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Optimization of Cutting Parameters in CNC Turning of AISI 304 & AISI 316 Stainless Steel

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ABSTRACT

This paper deals with finding optimal cutting parameters to get the better surface finish. It uses Taguchi method of experiments in arriving at optimal cutting speed, feed rate and depth of cut on turning operation. Turning is common method for cutting, especially for the finished machined products. Surface finish obtained in turning process depends upon so many factors like job material, tool material, tool geometry, machining parameters etc. This experimental study is carried out to find optimum parameters of CNC turning operation on AISI 304 and AISI 316 job materials using carbide coated tools.

***Keywords**: Turning Operation, AISI 304, AISI 316, Carbide coated tools, Optimum parameters, speed, feed, depth of cut, surface finish*

I. INTRODUCTION

The modern industry goal is to manufacture high quality products in short time. CNC machines are capable of achieving high quality accuracy and very low processing time. Turning is common method for cutting, especially for the finished machined parts. In machining, surface quality is one of the most specified customer requirements. Surface finish in one of the main results of process parameters such as tool geometry and cutting condition (cutting speed, feed rate, depth of cut, etc.)

AISI 304 & AISI 316 are considered as martensitic stainless steel and can be hardened like other alloy steels.

AISI 304 are widely used in aerospace industries for bearing , water valves, pumps, turbines, compressor components, shafting, surgical tools, plastic moulds nuclear applications etc. which demand high strength and high resistance to wear and corrosion.

Machinability is poor in turning AISI 304 because of low thermal conductivity, high ductility, high strength, high fracture toughness and rate of work hardening.

Coated carbides, boron carbides are basically a cemented carbide insert coated with one or more thinly layers of wear resistant material like Titanium CarboNitride. So in this investigation design of experiments employed for newly coated carbide tool on AISI 304 & AISI 316 in CNC turning with coolant conditions.

II. EXPERIMENTAL PROCEDURE

The experimental procedure involves turning the jobs of AISI 304 and AISI 316 materials on CNC lathe using carbide coated tool. Parameters depth of cut, speed and feed rates will be varied to arrive at optimal parameters using Taguchi method.

A. Machine and materials considered

Job material: (I) AISI 304

(II) AISI 316

Tool: Titanium Carbonitride coated tool

Machine: CNC lathe

Fig 2.1 CNC Lathe

Fig 2.2 Surface roughness tester

B. Methodology

Step 1: Job will be fed in to the CNC lathe

Step 2: Selection of tool and parameters will be programmed

Step 3: Cutting Operation will be done

Step 4: Surface finish will be measured and recorded for each experiment

Step 5: Taguchi method is used to arrive at optimum parameters

III. EXPERIMENTAL FUNCTION AND PARAMETERS

A. Objective Function

Since it is a turning operation, Taguchi smaller the better function is adopted.

Hence S/N ratio as per Taguchi function is:

$n = -10 \text{ Log}_{10}$ (mean of sum of squares of measured data)

n is S/N ratio in decibels(db)

B. Control factors and levels

Table:3.1-Factors and levels

Factors	Level		
	1	2	3
Speed (S in RPM)	600	900	1200
Feed(f in mm/Rev)	0.1	0.15	2
Depth of cut(D in mm)	0.4	0.8	1.2

IV. EXPERIMENTAL RESULTS

A. For AISI 304

Table 4.1 Surface finish for AISI 304

Sl No	Speed (RPM)	FEED (mm/Rev)	DEPTH OF CUT (mm)	SURFACE FINISH (µm)
1	600	0.1	0.4	0.72
2	600	0.15	0.8	0.8
3	600	0.2	1.2	2.06
4	900	0.1	0.8	0.85
5	900	0.15	1.2	1.3
6	900	0.2	0.4	0.63
7	1200	0.1	1.2	0.78
8	1200	0.15	0.4	0.55
9	1200	0.2	0.8	1.08

RPM-Rotations per minute; mm-millimeter; µm-Micrometer;Rev-Revolution

B. For AISI 316

Table 4.2 Surface finish for AISI 316

Sl No	Speed (RPM)	FEED (mm/Rev)	DEPTH OF CUT (mm)	SURFACE FINISH (µm)
1	600	0.1	0.4	0.9
2	600	0.15	0.8	1.06
3	600	0.2	1.2	2.29
4	900	0.1	0.8	0.88
5	900	0.15	1.2	1.42

6	900	0.2	0.4	0.86
7	1200	0.1	1.2	0.95
8	1200	0.15	0.4	0.63
9	1200	0.2	0.8	1.41

RPM-Rotations per minute; mm-millimeter; µm-Micrometer;Rev-Revolution

V. EXPERIMENTAL DATA ANALYSIS

By using Taguchi S/N ratio objective function the following data was obtained

A. For AISI 304

Table 5.1: Calculated S/N Ratios for AISI 304

Sl NO	n(db)
1	2.853
2	1.938
3	-6.277
4	1.412
5	-2.279
6	4.013
7	2.158
8	5.193
9	-0.668

B. For AISI 316

Table 5.2: Calculated S/N Ratios for AISI 316

Sl NO	n(db)
1	0.915
2	-0.506
3	-7.197
4	1.11
5	-3.046
6	1.31
7	0.446
8	4.013
9	-2.984

Individual factors S/N ratio is calculated by using these functions:

a. Speed

$\sum_{s1}$= n1+n2+n3

$\sum_{s2}$= n4+n5+n6

$\sum_{s3}$= n7+n8+n9

Average S/N ratio= $(\sum_{s1}+\sum_{s2}+\sum_{s3})/3$

b. Feed

$\sum_{f1}$= n1+n4+n7

$\sum_{f2}$= n2+n5+n8

$\sum_{f3}$= n3+n6+n9

Average S/N ratio= $(\sum_{f1}+\sum_{f2}+\sum_{f3})/3$

c. Feed

$\sum_{D1}$= n1+n6+n8

$\sum_{D2}$= n2+n4+n9

$\sum_{D3}$= n3+n5+n7

Average S/N ratio= $(\sum_{D1}+\sum_{D2}+\sum_{D3})/3$

C. For AISI 304

Table 5.3: Factor ranking for AISI 304

Level	Speed		Feed		Depth of Cut	
	$\sum_s$	Avg	$\sum_f$	Avg	$\sum_D$	Avg
1	-1.48	-0.49	6.42	2.14	12.05	4.01
2	3.14	1.04	4.85	1.61	2.68	0.89
3	6.68	2.22	-2.93	-0.97	-6.39	-2.13

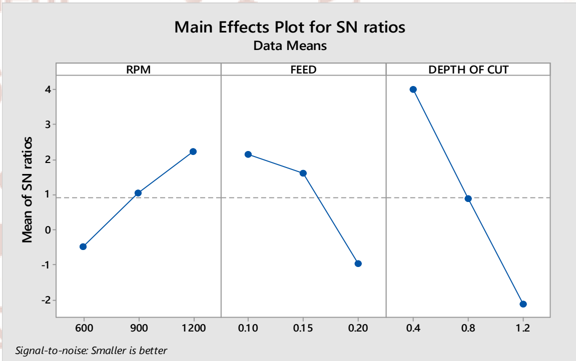

Fig 5.1 Signal to noise ratio for AISI 304

D. For AISI 316

Table 5.4: Factor ranking for AISI 316

Level	Speed		Feed		Depth of Cut	
	$\sum_s$	Avg	$\sum_f$	Avg	$\sum_D$	Avg
1	-0.67	-2.26	2.47	0.82	6.23	2.07
2	-0.62	-0.20	0.46	0.15	-2.38	-0.79
3	1.47	0.49	-8.87	-2.95	-9.79	-3.26

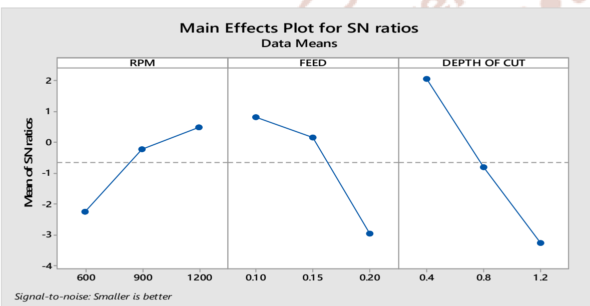

Fig 5.2 Signal to noise ratio for AISI 316

VI. OPTIMUM FACTORS

From the ranking table, The optimal parameter is arrived.

A. For AISI 304

Table 6.1: Optimal parameters values for AISI 304

Factor	Value
Speed (S in RPM)	1200
Feed(f in mm/Rev)	0.1
Depth of cut(D in mm)	0.4

B. For AISI 316

Table 6.2: Optimal parameters values for AISI 316

Factor	Value
Speed (S in RPM)	1200
Feed(f in mm/Rev)	0.1
Depth of cut (D in mm)	0.4

VII. CONCLUSION

In this experiment, We have conducted the turning operation of various parameter combinations by using Taguchi method and the following are the conclusions:

- For AISI 304, optimum parameters to achieve good surface finish by using Titanium Carbonitride coated tool is of around 1200 RPM speed, feed rate of around 0.1 mm/rev and 0.4mm depth of cut
- For AISI 316, optimum parameters to achieve good surface finish by using Titanium Carbonitride coated tool is of around 1200 RPM speed, feed rate of around 0.1 mm/rev and 0.4mm depth of cut
- From the above experiments, In general Good surface finish is proportional to speed and inversely proportional to depth of cut and feed rate.

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