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Investigation of Tool Wear under different Environmental Conditions in Turning of AISI D2 Steel using Taguchi Method

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ABSTRACT: Increasing the productivity and quality of machined parts at low cost are the main challenges of any manufacturing industries metal Cutting industry. Most of the product in this universe are gone through some kind of manufacturing process. There are various manufacturing process but turning is the commonly used process in manufacturing processes. The main objective of any manufacturing industries is to reduce the machining cost, it will be reduced by increasing tool wear .Therefore main objective of this research is to investigate the effect of cutting parameters tool shape & environmental conditions on the tool wear, for analysing tool wear an ANOVA technique based upon Taguchi method is used. Turning is a widely used metal removal process in manufacturing industry that involves generation of high cutting forces and temperatures. Lubrication becomes critical to minimize the effects on wear of cutting tool and, surface finish of work. In the present work an experimental investigation was conducted to characterize the machinability of uncoated carbide tools and surface integrity in turning of AISI D2 hardened steel (58-62 HRC) on a lathe. The cutting variables were cutting speed (70-90 m/min) and depth of cut (0.2-0.4 mm), meanwhile feed per tooth (0.1-0.3 mm) and three different cutting tool environments dry, wet, solid lubricant.and three different types of tool inserts are used .The experimental layout was designed based on the taguchi' machining and coolant conditions. The results indicate that there ia a considerable improvements in machining performance under solid lubrication compared to dry and wet machining

Keywords: Aisi D 2 Steel, Tool Wear, Taguchi Method,

I. INTRODUCTION

Cutting tool has been using since hundreds years ago and a lot of research has been done continuously to develop new tool material to improve the tool wear and tool wear of the finished product. The growth of industry is not possible without invention of new material and tool design. Many new materials are continuously invented which require more hard tools for their machining with proper surface need finish [1].

To make the production economical and to increase cutting tool wear with proper tool wear in the past commonly the tool materials were enhanced by various processes which helps in great control over the range of cutting tool properties [2]. To improve the productivity i.e. to increase the metal removal rate with better surface finish and economical machining some other methods like use of cutting fluids, Hot machining, Cryogenic cooling, Coated tools are adopted to reduce tool wear and to increase tool wear [3]. The most recent issue is the tool design by change in tool geometry.

In machining of parts, tool wear is one of the most specified customer requirements [5]. There are many parameters such as cutting speed, feed rate, and tool nose radius that are known to have a large impact on tool wear.

II. EXPERIMENTAL DETAILS

Many researchers worked on the geometry, tool shape, cutting parameters and different environments conditions (dry, wet, solid, minimum quality lubrication), but very few studied have been reported on the effect of shape of the carbide insert on the surface finish under different (dry, wet, solid) conditions. Also from the above literature it is illustrated that many researchers have reported the use of graphite, molybedenum di sulphide & calcium floride as solid lubricant, but as other material like (zinc sulphide, ferrite sulphide, boron oxide, hexagonal boron nitride & aluminium oxide also act as a solid lubricant. Hence the main objective of this research work is to fanthom the effect of combined effect of tool shape, cutting parameters and different environmental conditions (solid, dry, wet) on the tool wear and tool wear while machining of AISI D 2 steel WORK PIECE MATERIAL.

Fig. 1.

Typical applications for D2 Steel:

- Stamping or Forming Dies, Punches, Forming Rolls, Knives, slitters, shear blades, Tools, Scrap choppers, Tyre shredders

Table 1: Chemical Composition Of Aisi D 2 Steel.

S. NO	**METAL**	**RANGE**
1	CARBON	1.40-1.60%
2	SILICON	0.10-0.60%
3	MANGANESE	0.60%
4	CHROMIUM	11.00-13.00%
5	MOLYBDENUM	0.70-1.20%
6	VANADIUM	0.90-1.10%
7	PHOSPHORUS	0.012-0.021%
8	NICKEL	0.023%
9	SULPHUR	0.020%

Table 2: Cutting Parameters And Levels.

FACTORS	CUTTING PARAMETERS	LEVELS		
		1	**2**	**3**
1	ENVIRONMENT	DRY	WET	SOLID
2	SHAPE	TRIANGULAR	SQUARE	TRAPEZOIDIAL
3	DEPTH OF CUT (mm}	0.2	0.3	0.4
4	CUTTING SPEED (m/min)	70	80	90
5	FEED RATE (mm/rev)	0.1	0.2	0.3

III. EXPERIMENTAL DESIGN

Taguchi Method: Taguchi approach is used to design an experiment (DOE). It is well- known technique that provides process optimization used for high quality system. It provides optimum condition of process parameter that is least sensitive to the various causes of variations. Signal to noise ratio and orthogonal array are two major tools used in robust design. The S/N ratio characteristics can be divided into three categories (a) Nominal the best (b) Smaller the better (c) Larger is better features. For the surface roughness, the solution is “smaller is better” and S/N ratio is determined according to the following equation:

S/N = -10 Log_{10} [mean of sum of squares of measured data]

Where, S/N = Signal to Noise Ratio, n = No. of Measurements, y = Measured Value.

Selection of parameters and their levels must be taken into consideration before finalizing the design of experiments [8].

The taguchi method is a powerfull problem solving technique for improving process performance, yield and productivity , it reduces scrap rates , rework cost and manufacturing costs due to excessive variability in process.[9]

For this experiment work Taguchi orthogonal array L27 is selected, which give the order of experiment as shown in Table 3.

Table 3.

ENVIR- -ONMENT	TOOL SHAPE	SPEED	DEPTH OF CUT	FEED
DRY	TRIANGULAR	70	0.2	0.1
DRY	TRIANGULAR	70	0.2	0.2
DRY	TRIANGULAR	70	0.2	0.3
DRY	SQUARE	80	0.3	0.1
DRY	SQUARE	80	0.3	0.2
DRY	SQUARE	80	0.3	0.3
DRY	TRAPEZODIAL	90	0.4	0.1
DRY	TRAPEZODIAL	90	0.4	0.2
DRY	TRAPEZODIAL	90	0.4	0.3
WET	TRIANGULAR	80	0.4	0.1
WET	TRIANGULAR	80	0.4	0.2
WET	TRIANGULAR	80	0.4	0.3

WET	SQUARE	90	0.2	0.1
WET	SQUARE	90	0.2	0.2
WET	SQUARE	90	0.2	0.3
WET	TRAPEZODIAL	70	0.3	0.1
WET	TRAPEZODIAL	70	0.3	0.2
WET	TRAPEZODIAL	70	0.3	0.3
SOLID	TRIANGULAR	90	0.3	0.1
SOLID	TRIANGULAR	90	0.3	0.2
SOLID	TRIANGULAR	90	0.3	0.3
SOLID	SQUARE	70	0.4	0.1
SOLID	SQUARE	70	0.4	0.2
SOLID	SQUARE	70	0.4	0.3
SOLID	TRAPEZODIAL	80	0.2	0.1
SOLID	TRAPEZODIAL	80	0.2	0.2
SOLID	TRAPEZODIAL	80	0.2	0.3

The average value of S/N ratios has been calculated to find out the effects of different parameters and as well as their levels. Both ANOVA technique and S/N ratio are used to analyze the results and to reach on the best solution. The table indicate the response for S/N ratio in which rank show the relative importance of each factor to the response

Therefore, base upon the different setting of various parameters provided by the design of experiments as in table (3). The experiments are performed, and the tool wear is measured. At least three run with the same setting of parameters was taken into consideration and the mean SN ratio. All these calculation are performed using software Minitab-14.

IV. RESULTS AND DISCUSSION

Table 4: Output Data for Surface Rougnness and S/N Ratio.

Environment conditions	tool shape	Speed (m/min)	depth of cut (mm)	feed (rev/min)	Tool wear (MM)	S/N ratio
dry	Triangular	70	0.2	0.1	0.66	3.609121
dry	Triangular	70	0.2	0.2	0.73	2.733543
dry	Triangular	70	0.2	0.3	0.76	2.383728
dry	Square	80	0.3	0.1	0.54	5.352125
dry	Square	80	0.3	0.2	0.59	4.58296
dry	Square	80	0.3	0.3	0.63	4.013189
dry	Trapezoidal	90	0.4	0.1	0.67	3.478504
dry	Trapezoidal	90	0.4	0.2	0.72	2.85335
dry	Trapezoidal	90	0.4	0.3	0.78	2.158108
wet	Triangular	80	0.4	0.1	0.32	9.897

wet	Triangular	80	0.4	0.2	0.41	7.744323
wet	Triangular	80	0.4	0.3	0.53	5.514483
wet	Square	90	0.2	0.1	0.37	8.635966
wet	Square	90	0.2	0.2	0.41	7.744323
wet	Square	90	0.2	0.3	0.46	6.744843
wet	Trapezoidal	70	0.3	0.1	0.37	8.635966
wet	Trapezoidal	70	0.3	0.2	0.42	7.535014
wet	Trapezoidal	70	0.3	0.3	0.45	6.93575
solid	Triangular	90	0.3	0.1	0.21	13.55561
solid	Triangular	90	0.3	0.2	0.25	12.0412
solid	Triangular	90	0.3	0.3	0.27	11.37272
solid	Square	70	0.4	0.1	0.23	12.76544
solid	Square	70	0.4	0.2	0.24	12.39578
solid	Square	70	0.4	0.3	0.29	10.75204
solid	Trapezoidal	80	0.2	0.1	0.31	10.17277
solid	Trapezoidal	80	0.2	0.2	0.32	9.897
solid	trapezodial	80	0.2	0.3	0.33	9.629721

The ranks and the delta values for various parameters show that environment has the greatest effect on tool wear and is followed by feed and tool shape.

Table 5: Analysis of Variance for Tool Wear (At 95 %) Confidence Level.

SOURCE	DF	SEQ SS	ADJ SS	ADJ MS	F	P	% C
ENVI	2	283.828	283.828	141.914	446.09	0	85
TOOL SHAPE	2	7.809	7.809	3.905	12.27	0.001	4
SPEED	2	0.176	0.176	0.088	0.28	0.761	1
DEPTH OF CUT	2	8.648	8.648	4.324	13.59	0	3

FEED	2	15.311	15.311	7.655	24.06	0	5
RESIDUAL ERROR	16	5.09	5.09	0.318			2
TOTAL	26	320.863					100

S = 0.5640 R-SQ = 98.4% R-SQ(ADJ) = 97.4%

Table shows the result of ANOVA for tool wear as shown in table no 5 , it is observed from the ANOVA table ,the environment (85 %) is the most significant cutting parameter followed by feed (5 %) . However speed has least effect (1 %) in controlling tool wear ,which is not statistically significant.

Fig. 2. Pi- chart (% age contribution of each factor).Pi- chart shows the % age contribution of each factor during the machining process, it indicates that 85% contribution during the machining is by environmental factors. The main effect plot was constructed by using Taguchi orthogonal array technique with the help of Minitab software 14. The signal to noise ratio was found by considering smaller the better qualities features for surface roughness. The plot between data means and mean of the signal to noise ratio as shown in fig (3).

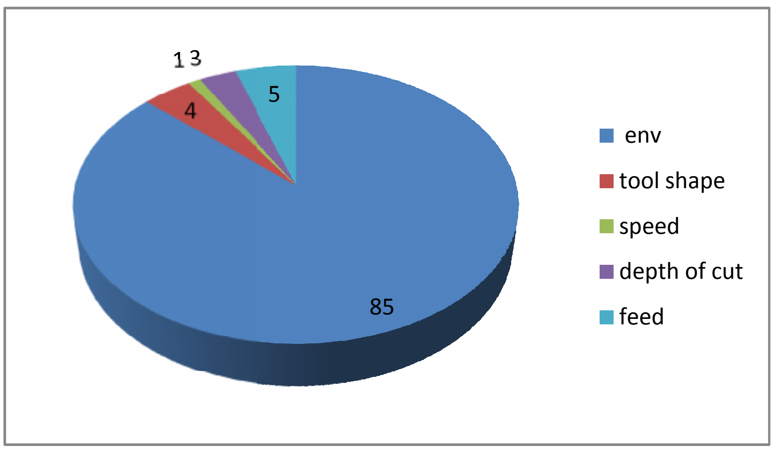

Fig. 2.

Response Table for Signal to Noise Ratios for tool wear. Smaller is better table 6.

Table 6.

LEVEL	ENVI	TOOL SHAPE	SPEED	DEPTH OF CUT	FEED
1	3.463	7.65	7.527	6.839	**8.456**
2	7.71	**8.11**	7.423	**8.225**	7.503
3	**11.398**	6.811	**7.621**	7.507	6.612
DELTA	7.935	1.299	0.198	1.386	1.844
RANK	1	4	5	3	2

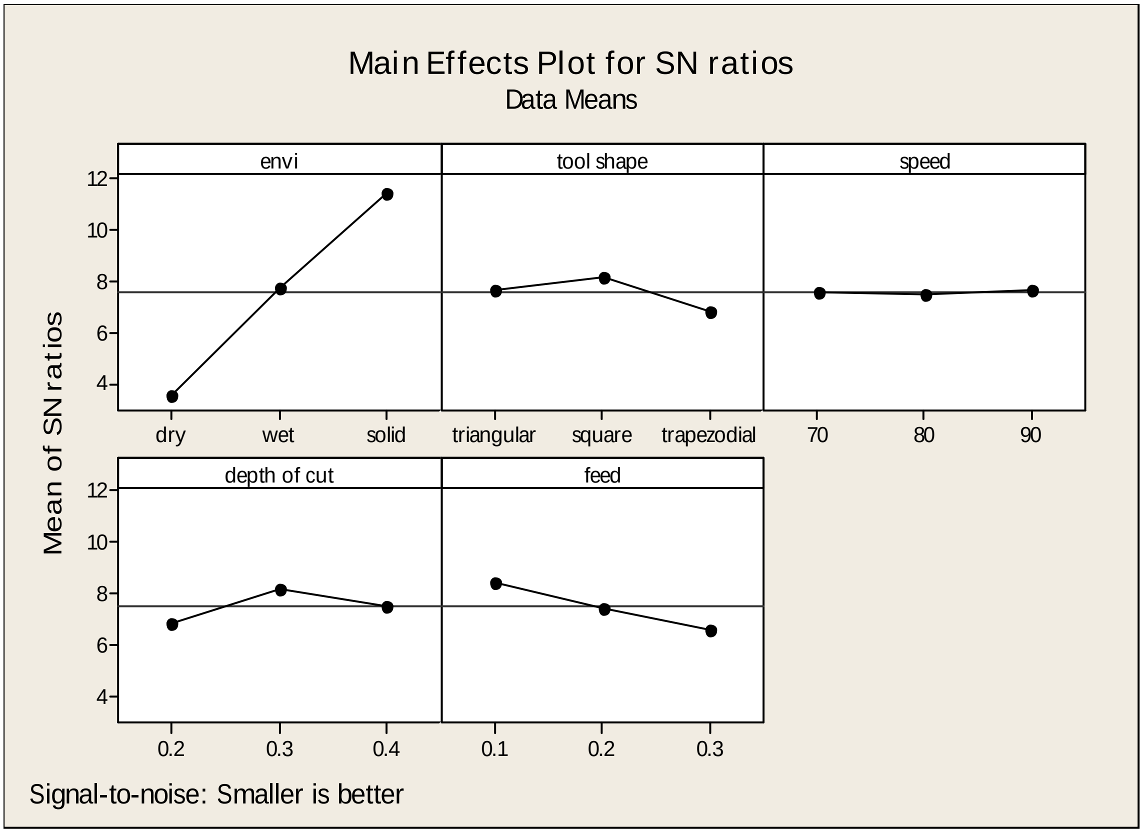

Fig. 3. Effect of turning parameters on tool wear.

Environment is found to be most significant factor & its contribution to tool wear is (85 %).

V. CONCLUSION

The present study was carried out to study the effect of input parameters on the tool wear,the following conclusions have been drawn from the study

1. The Tool Wear is mainly affected by environment conditions and feed, with the change of environment to solid the tool wear is less as compared to dry and wet machining,
2.From ANOVA analysis , parameters making significant effect on tool wear , environment and feed were found to be significant to tool wear for reducing the variations
3. The results obtained from conformation test shows that the error in experimental and predicted values is 2 % which is less than 10 %. It shows that our experimental results are fit to the best.
4. The effect of environment on tool wear is maximum solid lubricant 85%.

VI. SCOPE OF FUTURE WORK

a) Tool wear can also be measured by varying the other geometrical parameters as (tool nose radius, rake angle, side cutting edge angle etc.).
b) Tool wear can also check by using other shape of inserts.
c) Tool wear can also be measured by using chip breakers and wipers inserts.
d) tool wear can also be measured under different environmental like flood lubricants; Minimum quantity of cutting fluids, solid lubricants and gaseous lubricants .
e) Tool wear during hard turning can also be checked.
f) Mathematical modelling can be made

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