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Optimizing Parameters in Turning of Aluminum Alloy using Uncoated and Ceramic Coated Inserts

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Abstract:-In this thesis, the effect of cutting parameters cutting speed, feed rate, depth of cut, cutting tool and cutting fluid is investigated experimentally, to determine surface roughness and material removal rate during turning of Aluminum alloy7075 using L12 orthogonal array in Taguchi Method. The experiments will be conducted by varying machining parameters cutting speed 800rpm, 2400rpm, feed rate 0.2 mm/rev, 0.5mm/rev, depth of cut 0.3mm, 0.9mm, cutting tool Uncoated Carbide Insert, Ceramic coated Carbide Insert and cutting fluids Synthetic, Semi synthetic.

I. INTRODUCTION

Turning is a machining methodology at intervals that a cutter, typically a non-rotary tool bit, describes a helical tool path by moving plenty of or less linearly whereas the work rotates. The tool's axes of movement may well be virtually a line, or they could be on some set of curves or angles.

To remove the excess material from the work piece to produce cone-shaped or a cylindrical surface on a lathe is called turning.

II. LITERATURE SURVEY

In the paper by L. B. Abhang[1], the temperature generated on the cutter and experimental strategies for the mensuration of temperatures are reviewed. Special attention has been paid to tool- work thermometer technique and an experimental setup made-up to live the temperature on the cutter and work piece junction throughout metal cutting is represented. With this technique, the common temperature at the tool-chip interface is measured. The output of the thermometer is within the mill potential unit vary and measured by a digital millimeter. The setup for standardization and therefore the procedure is represented during this work.

In the paper by M. Dogra[2], presents a survey on variation in tool pure mathematics i.e. tool nose radius, rake angle, groove on the rake face, variable edge pure mathematics, wiper pure mathematics and curving edge tools and their impact on tool wear, surface roughness and surface integrity of the machined surface. Any modeling and simulation approaches on tool geometry as well as one approach developed in a very recent study, on variable micro-geometry tools, is mentioned briefly.

III. EXPERIMENTAL INVESTIGATION

The experiments are done on the CNC turning machine with the following parameters:

Cutting tool material – Uncoated carbide insert and ceramic coated carbide insert

Work piece material – Aluminum alloy 7075

Feed – 0.2 mm/rev, 0.5 mm/rev

Cutting speed – 800rpm, 2400rpm,

Depth of cut – 0.3mm, 0.9mm

Sample Size – Length - 210mm, Dia – 20mm

Taguchi parameter design for turning process

In order to identify the process parameters affecting the selected machine quality characteristics of turning, the following process parameters are selected for the present work: cutting speed, feed rate and depth of cut, cutting tool and cutting fluid. The selection of parameters of interest and their ranges is based on literature review and some preliminary experiments conducted.

Selection of Orthogonal Array

The process parameters and their values are given in table. It was also decided to study the five – factor interaction effects of process parameters on the selected characteristics while turning Aluminum alloy.

Selection of process parameters as per Taguchi Technique

Factors	Units	Level 1	Level 2
Cutting speed, N	**RPM**	800	2400
Feed Rate, f	**mm/rev**	0.2	0.5
Depth of cut, d	**mm**	0.3	0.9
Cutting tool		Uncoated Carbide	Ceramic Coated Carbide
Cutting Fluid		Synthetic oil	Semi Synthetic oil

Table-1: Process Parameters as per Taguchi Technique.

JOB NO.	Speed (rpm)	Feed Rate (mm/rev)	Depth of cut (mm)	Cutting Tool	Cutting Fluid
1	800	0.2	0.3	Uncoated Carbide	Synthetic
2	800	0.2	0.3	Uncoated Carbide	Synthetic
3	800	0.2	0.9	Ceramic coated	Semisynthetic
4	800	0.5	0.3	Ceramic coated	Semisynthetic
5	800	0.5	0.9	Uncoated Carbide	Semisynthetic
6	800	0.5	0.9	Ceramic coated	Synthetic
7	2400	0.2	0.9	Ceramic	Synthetic

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				coated	
8	2400	0.2	0.9	Uncoated Carbide	Semisynthetic
9	2400	0.2	0.3	Ceramic coated	Semisynthetic
10	2400	0.5	0.9	Uncoated Carbide	Synthetic
11	2400	0.5	0.3	Ceramic coated	Synthetic
12	2400	0.5	0.3	Uncoated Carbide	Semisynthetic

Table.2. Process Parameters taken for machining

Fig.1. Final Turned Pieces

IV. OBSERVATION

The following are the surface roughness values observed after machining for 12 experiments for both uncoated carbide tool and ceramic coated carbide tool.

SURFACE ROUGHNESS

JOB NO.	Speed (rpm)	Feed Rate (mm/rev)	Depth of cut (mm)	Cutting Tool	Cutting Fluid	Surface roughness (R_a) μm
1	800	0.2	0.3	Uncoated Carbide	Synthetic	1.81
2	800	0.2	0.3	Uncoated Carbide	Synthetic	1.805
3	800	0.2	0.9	Ceramic coated	Semisynthetic	2.14
4	800	0.5	0.3	Ceramic coated	Semisynthetic	1.67
5	800	0.5	0.9	Uncoated Carbide	Semisynthetic	2.07

6	800	0.5	0.9	Ceramic coated	Synthetic	1.89
7	2400	0.2	0.9	Ceramic coated	Synthetic	1.45
8	2400	0.2	0.9	Uncoated Carbide	Semisynthetic	1.59
9	2400	0.2	0.3	Ceramic coated	Semisynthetic	1.26
10	2400	0.5	0.9	Uncoated Carbide	Synthetic	1.51
11	2400	0.5	0.3	Ceramic coated	Synthetic	1.32
12	2400	0.5	0.3	Uncoated Carbide	Semisynthetic	1.39

Table.3. Measured Surface Roughness Values

MATERIAL REMOVAL RATE - MRR is calculated using the following formula

In turning, MRR= π * D * d * f * N

D = Dia of workpiece (mm)

f = feed rate (mm/rev)

d = depth of cut (mm)

N = Cutting Speed (rpm)

JOB NO.	Speed (rpm)	Feed Rate (mm/rev)	Depth of cut (mm)	Cutting Tool	Cutting Fluid	Material Removal Rate (mm^3/sec)
1	800	0.2	0.3	Uncoated Carbide	Synthetic	50.24
2	800	0.2	0.3	Uncoated Carbide	Synthetic	50.24
3	800	0.2	0.9	Ceramic coated	Semisynthetic	150.72
4	800	0.5	0.3	Ceramic coated	Semisynthetic	125.6
5	800	0.5	0.9	Uncoated Carbide	Semisynthetic	376.8
6	800	0.5	0.9	Ceramic coated	Synthetic	377.1
7	2400	0.2	0.9	Ceramic coated	Synthetic	452.16
8	2400	0.2	0.9	Uncoated Carbide	Semisynthetic	452
9	2400	0.2	0.3	Ceramic coated	Semisynthetic	150.72
10	2400	0.5	0.9	Uncoated Carbide	Synthetic	1130.4
11	2400	0.5	0.3	Ceramic	Synthetic	376.8

				coated		
12	2400	0.5	0.3	Uncoated Carbide	Semisynthetic	376

Table.4. Measured Material Removal Rate Values

V. OPTIMIZATION OF MACHINING PARAMETERS USING MINITAB SOFTWARE

LESSER SURFACE ROUGHNESS

In this project, Taguchi method is used to optimize the process parameters Speed, Feed rate, Depth of cut, Cutting tool and Cutting fluid for lesser surface roughness values. The optimization is done in Minitab 17 software.

Options – Smaller is better

S/N Ratios Results Table

Worksheet 1 ***

↓	C1	C2	C3	C4-T	C5-T	C6	C7
	Cutting Speed (rpm)	Feed (mm/rev)	Depth of Cut (mm)	Cutting Tool	Cutting Fluid	SURFACE ROUGHNESS	SNRA1
1	800	0.2	0.3	UncoatedCarbide	Synthetic	1.810	-5.14157
2	800	0.2	0.3	UncoatedCarbide	Synthetic	1.805	*
3	800	0.2	0.9	Ceramiccoated	Semisynthetic	2.150	-6.64877
4	800	0.5	0.3	Ceramiccoated	Semisynthetic	1.670	-4.45433
5	800	0.5	0.9	UncoatedCarbide	Semisynthetic	2.070	-6.31941
6	800	0.5	0.9	Ceramiccoated	Synthetic	1.890	-5.52924
7	2400	0.2	0.9	Ceramiccoated	Synthetic	1.450	-3.22736
8	2400	0.2	0.9	UncoatedCarbide	Semisynthetic	1.590	-4.02794
9	2400	0.2	0.3	Ceramiccoated	Semisynthetic	1.260	-2.00741
10	2400	0.5	0.9	UncoatedCarbide	Synthetic	1.510	-3.57954
11	2400	0.5	0.3	Ceramiccoated	Synthetic	1.320	-2.41148
12	2400	0.5	0.3	UncoatedCarbide	Semisynthetic	1.390	-2.86030

Table.5. Calculated Signal to Noise Ratios for Smaller is better

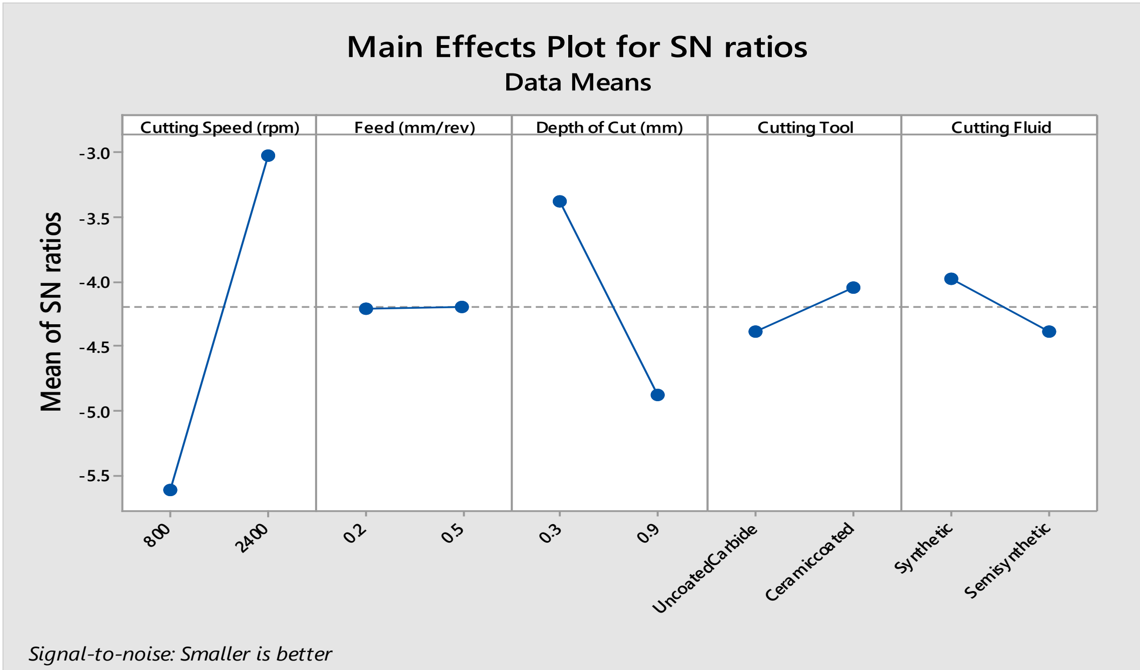

Fig.2. Effect of machining parameters on Surface Roughness for S/N ratio for Smaller is better

Regardless of the category of the performance characteristics, a greater S/N value corresponds to a better performance. Therefore, the optimal level of the machining parameters is the level with the greatest value.

Speed:-The effect of parameter Speed on Surface Roughness is shown above figure S/N ratio. So the optimum Speed is 2400rpm.

Feed Rate:-The effect of parameter feed rate on Surface Roughness is shown above figure S/N ratio. So the optimum feed rate is 0.5mm/rev.

Depth of cut:-The effect of parameter Depth of cut on Surface Roughness is shown above figure S/N ratio. So the optimum Depth of cut is 0.3mm.

Cutting Tool:-The effect of parameter cutting tool on Surface Roughness is shown above figure S/N ratio. So the optimum cutting tool is Ceramic Carbide Insert.

Cutting Fluid:-The effect of parameter cutting Fluid on Surface Roughness is shown above figure S/N ratio. So the optimum cutting fluid is Synthetic.

HIGHER MRR

Taguchi method is used to optimize the process parameters Speed, Feed rate, Depth of cut, Cutting tool and Cutting fluid for higher Material Removal Rate values.

Options – Larger is better

S/N Ratios Results Table

Worksheet 1 ***

↓	C1	C2	C3	C4-T	C5-T	C6	C7
	Cutting Speed (rpm)	Feed (mm/rev)	Depth of Cut (mm)	Cutting Tool	Cutting Fluid	MRR	SNRA2
1	800	0.2	0.3	UncoatedCarbide	Synthetic	50.24	34.0210
2	800	0.2	0.3	UncoatedCarbide	Synthetic	50.24	*
3	800	0.2	0.9	Ceramiccoated	Semisynthetic	150.72	43.5634
4	800	0.5	0.3	Ceramiccoated	Semisynthetic	125.60	41.9798
5	800	0.5	0.9	UncoatedCarbide	Semisynthetic	376.80	51.5222
6	800	0.5	0.9	Ceramiccoated	Synthetic	377.10	51.5291
7	2400	0.2	0.9	Ceramiccoated	Synthetic	452.16	53.1058
8	2400	0.2	0.9	UncoatedCarbide	Semisynthetic	452.00	53.1028
9	2400	0.2	0.3	Ceramiccoated	Semisynthetic	150.72	43.5634
10	2400	0.5	0.9	UncoatedCarbide	Synthetic	1130.40	61.0646
11	2400	0.5	0.3	Ceramiccoated	Synthetic	376.80	51.5222
12	2400	0.5	0.3	UncoatedCarbide	Semisynthetic	376.00	51.5038

Table.6. Calculated Signal to Noise Ratios for Larger is better

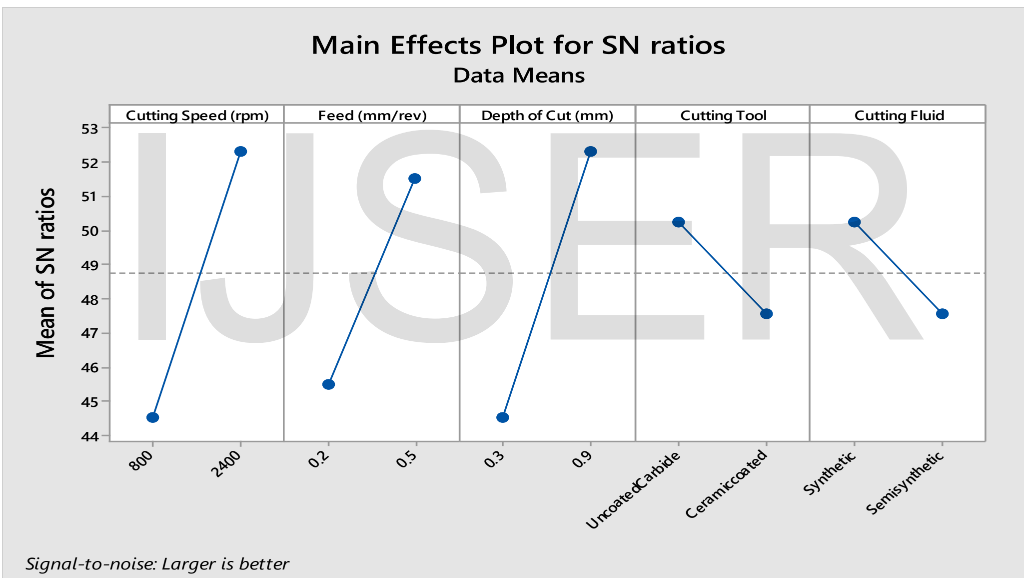

Fig.3. Effect of machining parameters on MRR for S/N ratio for Larger is better

Speed:-The effect of parameter Speed on MRR is shown above figure S/N ratio. So the optimum Speed is 2400rpm.

Feed Rate:-The effect of parameter feed rate on MRR is shown above figure S/N ratio. So the optimum feed rate is 0.5mm/rev.

Depth of cut:-The effect of parameter Depth of cut on MRR is shown above figure S/N ratio. So the optimum Depth of cut is 0.9mm.

Cutting Tool:-The effect of parameter cutting tool on MRR is shown above figure S/N ratio. So the optimum cutting tool is Uncoated Carbide tool.

Cutting Fluid:-The effect of parameter cutting Fluid on MRR is shown above figure S/N ratio. So the optimum cutting fluid is Synthetic.

VI. CONCLUSION

Taguchi method is used to optimize the parameters for lesser surface roughness and higher MRR in Minitab software. By observing the experimental results the following conclusions can be made:

For minimum surface roughness values, the optimum parameters are Speed - 2400rpm, feed rate – 0.5mm/rev, Depth of cut - 0.3mm, cutting tool – Ceramic coated Carbide Insert and cutting fluid - Synthetic. For maximum MRR values, the optimum parameters are Speed - 2400rpm, feed rate - 0.5mm/rev, Depth of cut - 0.9mm, cutting tool – Uncoated Carbide Insert and cutting fluid - Synthetic.

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