence of coolant affects the Surface Roughness. Therefore an attempt has been made to conduct experimental investigation to optimize the Surface Roughness parameters in turning of EN1A steel on CNC lathe.

2. EXPERIMENTATION

Optimization of Machining Parameters (3 factors and 3 level analyses) and studies on Surface Roughness, MRR and Machining Time using TNMG 16 04 08 with and without Coolant in CNC lathe (ACE) using L9:

Trial No	Turning Parameter			Output Responses						
	A Cutting Speed (rpm)	B Feed (mm/rev)	C Depth Of Cut (mm)	Surface Roughness, Ra (µm)	Weight of specimen Before Turning (gm)	Weight of specimen After Turning (gm)	Machining Time (actual), t (sec)	Machining Time (theoretical), t (sec)	MRR(a) (mm³/min)	MRR(t) (mm³/min)
1	1000	0.1	0.2	2.74	197.301	182.914	49	39	2624.49	1200
2	1000	0.2	0.4	3.85	197.301	180.613	30	21	7237.59	7500
3	1000	0.3	0.6	3.91	197.301	179.305	24	18	14796.70	16800
4	2000	0.1	0.4	3.32	197.301	181.12	26	20	7990.47	7400
5	2000	0.2	0.6	3.43	197.301	179.095	17	22	19000	22600
6	2000	0.3	0.2	3.46	197.301	184.003	13	20	11526.78	11800
7	3000	0.1	0.6	2.42	197.301	178.564	19	28	14961.54	17200
8	3000	0.2	0.2	3.35	197.301	183.381	13	21	13214.28	12800
9	3000	0.3	0.4	3.41	197.301	181.700	11	17	23214.28	33400

L9 Orthogonal Array with Observations with Coolant.

Trial No	Turning Parameter			Output Responses						
	A Cutting Speed (rpm)	B Feed (mm/ rev)	C Depth Of Cut (mm)	Surface Roughness, Ra (µm)	Weight of specimen Before Turning (gm)	Weight of specimen After Turning (gm)	Machining Time (actual), t (sec)	Machining Time (theoretical), t (sec)	MRR(a) (mm³/min)	MRR(t) (mm³/min)
1	1000	0.1	0.2	3.19	197.301	182.706	70	58	2790.34	1200
2	1000	0.2	0.4	4.19	197.301	181.298	99	72	7474.44	7500
3	1000	0.3	0.6	4.29	197.301	178.660	94	70	14590.11	16800
4	2000	0.1	0.4	3.67	197.301	180.792	85	62	7890.48	7400
5	2000	0.2	0.6	3.79	197.301	178.520	19	26	18650	22600
6	2000	0.3	0.2	3.85	197.301	184.191	14	21	11930.35	11800
7	3000	0.1	0.6	2.84	197.301	177.867	19	28	14758.24	17200
8	3000	0.2	0.2	3.71	197.301	183.532	13	22	11776.78	12800
9	3000	0.3	0.4	3.82	197.301	181.373	11	19	22992.85	33400

3. RESULTS AND DISCUSSION

In this experiment turning operation was done on the work piece i.e., EN 1A Steel on a CNC lathe. Uncoated Carbide Insert was used for turning. 3 factors were selected i.e., Speed (rpm), Feed (mm/rev) and Depth of Cut (mm) at 3 levels and coolant was not used. Surface Roughness was measured using Profilometer (Talysurf) and the readings are tabulated in Table.

3.1 Analysis of Variance for Surface Roughness:

Source	DF	Seg SS	Adj SS	Adj MS	F	P	RANK	Contribution
Speed (rpm)	2	1.7727	1.7727	0.8864	1.85	0.351	**2**	**19.64%**
Feed (mm/rev)	2	6.2228	6.2228	3.1114	6.50	0.133	**1**	**69.00%**
Depth of Cut (mm)	2	1.0280	1.0280	0.5140	1.07	0.482	**3**	**11.36%**
Error	2	0.9577	0.9577	0.4788				
Total	8	9.9812			9.42			**100%**

Without coolant

Source	DF	Seg SS	Adj SS	Adj MS	F	P	RANK	Contribution
Speed (m/min)	2	2.412	2.412	1.2061	1.57	0.388	**2**	**18.98%**
Feed (mm/rev)	2	8.686	8.686	4.3430	5.67	0.150	**1**	**68.56%**
Depth of Cut (mm)	2	1.573	1.573	0.7865	1.03	0.493	**3**	**12.46%**
Error	2	1.532	1.532	0.7662				
Total	8	14.204			8.27			**100%**

With coolant

3.2 Response Table of Signal to Noise Ratios for Surface Roughness:

Levels	Speed (rpm)	Feed (mm/rev)	Depth of Cut (mm)
1	-11.72	-10.15	-11.06
2	-11.53	-11.80	-11.79
3	-10.70	-12.00	-11.10
Delta	1.02	1.85	0.74
Rank	**2**	**1**	**3**

Without coolant.

Levels	Speed (rpm)	Feed (mm/rev)	Depth of Cut (mm)
1	-10.769	-8.951	-10.012
2	-10.637	-10.972	-10.929
3	-9.611	-11.093	-10.075
Delta	1.158	2.142	0.917
Rank	**2**	**1**	**3**

With coolant.

3.3 Graph showing the Main Effects Plot for S/N ratios of Ra(without coolant):

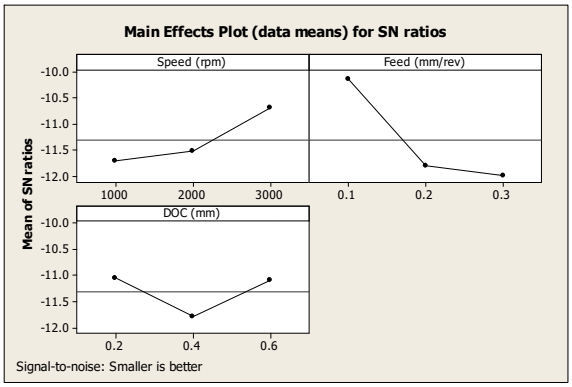


Figure 5: S/N ratio values for Surface Roughness

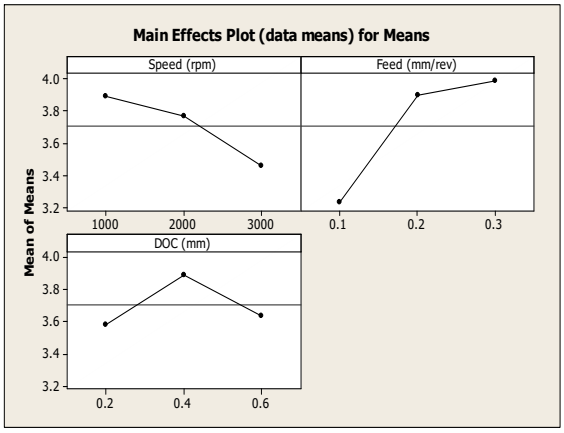


Figure 6: Mean values for Surface Roughness

Highest S/N ratio gives optimum machining parameter. Hence from Figure 5 and Figure 6 it can be observed that optimum values of machining parameters to get minimum Surface Roughness are Speed (3000 rpm), Feed (0.1mm/rev) and Depth of Cut (0.2mm).

Confirmation Test: Turning was conducted at optimum cutting parameters i.e., Speed 3000 rpm, feed 0.1mm/rev and Depth of Cut 0.2mm and found that Surface Roughness as 1.94 µm.

Graph Showing the Main Effects Plot for S/N Ratios of Ra(with coolant):

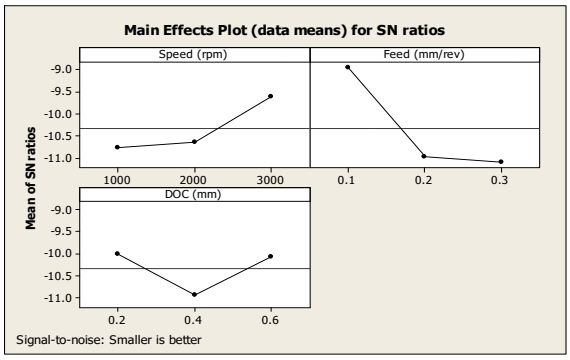
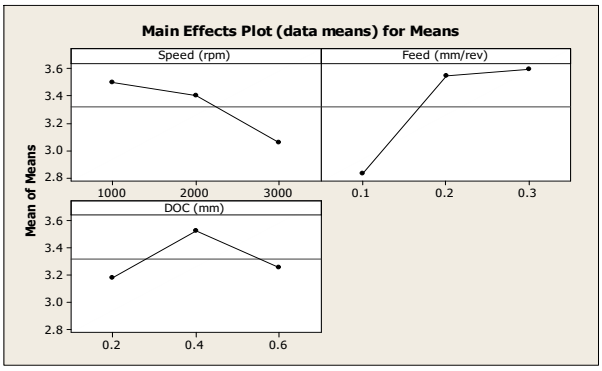


Figure 5: S/N ratio values for Surface Roughness



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Confirmation Test: Turning was conducted at optimum cutting parameters i.e., Speed 3000 rpm, feed 0.1mm/rev and Depth of Cut 0.2mm and found that Surface Roughness as 1.37 µm.

3.4 To Study the Comparison of Actual And Theoretical Values of MRR(without coolant):

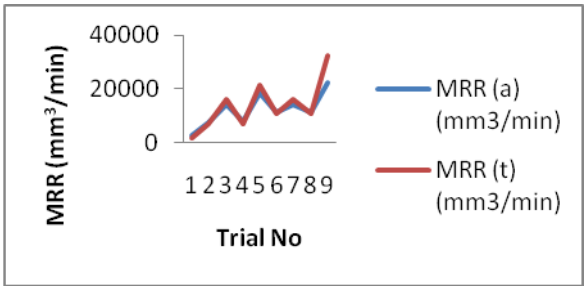
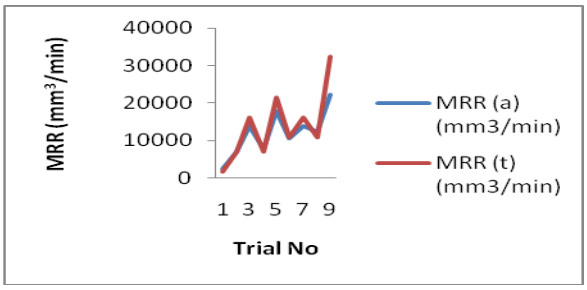


Figure 7: shows the comparison of Actual and Theoretical values of MRR

From Figure 7 it can be seen that for all the trials of this experiment, Theoretical value of Material Removal Rate is more compared to Actual values of Material Removal Rate. Further it can be observed that Material Removal Rate is Maximum when the values of Speed, Feed and Depth of Cut are at maximum levels i.e., 3000 rpm, 0.3 mm/rev and 0.4 mm respectively. Also it can be observed that Material Removal Rate is Minimum when the values of Speed, Feed and Depth of Cut are at minimum levels i.e., 1000 rpm, 0.1 mm/rev and 0.2 mm respectively.

To Study the Comparison of Actual And Theoretical Values of MRR(with coolant):



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4. CONCLUSION:

Following is the summary drawn based on the experiment conducted on EN 1A Steel alloy during turning operation with Uncoated Carbide Inserts without coolant.

1. Regression Model has been developed for Surface Roughness without coolant relating Speed, Feed and Depth of Cut to predict the value of the surface roughness.
2. The Analysis of Variance was performed to identify the influence of Machining Input parameters considered were Speed, Feed and Depth of Cut on the output Responses Surface Roughness using MINITAB software. Based on the Analysis of Variance the input parameters that are influencing the Output parameter Surface Roughness in their decreasing order are Feed, Speed and Depth of Cut.
3. Feed has the highest contribution of 69% followed by Speed 19.64% and Depth of Cut 11.36%.
4. The optimum values of machining parameters to get Optimum Surface Roughness are Speed of 3000 rpm, Feed of 0.1mm/rev and Depth of Cut of 0.2mm. Surface Roughness is found that is 1.94 µm. And average Surface Roughness is found to be 3.70 µm.
5. The Material Removal Rate is Maximum i.e., 22992.85 mm^3/min when the values of Speed, Feed and Depth of Cut are 3000 rpm, 0.3 mm/rev and 0.4mm respectively. And Machining Time is 11 sec i.e., Minimum at this level.
6. The Material Removal Rate is Minimum i.e., 2790.34 mm^3/min when the values of Speed, Feed and Depth of Cut are 1000 rpm, 0.1 mm/rev and 0.2 mm respectively. And Machining Time is 70 sec i.e., 1.5 times the Average at this level.
7. The average Material Removal Rate is 12540.06 mm^3/min.

Following is the summary drawn based on the experiment conducted on EN 1A Steel alloy during Turning operation with Uncoated Carbide Inserts with Coolant.

1. Regression Model has been developed for Surface Roughness without coolant relating Speed, Feed and Depth of Cut to predict the value of the surface roughness.
2. The Analysis of Variance was performed to identify the influence of Machining Input parameters considered were Speed, Feed and Depth of Cut on the output Responses Surface Roughness using MINITAB software. Based on the Analysis of Variance the input parameters that are influencing the Output parameter Surface Roughness in their decreasing order are Feed, Speed and Depth of Cut.
3. Feed has the highest contribution of 68.54% followed by Speed 18.98% and Depth of Cut 12.46%.
4. The optimum values of machining parameters to get Optimum Surface Roughness are Speed of 3000 rpm, Feed of 0.1mm/rev and Depth of Cut of 0.2mm.Surface Roughness is found that is 1.37 µm. And average Surface Roughness is found to be 3.32 µm.
5. Improvement of Surface Roughness by 29.34% at the optimum values and by 10.27% at the average after using the coolant
6. The Material Removal Rate is Maximum i.e., 23214.28 mm^3/min when the values of Speed, Feed and Depth of Cut are 3000 rpm, 0.3 mm/rev and 0.4mm respectively. And Machining Time is 11 sec i.e., Minimum at this level.
7. The Material Removal Rate is Minimum i.e., 2624.49 mm^3/min when the values of Speed, Feed and Depth of Cut are 1000 rpm, 0.1 mm/rev and 0.2 mm respectively. And Machining Time is 49 sec i.e., Maximum at this level.
8. The average Material Removal Rate is 12729.57 mm^3/min after using the coolant. Improvement of Material Removal Rate by 1.48% at the average.

ACKNOWLEDGEMENT

I wish to express my sincere gratitude to my parents, family members, friends, colleagues, students. I thank to management of NHCE for the endless support. Special thanks to Mr. Salman Khan for his kind hearted behavior as person himself and for his attitude for being human which has inspired me throughout my life.Above all, to the Great Almighty, the author of knowledge and wisdom, for his courtless love.

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