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Parametric Appraisal for Surface Roughness of Tool Steel While Turning Using Taguchi Method

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***Abstract:** The primary aim of the work is to help achieve an optimum condition of input parameters of process parameters (cutting speed, feed rate and cutting depth) that yields in minimum surface roughness value while machining on lathe of tool steel grade D3 coated carbide insert using a water based coolant. The Taguchi L9 array was used experimental design and the results are additional variance analysis (ANOVA). Results have shown most dominating factor for roughness was feed rate At last valedictory test were conducted to confirm the values that leads to check the effectiveness of the analysis of roughness.*
***Index Terms**: Taguchi, DOE, Anova,L9.*

I. INTRODUCTION

Production hubs around the globe are constantly looking for cost-effective solutions with reduced weighting times and high surface finish to maintain their competitiveness. Mostly iron based metal parts are traditionally machined using lathe for rough cut and then gone through heat-treatment and finally finished using grinding. Hard turning using a SPCT has replaced grinding for such applications to some extent in recent years. Surface roughness has focused seriously for long. It has formulated an crucial design feature in many applications like when component is exposed to cyclic loading, precise fits, fastener holes, and esthetic requirements D singh et al(2007). D3 tool steel is among one of the best choice material as it can maintain its strength and hardness at elevated temperature and its unmatched wear resistance. It is suitable for manufacturing of cold work dies and rolls.At the same time its high harness and toughness became hindrance for ease of its machine ability. Turning is traditional machining method that could be cost effective method of machining of D3 tool steel. However there is not much evidence regarding turning of material like tool steel in literature.

Ravinder et al(2014) worked on AISI O3 steel in order to optimise the parameter for surface roughness and MRR and compared the different method for multi optimize the output parameter, they found the WSN method best for multi optimize the input parameters. **Chaudhari et al(2011)** studied mild steel using L9 OA with response parameter surface roughness and tool wear under the environment of MQL(minimum quantity lubrication). The results showed that rpm, depth of cut and feed rate are influential factor to govern the wear. They also showed that MQL provides solution for many problem during turning. **Thamizhmanii et al (2007);** used Taguchi method keeping cutting speed, feed rate and D.o.C as input parameters for response factor as surface roughness of SCM-440 alloy steel and found that depth of cut influence the most and experimental yields thereof were studied using ANOVA method. The authors claimed that depth of cut was significant factor which contributed to the surface roughness. **Sahoo and Sahoo (2011)** use the RSM and taguchi mehod to predict the roughness of D2 tool steel using Tin coated tool.they also kept speed, feed and D.o.C. as input parameter. Their results showed that feed rate is the dominated factor to control the smoothness followed by depth of cut. They have used L27 array for experimentation. **Selvaraj et al (2010)** worked on AISI 304 austenitic stainless steel to show influencing the cutting parameters such as speed, feed & cutting depth on material surface ruggedness during dry turn. An experimental plan based on the technique of Taguchi was used for data acquisition. In order to investigate cutting properties for the material using a coated Tic carbide tool TiC, an orthogonal array L9, S / N ratio and ANOVA was employed. They found feed speed and cut speed . Sharma Vikas et al (2018) focused on same material and optimized the input factors of turning for surface quality using MCDM methods. Viyat et al(2019) aimed to find best parameters setting for die steel using TLBO algorithm.

II. EXPERIMENTAL DETAILS

In this study cylindrical work piece D3 tool steel was used. Details of the workpiece material as shown in Table below

Table1: Work piece material Properties

Typical Analysis %	C – 2.2%	Mn– 0.4%	Cr – 12%	V – 1%
Standard specification	AISI D3.			
Color code	Red/Gray			

Experiments were carried out on rigid NH22 (HMT, India) lathe having capabilities to carry out special designed experiments. For enhancing accuracy of experimental study, work-piece material was held between centers and tailstock (revolving center) and the overhanging of cutting tool was kept at the minimal. The carbide inserts CCMT 060208(SANDVIK –COROMANT) are used for this experimentation.

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Figure 1 Experimental Set Up used

The factor selection were made on the behalf of literature survey and levels are decided with the help of pilot test as well as literature survey done so far. A water base coolent is used throughout experiments for ease of machining and cooling purpose grade:- SAE 40.

Table 2: Cutting Parameters

S.N.	A	B	C
Factors	Speed	Feed	Depth of Cut
Levels	3	3	3
1	420	0.2	1
2	325	0.1	0.6
3	192	0.05	0.2
Units	Rpm	mm/rev	mm

Experiments were carried according to L9 array that has been decided after reaching number of factors and levels of each factor.

Traditional methods are complex and number of experiments needed for the same are very large in number as soon as the number of factors and levels increased and these studies are considered for off line quality control **(muluk et al 2004).** A Taguchi design does not need all possible combinations of input parameters, rather it use only some of them for experimentation. It is balanced so that every level of factor assigned equal weightage.

In the above said method, the term 'signal' meant by the output value we are looking for and the term 'noise' represents the undesirable value (S.D) for the output characteristic. So the S/N ratio is the ratio of the mean to the S.D. S/N ratio and gives us idea how much our target value is deviating from the mean value.

$$\eta = -10\log(M.S.D) \qquad (1)$$

where $M.S.D$ is the mean square deviation for the output characteristic.The better characteristic quality for surface ro ughness must be taken in order to achieve optimum cutting performance. The better quality characteristic of the M.S.D. for the – lower – the–better is:

$$\left(S/N\right)_{SB} = 10\log(MSD_{LB})\ldots\ldots \qquad . (2)$$

$$\text{Where} \quad MSD_{SB} = \frac{1}{R}\sum_{j=1}^{R} (y^2{}_j)$$

Where, Si for the I - th test is the ruggedness of the surface v alue. Table 3 shows the surface roughness test results and th e associated S / N ratio. Surface roughness is indicated in th e S / N response table and S / N response diagram

Table 3: L9 Array for input Parameters

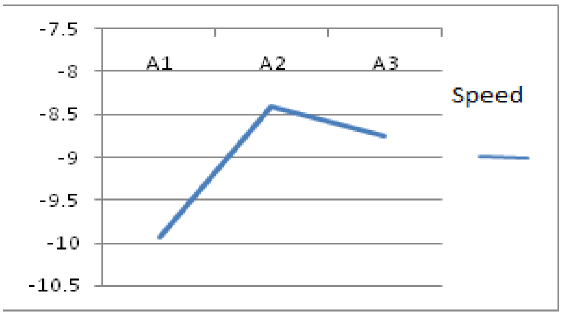
Exp. No.	Run No.	Speed	Feed	DoC	SR	SN ratio
1	6	420	0.2	1.0	4.638	-13.329
2	4	420	0.1	0.6	2.798	-8.938
3	8	420	0.05	0.2	2.376	-7.524
4	3	325	0.2	0.6	3.910	-11.848
5	1	325	0.1	0.2	2.451	-7.806
6	5	325	0.05	1.0	1.883	-5.574
7	6	192	0.2	0.2	2.374	-7.584
8	9	192	0.1	1.0	3.704	-11.387
9	2	192	0.05	0.6	2.311	-7.280

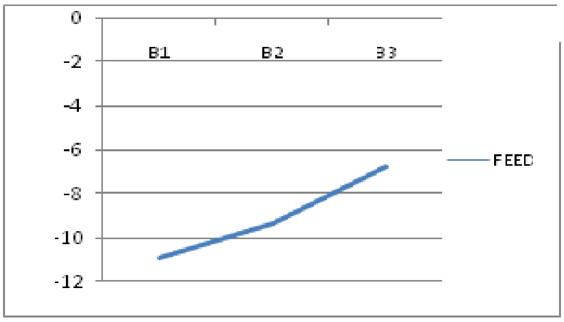
III. RESULT AND ANALYSIS

Result from L9 array was analysed through Annova using minitab 14 version . From figure it can be seen for the figure feed rate and D.o.C are the most influencial for the surface roughness. As spindle speed varies, there is slight change in surface roughness first it improves and then somewhat decreases. In case of depth of cut and feed rate surface finish increases with reduction in these parameters. The different input parameters used in the experimentation can be ranked in order of increasing effect as spindle speed, depth of cut and the feed rate.

Table 4: ANOVA results for Surface Roughness S/N ratio

Source	DF	Seq SS	SS Adj	Adj MS	F	P	%age contribution
Speed	2	0.9998	0.9998	0.4999	1.46	0.273	7.51
Feed	2	6.3324	6.3324	3.1662	9.27	0.004	44.662
DOC	2	3.0887	3.0887	1.5444	4.52	0.037	21.784
Error	11	3.7572	3.7572	0.3416			
Total	17	14.1782					
S= 0.584434 R-seq = 73.5% R-seq(adj)= 59.055%							
Order of significance:- 1. Feed rate 2.DOC							





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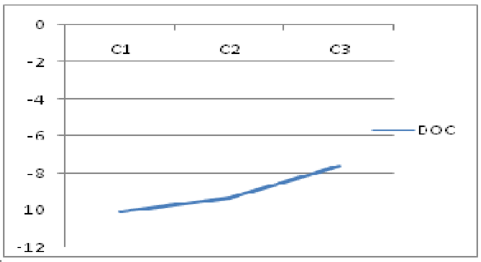

Results analyzes showed that the A2 B3 C3 is the perfect surface ruggedness parameter setting. We concluded in the study that the optimum parameter setting for the spindle speed is 325 rpm, the feed rate is .05 mm / rev, the DoC as 0.2 mm, while the roughness of the surface of the AISI D3 tool steel is rotated. The estimate of the mean (μ) is based only on the average results yields from the experimentations. So necessary to reflect the values of an output for a certain level of confidence as an area within which it is likely to fall (Ross, 1996). The confidence interval (CI) is called this range. In other words, a maximum and minimum value is the interval between trust, between which the true average should drop at a certain confidence percentage (Ross, 1996). The Taguchi method has been applied to estimate mean results and to determine the confidence interval of the predicted average. The average surface ruggedness of the confirmatory experim ents must be within a confidence interval of 95 percent CI (α =0.05).The predicted optimum value of surface roughness is calculated as Optimum combination for surface roughness is A2 B3 C3

Hence, μ_{SR} = (A2 + B3 + C3) – (2 μ) = 1.462

6. Confirmation tests

As for confirm the predicted value of surface roughness experiment was carried out for confirmation the same. Results was fairly agree with the predicted value. Given below table shows the results.

Table 5: Confirmation test results

Response	Predicted value	Experimental value	CI_{CE}
Surface roughness(μm)	1.462	1.86	0.252 < μ SR < 2.672

IV.CONCLUSION

We know all that it is always difficult to turn hard material in this study to turn D3 tool steel to reduce costs while concentrated on roughness, the main concern of which was the application of Taguchi method to find the settings of independent factor that improve dependent surface finish during machining of D3 tool steel using lathe machine under wet conditions . For optimizing the input factors, a Taguchi orthogonal array technique was employed to design the experiments, the S / N ratio and the Variance Analysis (ANOVA). The findings from ANOVA show that surface roughness is influenced by the feed rate, the cutting speed and the depth of the cut. 44.662%, depth of cut is 21.784%, and speed is 7.05%. A valedictory experiment was also executed and verified the effectiveness of the Taguchi optimization method. Further same Study can be done regarding forces and material removal rate etc and for multi-optimization work can be carried out. This same study can be carried out using dynamometers that can further give idea regarding forces involved and tool material and other power related factors can be decided.

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