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Application of the Taguchi Technique for Finding Influence of Turning Process Parameters on Hardness of AISI 1040 medium carbon steel Material Specimen

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Abstract: A conventional method to manufacture parts to a specific dimension involves the removal of excess material by machining operation with the help of cutting tool. Turning process is the one of the methods to remove material from parts. In this work the relation among change in hardness on on the material surface because of the turning operation with respect to different machining parameters like spindle speed, feed and depth of cut have been investigated. Taguchi method has been used to plan the experiments and AISI 1040 metal selected as a work piece and coated carbide tool as a tool material in this work and hardness after turning has been measured on Brinell harness tester. The obtained experimental data has been analyzed using signal to noise and. The main effects have been measured and percentage contribution of various process parameters affecting hardness also determined.

Key words: Turing, Taguchi, AISI 1040 Brinell hardness, S/N ratio, Regression

1 Introduction

Globalization of world market creates a challenge in products marketing, due to high competition induces in manufacturing to produce better quality product within a shorter period of time as well as low cost. Precise product could be produced while utilizing the machine as optimum working condition. Optimum machining parameters are of great concern in the manufacturing environment, where the economy of machining operation plays a key role in competitiveness in the market.

1.1 Lathe machine

A lathe machine is a machine tool that is used to extract metals from a work piece to give the desired shape and size. In other words, it is a machine that

is used to hold a work piece to remove various pieces, such as with the help of turning, grooving, chamfering, knurling, facing, tools.

1.2 Turning operation

A common method to create specific dimension involves the removal of excess material by machining operation by cutting tool. Turning process is the process of remove material from cylindrical and non-cylindrical parts. It is used to reduce the diameter of the work piece, usually to a specified or different diameter.

1.3 Brinell hardness

The Brinell hardness was the first widely used and standardized hardness test in engineering and metallurgy proposed in 1900 by Swedish engineer Johann August Brinl. The large size of indentation and the potential disadvantage for testing - the piece limits its usefulness. However, its useful feature was also that the hardness VU divided by two gave the estimated UTS in KSI for steels. This characteristic sometimes contributed to hardness testing in its early lap.

$$\text{BHN} = \frac{\text{applied load in kg}}{\text{area of impression or indention in mm}}$$

2. Taguchi Method

Taguchi method is a powerful tool for the design of high quality systems. It provides simple, efficient and systematic

Experiment	P1	P2	P3
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

approach to optimize design for performance, quality and cost. Taguchi method is

efficient method for designing process that operates

consistently and optimally over a variety of conditions. Taguchi approach to design the of experiments easy to adopt and apply for users with limited knowledge of statics, hence gained wide popularity in the engineering and scientific community. The desired cutting parameters determined by handbook

Figure 2.1 Procedure & Steps of Taguchi Perameter Design

3. Experimental Setup

3.1 Work piece material

The work piece material selected for investigation is AISI 1040 steel. AISI 1040 finds wide varieties of application not only for forging, casting, axel shaft, crank shaft and connecting rods but also used for low cost die material in tool and die making industries. This steel can be hardened and tempered to provide a greater strength and wear resistance in comparison in low carbon steels. The work piece

used for experiment is round bar with 40 mm diameter and 165 mm length.

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Specification of work material

Chemical composition

Elements

Carbon (C): 0.37% - 0.44%

Manganese (Mn): 0.60% - 0.90%

Silicon (Si): 0.17% - 0.37%

Phosphorus (P): ≤ 0.040%

Sulfur (S): ≤ 0.050%

Machining Process

The cutting tests were performed on medium duty

conventional lathe machine and coated carbide tool. The experiments were conducted as per the orthogonal array and hardness for various combinations of parameters was measured using Brinell hardness tester.

Plan of Experiment

The experiment was planned using Taguchi's orthogonal array in the design of experiments, which help in reducing the number of experiments. The L9 orthogonal array. The cutting parameter identified were spindle speed, feed rate and depth of cut. The controls parameter and their level indicated in table.

Table 3.1Process and parameters and their level

Table 3.2 The Basic Taguchi L_9 orthogonal array

S.No.	Process Parameter	Levels		
		Low	Medium	High
1.	Spindle speed (rpm)	600	900	1200
2.	Feed Rate (mm/rev)	0.2	0.3	0.4
3.	Depth of Cut (mm)	1	1.5	2

Table 3.3 Consolidated design of experiment table

E..N.	(Ss)	(F)	(D)	Hardness (BHN)
1	600	0.2	1	213.46
2	600	0.3	1.5	221.96
3	600	0.4	2	200.12
4	900	0.2	1.5	209.98
5	900	0.3	2	211.32
6	900	0.4	1	234.48
7	1200	0.2	2	212.25
8	1200	0.3	1	207.65
9	1200	0.4	1.5	209.05

4 Analysis of the signal to noise (S/N) ratio

Higher the better

It is when the occurrences of some undesirable product characteristics is to be maximized. It is given by

S/N= -10 X log10(Σ(1/yi^2)/N)

Hardness for each of the parameter at each level is calculated. These also called as main effects.

Table 4.1 S/N Ratio Summary Sheet

Exp. No	Hardness (BHN)	S/N ratio (dB)
1	213.46	46.58
2	221.96	46.92
3	200.12	46.02
4	209.98	46.44
5	211.32	46.49
6	234.48	47.40
7	212.25	46.53
8	207.65	46.34
9	209.05	46.40

Results	Actual Experimental Value	Prediction (Taguchi Method)	Prediction (Regression Modelling)
Level	S2 + F3+ D1	S2 + F3+ D1	S2 + F3+ D1
Hardness (BHN)	234.48	224.95	219.65
S/N Ratio (dB)	47.40	47.04	46.83

Table 4.2 Mean response table for hardness

Symbol	Controllable Factors	Hardness (BHN)		
		L	**M**	**H**
Ss	Spindle speed (rpm)	213.84	**218.59**	209.65
F	Feed Rate (mm/rev)	211.89	213.64	**214.55**
D	Depth of Cut (mm)	**218.53**	213.66	207.89

Table4.3 Mean response of S/N for hardness

Symbol	Controllable Factors	S/N ratio value of Hardness (dB)		
		L	**M**	**H**
Ss	Spindle speed (rpm)	46.50	**46.77**	46.42
F	Feed Rate (mm/rev)	46.51	46.58	**46.60**
D	Depth of Cut (mm)	**46.77**	46.58	46.34

the level that gives the highest value of parameter in each level in the experimental region denoted by bold letter. The estimated main effects can be used for this purpose.

5. Main effects

Main effects plots for the experiments have been given below.

Table 5.3 final comparison of confirmation of experiment for hardness

Hardness (BHN)	S/N ratio (dB)
234.48	47.40

From the response graph plotted between turning parameters and hardness of AISI 1040, it is observed that there is increase in hardness as the speed is increased at 900 rpm but when speed is further increased hardness goes decreased. The hardness increases when feed rate is changed from 0.2 mm/rev to 0.3 mm/rev and 0.3 to 0.4 mm/rev, but when depth of cut is 1 mm then hardness increases, but as the depth of cut is further increased then hardness decrease considerably.

5.1 Conformation of experiment

While considering three factors the experiments were conducted and result is that the combination of Higher Spindle speed (Ss3), higher Feed rate ((F3) and lower Depth of cut (D1), then the Hardness is maximum.

Figure 5.4 final confirmation of experiment

6. Mathematical regression Modelling

For the combination of parameters setting hardness value for AISI 1040 is tabulated. Empirical formula has fined out by using regression modeling. Modeling of parameters To generalize the results, the Modeling of input parameters (Spindle Speed, Feed rate, Depth of cut) and output parameter (Hardness) is done using REGRESSION MODELLING and MATLAB Software R2011b.

$$H = 236.37 (\text{Spindle speed})^{-0.0087} * (\text{Feed rate})^{0.0150} * (\text{Depth of cut})^{-0.0694}$$

Comparison of Result

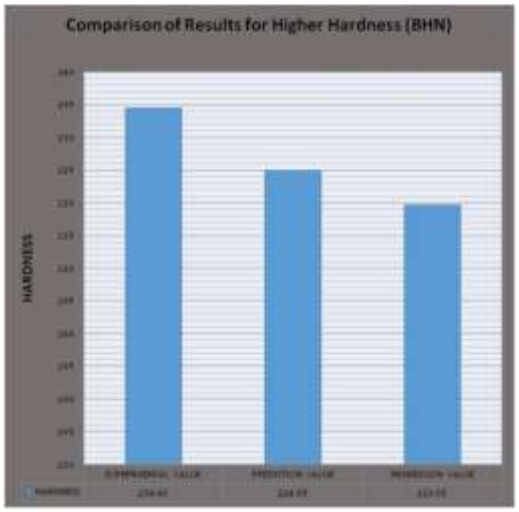

Figure 6.1 Comparison of result for higher hardness

6.1 Summary

In the present work, the relationship between hardness and various process parameters namely spindle speed, feed rate and depth of cut has been
developed. Taguchi method has been adopted for the design of experiments and the results have been analyzed by maximize S/N ratio.

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