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Optimization of Process Parameters of Stainless Steel 410 by Tungsten Carbide Tool Inserts

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ABSTRACT

The work reveals the analysis of surface harness by machining STAINLESS STEEL 410 utilizing tungsten carbide tool. The STAINLESS STEEL 410 is a chromium based super compound generally utilized in dental and surgical parts because of its astounding mechanical property and destructive obstruction attributes.

Metal expelling process on this super combination is continually testing one because of work solidifying. Device geometry, machining conditions and instrument material are the fundamental elements which influences the nature of machining. Hence forth right now, various devices additions of tungsten Carbide is utilized for the process of machining. The turning is completed in Computer numerical control Lathe to locate the best working conditions. There Taguchi's L9 method is used here thus the 9 trails of experiments are carried out. The various machining parameters are cutting depth, Speed of spindle and rate of feed and the yield reaction is surface unpleasantness. The models for predication are created utilizing ANOVA. The Taguchi’s optimization technique has been utilized. The outcome demonstrated that anticipated models are huge Carbide devices are perfect.

KEYWORDS

Material Removal Rate, Optimization of Machining Parameters, Stainless Steel 410, Surface Roughness, Taguchi Methodology.

Introduction

Even though we could see the rapid growth in the manufacturing sector the complete potential of the machine tools has not yet been utilized. This has led to the greatest problem in the complete optimization of the tools. Hence it has become an essential part to increase the life time and potential capability of the tools. Thus, many of the researchers are forced to look into this area to reduce the cost and material wastage. On the other hand, there are many new materials which are been introduced recently in the industry with the properties of high hardness and toughness. For example, stainless steel alloy has various applications in aerospace industry, medical world and as well in the cryogenic storage tanks and even in the food producing industries. All these applications made possible only because of the main fact that it is able to withstand pressure, heat and oxidation. Due to the properties such as work hardening characteristics and extreme toughness it is much harder to machine. The tools with sharp tips are utilized for such machining, even at high machining temperature, it would maintain the hardness of the cutting edge with increased wear resistance what's more, viable in any event, for longer season of creation runs. The tipped devices have been constructed with a robust structure in order to withstand the high hardness. Thus, the quality of machining has been increased with the increased metal removal rate. Hence, we use Tungsten Carbide tools for analysis of turning STAINLESS STEEL 410 using CNC lathe. To facilitate the machine under best operating conditions we used the taguchi optimization technique.

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Fig. 1. Stainless steel 410

Literature Review

A. Seini Leung Soo et al (2016)

At the feed rate about 200 m/min the tool life over uncoated PCBN is increased by the Ti-Si-N coating. There are no possibilities for attaining benefits of coatings in case of machining at the rate of 300 m/min.

B. Cantero et al (2013)

The machining of the Inconel at various conditions such as dry and wet with the help of the carbide tools that are cemented are analyzed in this paper. It has been observed that the side edge angle influences the more in the tool wear.

C. Ahmadreza Hosseini Tazehkandi et al (2010)

Wear rate of the tool and wear mechanisms are experimentally investigated after turning Inconel 718. It was identified that the most dominant one are the abrasive and adhesive wear.

D. Thakur et al (2009)

Force of cutting, pressure of the specific cutting, temperature of cutting, wear of tool are some of the machining parameters which are investigated and optimized.

E. Costes et al (2007)

The optimal grade and method of the wear are investigated by this technique. A reduced rate of Cubic Boron Nitride consisting of the ceramic binder and smaller grains size are identified to produce the better outcome.

F. Ezugwu et al (2005)

Relationship between process parameters and cutting are analyzed and predicted by the artificial neural network (ANN).

G. Lietal (2002)

The results revealed that PVD coated carbide tools are more superior when compared with the CVD coated tool.

Selection of Tool Material and Work Piece

The experiment aimed at finding out the material which gives optimal process parameters with high MRR and reduced roughness of the surface. After reviewing various literature papers, the material of the work piece and the tungsten carbide apparatus embed was chosen.

Work Piece Material

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STAINLESS STEEL 410 is being used as the work piece. The alloy has the reduced machinability properties and is hard to scratch and has highly tough and consists of high work hardening abilities. The mechanical properties of the alloy such as the corrosion resistance are easily achieved when it is hardened and tempered. The wet condition was preferred to carry out the experiment with the assistance of grease. The components of the work piece are given in the Table 1.

Table 1. Work Piece Specifications

Work piece Specifications	
Length	80 mm
Diameter	30 mm

1) Chemical Arrangement

The various arrangement of chemicals in the STAINLESS STEEL 410 is given in the Table 2.

Table 2. Chemical Composition

Element	**Composition (%)**	
	Minimum	**Maximum**
C	0.08	0.16
Mn	-	2
Si	-	2
S	-	0.04
Cr	11.5	13.5

Methodology

CNC Lathe

The substantial CNC machine with cutting edge SIMENS SINUMERIK 802D control frameworks was utilized for the machining. This machine is equipped for taking care of the different info boundaries. The setups of the machine is appeared in Table 3. The figure 1 shows the CNC machine machining the work piece.

Table 3. Details of CNC Lathe

S. No	**Specifications**	**Range**	**Unit**
1	Swing over carriage	190	Mm
2	Distance between centers	230	Mm
3	Height of Centre	175	Mm
4	Spindle bore diameter	50	Mm
5	Spindle speed	6000	Rpm

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Fig. 2. CNC Lathe Machine

Determination of Machining Parameters

The interaction boundaries utilized for machine STAINLESS STEEL 410 is appeared in the table 4. Speed of shaft, pace of feed and cutting profundity are the boundaries which are utilized and they are chosen in three levels.

Table 4. Machining Parameters

Cutting Parameter	Unit	Level Factors		
Z		**1.**	**2.**	**3.**
Speed of spindle	Rpm	1700	1900	2100
Rate of feed	m/min	0.15	0.2	0.25
Cutting depth	mm	0.4	0.6	0.8

Each component comprises of three distinct levels. Thus, absolutely 27 tests ought to be done in a full factorial plan. To diminish the quantity of investigations Taguchi L9 symmetrical cluster is embraced and is utilized in the analysis. For each boundary, three levels are appointed. Likewise, the total amounts of trials are 27. The Taguchi L9 is utilized to improve the machining and to diminish the amount of runs surface brutality. L9 show with coded and real characteristics after experimentation. The surface repulsiveness is procured from Surface Roughness meter. Surface repulsiveness is the extent of the typical of apexes and the bowls found upon the smooth line on a superficial level.

Surface Roughness Analysis Using Tungsten Tool

TNMG 15-04-04 speaks to the device nomenclature with 04 mm thickness, 4 mm corner radius and 15 mm cutting edge length. Carbide material consisting 68 HRC hardness is used in this apparatus. The point of moving toward the apparatus is 55 degree.

Hereditary Calculation

To find better boundaries of machining, the backslide model delivered from ANOVA is given as commitment of any of the non-ordinary methodologies. At the present time, Algorithm is used. It is a bio-inspired estimation used to find ideal response for the given non-polynomial condition. The pseudo code of GA is given under.

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Experimental Work

Taguchi Analysis: MRR V/S LA, LB, LC

1) Response Table

Table 5. Signal/Noise - Larger Is Better

Level	A.	B.	C.
1	-5.48	-6.575	-7.127
2	-4.851	-4.789	-4.736
3	-4.059	-3.027	-2.528
Delta	1.421	3.548	4.599
Rank	3	2	1

Table 6. Means

Level	A	B	C
1	0.57	0.49	0.45
2	0.5833	0.5867	0.5933
3	1.64	2.7167	1.75
Delta	0.07	0.2267	0.3
Rank	3	2	1

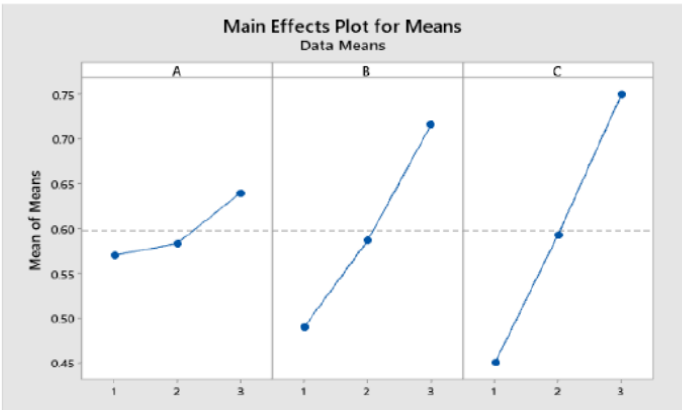

Fig. 3

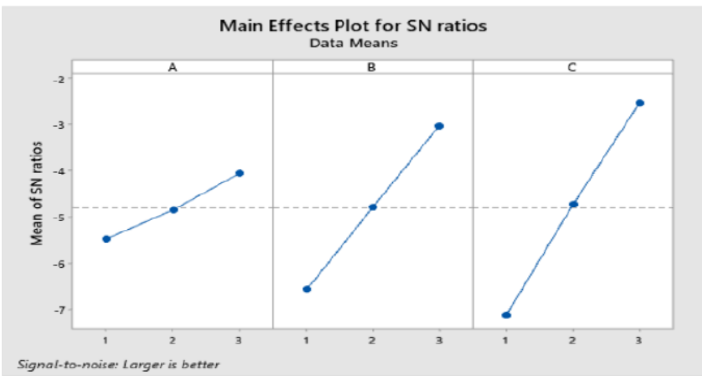

Fig. 4

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Taguchi Analysis: SR V/S LA, LB, LC

1) Response Table

Table 7. Signal/Noise - Smaller Is Better

Level	**A**	**B**	**C**
1	1.3336	2.6729	1.0777
2	-1.0523	0.6204	0.1637
3	0.5954	-2.4166	- 0.3647
Delta	2.3859	5.0894	1.4424
Rank	2	1	3

Table 8. Means

Level	**A**	**B**	**C**
1	0.895	0.74	0.949
2	1.157	0.94	1.001
3	0.96	1.32	1.062
Delta	0.262	0.58	0.113
Rank	2	1	3

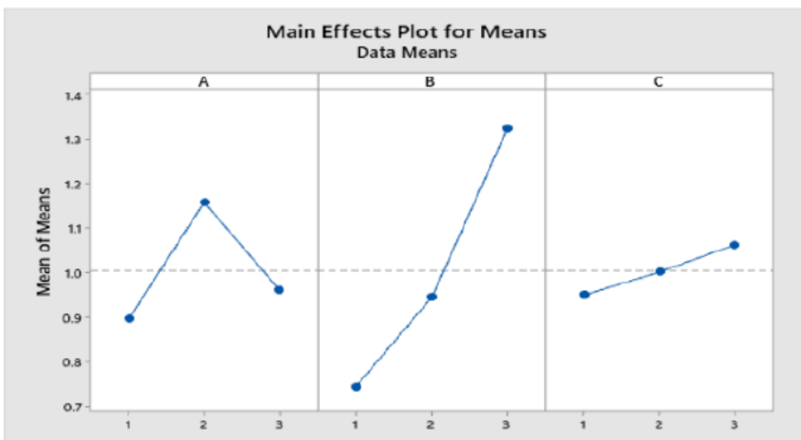

Fig. 5

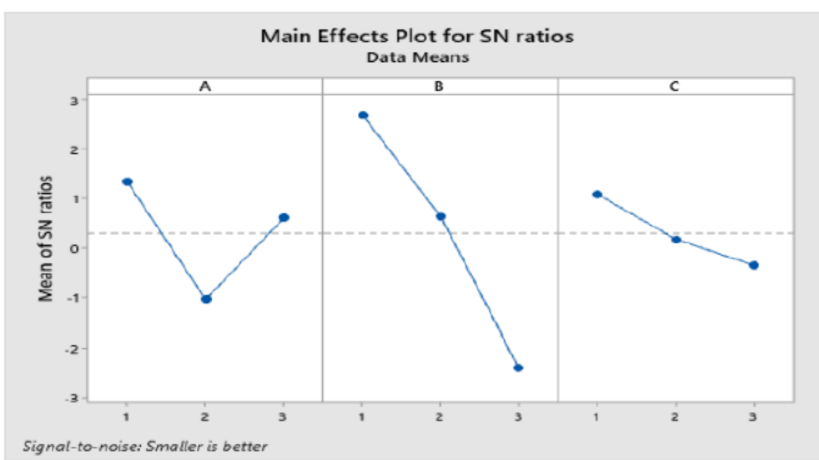

Fig. 6

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General Linear Model: MRR V/S LA, LB, LC

1) Variance Analysis

Table 9

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
A	3	0.008289	3.73%	0.008289	0.004144	0.717	0.0122
B	3	0.077622	34.94%	0.077622	0.038811	6.717	0.0015
C	3	0.135089	60.81%	0.135089	0.067544	11.79	0.0008
Error	3	0.001156	0.52%	0.001156	0.000578		
Total	8	0.222156	100.00%				

2) Coefficients

Table 10

Term1	Coef1	SE Coefi	95% CI	T-Value	P-Value	VIF
Consistent	0.59778	0.00801	(0.56330, 0.63225)	74.61	0	
A						
1	-0.0278	0.0113	(-0.0765, 0.0210)	-2.45	0.134	1.33
2	-0.0144	0.0113	(-0.0632, 0.0343)	-1.27	0.33	1.33
B						
1	-0.1078	0.0113	(-0.1565, -0.0590)	-9.51	0.011	1.33
2	-0.0111	0.0113	(-0.0599, 0.0376)	-0.98	0.43	1.33
C						
1	-0.1478	0.0113	(-0.1965, -0.0990)	-13.04	0.006	1.33
2	-0.0044	0.0113	(-0.0532, 0.0443)	-0.39	0.733	1.33

3) Regression Equation

MRR = 0.59778 - 0.0278 A_11 - 0.0144 A_21 + 0.0422 A_31 - 0.1078 B_11 - 0.0111 B_2 + 1.1189 B_31- 0.1478 C_11 - 0.0044 C_21 + 0.1522 C_13

General Linear Model: SR v/s LA, LB, LC

1) Variance Investigation

Table 11

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
A	2	0.11168	16.79%	0.11168	0.055839	0.935	0.0097
B	2	0.52236	78.53%	0.52236	0.261181	4.374	0.0022
C	2	0.01919	2.89%	0.01919	0.009597	0.161	0.0384
Error	2	0.01194	1.80%	0.01194	0.005971		
Total	8	0.66518	100.00%				

2) Coefficients

Table 12

Term	Coefi	SE Coefi	95% CI	T-Value	P-Value	VIF
Consistent	1.004	0.0258	(0.8932, 1.1148)	38.98	0.001	
A						
1	-0.109	0.0364	(-0.2657, 0.0477)	-2.99	0.096	1.33
2	0.153	0.0364	(-0.0037, 0.3097)	4.2	0.052	1.33
B						
1	-0.2607	0.0364	(-0.4174, -0.1039)	-7.16	0.019	1.33
2	-0.0597	0.0364	(-0.2164, 0.0971)	-1.64	0.243	1.33
C						
1	-0.055	0.0364	(-0.2117, 0.1017)	-1.51	0.27	1.33

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2	-0.003	0.0364	(-0.1597, 0.1537)	-0.08	0.942	1.33

3) Regression Equation

SR = 1.0040 - 0.1090 A_11 + 0.1530 A_21 - 0.0440 A_31 - 0.2607 B_11 - 0.0597 B_2 + 1.3203 B_13- 0.0550 C_11 - 0.0030 C_12 + 0.0580 C_13

Conclusion

After turning the STAINLESS STEEL 410 MRR and roughness of surface are found as the parameters. Thus, the results are inferred from the above work.

- Examination of Variance shows that the commitment of profundity of cut is 71.46% on MRR
- In Taguchi investigation for MRR the position of the boundaries is discovered to be in the request for Cutting profundity, Speed of axle and pace of feed.
- Examination of Variance for Surface unpleasantness shows that the most contributing element is Depth of Cut (42.31%).
- Taguchi Analysis for Surface Roughness shows that the position of the boundaries are in the request for Cutting pace, pace of feed and Speed of axle.
- Profundity of Cut and feed rate are the most influencing factors for surface harshness. With the increment of cutting profundity, the surface harshness esteem is expanded.

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