Experimental Investigation in Effect of Tool Hardness on Surface Roughness for AISI D2 Steel

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Abstract— In this study attempts to Experimental Evaluation of Surface Roughness and Flank Wear in different HRC on AISID2 material Hard Turning process parameters (constant speed and feed on diff. HRC. on responses (like:surface roughness and Tool wear) using taguchi techniques. For the study L16 orthogonal array is selected for experimentation. Experiment shows that hardness is not create much effect in Ra, MRR and Tw, with compare to other two parameter Feed and Cutting speed for the D2 material we can get the formula base on this experiment for the use of practical application.

Key words: Cutting Material Hardness (hrc) , Feed (mm/Rev) , Cutting Speed (m/min)

I. INTRODUCTION

Turning is the removal of metal from the outer diameter of a rotating cylindrical work piece. Turning is used to reduce the diameter of the work piece, usually to a specified dimension, and to produce a smooth finish on the metal. Often the work piece will be turned so that adjacent sections have different diameters.

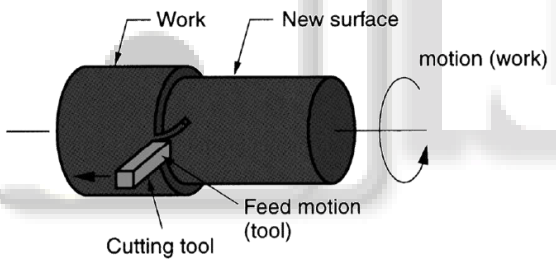

Fig.1: Turning Operation

A. Speed

Speed always refers to the spindle and the work piece. When it is stated in revolutions per minute (rpm) it tells their rotating speed. But the important feature for a particular turning operation is the surface speed, or the speed at which the work piece material is moving past the cutting tool.

B. Feed

Feed always refers to the cutting tool, and it is the rate at which the tool advances along its cutting path. On most power-fed lathes, the feed rate is directly related to the spindle speed and is expressed in mm (of tool advance) per revolution (of the spindle), or mm/rev.

C. Depth of Cut

Depth of cut is practically self explanatory. It is the thickness of the layer being removed.

AISI D2 is a high-carbon, high-chromium tool steel, alloyed with molybdenum and vanadium characterized by:

— High wear resistance
— High compressive strength
— Good through-hardening properties
— High stability in hardening
— Good resistance to tempering-back

AISI D2 is recommended for tools requiring very high wear resistance, combined with moderate toughness (shock-resistance). AISI D2 can be supplied in various finishes, including the hot-rolled, pre-machined and fine machined condition.

II. LITERATURE REVIEW

Jatinder Kumar has concluded that both output parameters (surface roughness and tool flank wear) cannot be minimize together by using same combination of input parameters. Therefore, it is recommended to set the priorities output parameters depending upon the end use and environment.

Senthilkumar has found the average % of error for the flank wear and surface roughness is 22.24 and –2.69, respectively, which is an acceptable prediction error. Results predicted by neural network model are compared with the experimental results, which show that the predicted values are closer to the experimental values showing the supremacy of the system.

Vikas B. Magdum has concluded his implies that the level of parameters at designated levels as A2, B2, C1, D1 are the best combination to get minimum thrust force Z in turning of EN 8 bar.

Ashok Kumar Sahoo has concluded for achieving good surface finish on the D2 work piece, higher cutting speed, lower feed and lower depth of cut are preferred.

Alaattin Kaçal has concluded For both cutters, while the machining force increased depending on the increase of the feed rate and cutting depth, it decreased depending on the increase of the cutting speed With regards to machining force, CBN cutting inserts exhibited better performance than ceramic inserts.

A. K. M. Nurul Amin has concluded Temperature and cutting speed had the most significant effects on resultant surface roughness and generated peak vibration amplitudes.

M.A. Lajis has concluded Overall enhanced machinability is achievable by preventing Catastrophic damage of the cutting tool at higher levels of feed and cutting speed.

Sudhansu Ranjan Das has concluded rom the experimentation it is found that, depth of cut did not impact the surface roughness in the studied range, significantly. The most optimal results for surface roughness were observed when cutting speed was set at 150 m/min and feed of 0.05 mm/rev.

After literature review of number of papers we have observed that most of research have been carried out to study the effect of various process parameters on speed,feed and dept of cut on same HRC. So, we will Evaluation difference HRC on constant cutting parameter (speed and feed) based on taguchi methodology (L16 orthogonal array) experiments have to carryout.

III. DESIGN OF EXPERIMENT & METHODOLOGY

INTRODUTION OF DOE

In industry, designed experiments can be used to systematically investigate the process or the product variables that influence the product quality. In design of experiments, the experimenter is often interested in the effect of some process or investigation. Increasing productivity and improving quality are important goal in any business. The method for determining how to increase productivity and improving quality are evolving. After identify the process condition and product components that influence the product quality, one can have direct improvement efforts to enhance the product's manufacturability, reliability, quality, and field performance. Applying Taguchi methodology to optimize the experimentation to L16 orthogonal array.

Table -1 Level Design

EXPERIMENTAL VARIABLE	**LEVEL 1**	**LEVEL 2**	**LEVEL 3**	**LEVEL 4**
CUTTING MATERIAL HARDNESS (HRC)	45	51	57	64
FEED (mm/rev)	0.150	0.185	0.220	0.250
CUTTING SPEED (m/min)	150	180	210	250

In the present work experiments were designed on the basis of experimental design technique using Taguchi (43 design means 4 levels and 3 factors).

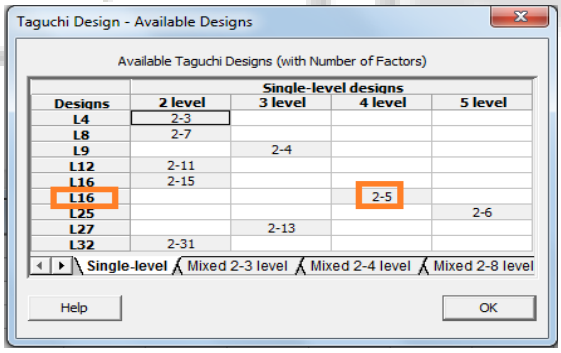

Fig.2: basis of experimental design technique

Table -2 Design of Experiment

SR NO	HRC	FEED	CUTTING SPEED
1	45	0.150	150
2	45	0.185	180
3	45	0.220	210
4	45	0.255	240
5	51	0.150	180
6	51	0.185	150
7	51	0.220	240
8	51	0.255	210
9	57	0.150	210
10	57	0.185	240
11	57	0.220	150
12	57	0.255	180
13	63	0.150	240
14	63	0.185	210
15	63	0.220	180
16	63	0.255	150

IV. EXPERIMENTAL SETUP

A. Preparation of work piece

The work-piece of the D2 material for Heat Treatment to achieve the hardness as per the following group.

1. 45 to 51 HRC
2. 51 to 57 HRC
3. 57 to 64 HRC

The heat treatment will be done at ANAND HEAT TREATERS, AHMEDABAD. To get the required hardness following cycle has been adopted.

After completing the heat treatment process, the AISI D2 Steel has been turned on the CNC Turning machine in VIJAY MILLING ENTERPRIZE, AHMEDABAD.

- Work piece material: AISI D2
- SIZE: 50(dia) × 150(lenth) MM

Table -3 Chemical composition of AISI D2

Element	C	Si	Mn	Cr	Mo	V
Specifications	1.50 - 1.60	0.1-0.4	0.15 - 0.45	11.0 - 12.0	0.60 - 0.80	0.9-1.1
1	1.55	0.3	0.4	11.8	0.80	1.000
2	1.56	0.2	0.4	12.0	0.70	0.900
3	1.57	0.3	0.4	11.3	0.70	0.900
4	1.58	0.3	0.4	11.2	0.80	0.900

B. Machine specification

specification of the same machine is described as under.

Machine MODEL : DX150

Manufactured by : Jyoti CNC

1. Capacity: Max. swing over bed – 375 mm
   Max. tuaning lathe – 350 mm
   Std. turning dia. – 150 mm
   Max. turning dai. – 250 mm

2. Slides : cross(x-axis) travel – 150 mm
   Longitudinal (z- axis) travel – 350 mm
   Rapid feed (x & z axis) – 24 m/min
3. Main spindle: motor power- 10.5/7 kw
   Bore- 50 mm
   Speed range – 50- 4500 rpm
4. Accuracy: 0.007
5. Weight: 3000 kg
6. Dimemsion (l*b*h): 1950*1375*1950 mm

C. Measure response parameter

1) Surface roughness (Ra)

Surface topography or surface roughness, also known as surface texture are terms used to express the general quality of a machined surface, which is concerned with the geometric irregularities and the quality of a surface . I have measured surface roughness by surface roughness tester. The Ra value, also known as centre line average (CLA) and arithmetic average (AA) is obtained by averaging the height of the surface above and below the centre line.

Fig.3: Surface roughness

Table - 4 Specification of Surface roughness

Measurement parameters (µm): Ra.
Range:-360 µm (-200 to +160)
Measuring Method: - Skidded
Dimension (W × D × H):- Display Unit - 52.1 × 65.8 × 160mm
Drive unit-115 × 23 × 26(mm)
Power supply: -Two way (Battery and AC adapter)
Charger: DC 6V, with 3-hour recharging time.
Dimension: 110 ×70 ×24(mm)
Mass: - about 0.5 kg

2) Cutting tool wear

Depth of Tool wear has been measured by tool maker's microscope. Specification given below:

MODEL - CARL-ZEISS
RANG - 50*150 MM
ACCURACY - 0.001(1µ)

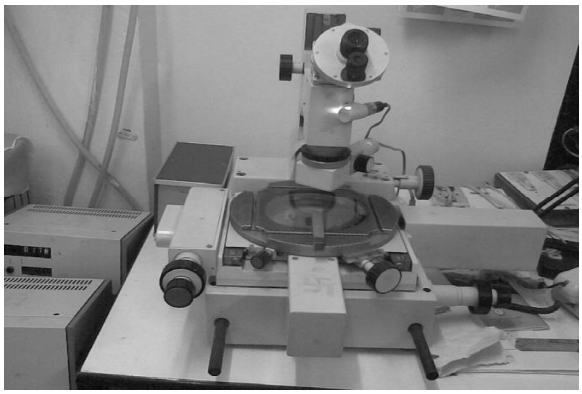

Fig.4: tool maker's microscope

3) Material removal rate (mrr)

The material removal rate (MRR) of the work piece is the Mass of the material removal per minute. Weight of specimen before and after machining measured with 0.001 gm accuracy. MRR measured on weight base. Following equation is used to determine the material removal rate (MRR) value:

$$MRR(gm/min) = \frac{Mass(Before\ machining) - Mass\ (After\ machining)(gm)}{Machining\ time(\text{min})}$$

V. RESULT TABLE

SR NO	HRC	FEED	CUTTING SPEED	TOOL WEAR	MRR	SR
1	45	0.15	150	0.282	937.5	3.153
2	45	0.185	180	0.302	1387.5	4.720
3	45	0.22	210	0.322	1925.0	3.903
4	45	0.25	250	0.359	2604.2	5.757
5	51	0.15	180	0.324	1125.0	3.700
6	51	0.185	150	0.260	1156.3	3.873
7	51	0.22	250	0.378	2291.7	1.397
8	51	0.25	210	0.303	2187.5	3.743
9	57	0.15	210	0.366	1312.5	3.883
10	57	0.185	250	0.400	1927.1	2.975

11	57	0.22	150	0.238	1375.0	3.109
12	57	0.25	180	0.261	1875.0	4.112
13	64	0.15	250	0.422	1562.5	3.121
14	64	0.185	210	0.344	1618.8	3.117
15	64	0.22	180	0.280	1650.0	4.107
16	64	0.25	150	0.219	1562.5	3.137

VI. DATA ANALYSIS

The present chapter gives the application of the Taguchi methodology. The scheme of carrying out experiments was selected and the experiments were conducted to investigate the effect of process parameters on the output parameters e.g. Tool Wear, MRR and Surface finish. The experimental results are discussed subsequently in the following sections. The selected process variables were varied up to four levels and L 16 orthogonal array was adopted to design the experiments.

Table – 5 S/N ratios for Tool Wear

Level	Cutting Material Hardness	Feed	Cutting Speed
1	0.3163	0.3485	0.2498
2	0.3163	0.3265	0.2918
3	0.3163	0.3045	0.3338
4	0.3163	0.2855	0.3898
Rank	3	2	1

The significant parameters can be easily identified and rank the parameter as per the response table for S/N Ratio and means.

The most significant parameters for Tool wear is Cutting speed.

Table – 6 ANOVA for Tool Wear

Source	DF	Seq SS	Adj SS	Adj MS	F	P	%
Hardness	3	0	0	0	**		0
Feed	3	0.008915	0.008915	0.002972	**		17.19748
Cutting	3	0.042924	0.042924	0.014308	**		82.80252
Speed							
Error	6	0	0	0			0
Total	15	0.051839					

S = 3.366996E-17 R-Sq = 100.00% R-Sq(adj) = 100.00%

It is show cutting speed is the most significance parameter for Tool Wear is 82.80% then after Feed 17.19%

Table – 7 S/N ratios for MRR

Level	Cutting Material Hardness	Feed	Cutting Speed
1	1714	1234	1258
2	1690	1522	1509
3	1622	1810	1761
4	1598	2057	2096
Rank	3	2	1

The significant parameters can be easily identified and rank the parameter as per the response table for S/N Ratio and means.

The most significant parameters for MRR is Cutting speed.

Table – 8 ANOVA for MRR

Source	DF	Seq SS	Adj SS	Adj MS	F	P	%
Hardness		35670	35670	11890	4.02	0.069	1.14
Feed	3	1521994	1521994	507331	171.5	0	48.85
Cutting Speed	3	1539947	1539947	513316	173.53	0	49.43
Error	6	17749	17749	2958			0.56
Total	15	3115360					

S = 54.3887 R-Sq = 99.43% R-Sq(adj) = 98.58%

As shown in above table R-sq value is 99.43% and the most significance parameter which is effect to MRR is Cutting speed 49.43% and then after Feed 48.85% these two parameter are effect to the MRR.

Table – 9 S/N ratios for Surface Roughness

Level	Cutting Material Hardness	Feed	Cutting Speed
1	15.980	8.043	11.375
2	15.565	12.233	13.650
3	14.383	17.295	15.925
4	13.978	22.335	18.955
Rank	3	1	2

The significant parameters can be easily identified and rank the parameter as per the response table for S/N Ratio and means.

The most significant parameters for Surface Roughness is Feed.

Table – 10 ANOVA for Surface Roughness

Source	DF	Seq SS	Adj SS	Adj MS	F	P	%
Hardness		10.817	10.817	3.606	4.04	0.069	1.79
Feed	3	460.531	460.531	153.51	172.17	0	76.43
Cutting Speed	3	125.834	125.834	41.945	47.04	0	20.88
Error	6	5.35	5.35	0.892			0.887
Total	15	602.532					

S = 0.944259 R-Sq = 99.11% R-Sq(adj) = 97.78%

As see in above table R-sq value is 99.11% and most significance parameter is Feed 76.43% so we observe that cutting speed and feed are the most significance parameter in our experiment.

VII. FUTURE WORK

- Result discussion is remaining.
- Developed regression model for SR, Tool wear and MRR
- Research Paper will have to publish.
- Valuable Conclusion is remaining.
- Thesis writing.

VIII. CONCLUSION

We Conclude with learn for this experiment, Hardness is not create much effect in Ra, MRR and Tw, with compare to other two parameter Feed and Cutting speed for the D2 material we can get the formula base on this experiment for the use of practical application. Anova table is show the most significance parameter to our desire result so it clear the understanding how much percent those parameter is effect to our result.

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