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Optimization of Lathe Machine Parameter of Turning Hardened Material IS 2062:2011 E250 Grade A for Surface Roughness and MRR.

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ABSTRACT

In Today's era of manufacturing Business Industry due to high demand of good quality and high degree of Accuracy, It is very essential to select the optimum Machining Parameter to improve the Material Removal Rate and Increase the Productivity at Minimum Cost .The Quality is mainly the function of Surface Roughness and Productivity is the Function of Material Removal Rate. This Paper mainly focus on the optimizing the process parameter based on Taguchi method for minimizing the surface Roughness and maximizing the M.R.R .The experiment were carried out to turn the material IS 2062 on Lathe Machine. Three main cutting parameters were selected such as cutting velocity, feed rate and Depth of Cut and three levels were selected. MINITAB 17 is use to design orthogonal array L9 according to Taguchi Method. The signal to Noise Ratio for surface roughness and M.R.R were evaluated to determine the effect of Parameter on Quality Characteristics. Analysis of variance (ANNOVA) with the help of MINITAB 17SOFTWARE use to determine the effect of most Significant Parameters on the Quality Characteristics such as Surface Roughness and Material Removal Rate and percentage of contribution for effecting the quality characteristics. ANNOVA is applied to identify the Ranking of Parameter which is mostly significant effect. In this investigation, itis observed that feed rate is most influencing parameter for Surface Roughness and Depth of cut is most significance Factor for MRR.

Keywords - : Hardened, MRR, Orthogonal Array, TaguchiMethod, ANOVA, Minitab 17

1.INTRODUCTION

Manufacturing is an important aspect for the development of any country and GDP of country is also depend on the manufacturing .Metal cutting of the Hardened material is difficult to cut and involve more consumption of Energy and wastage of Material .

In metal cutting industries, to machine the hardened material, operating parameters are decide depending on the operator skill and experience or need to select some advance manufacturing process which increase the cost of production. In metal industries, turning is major operation carried out to remove the material at different Material Removal Rate depends on the hardness of material .To remove the material different parameters such cutting speed ,Feed Rate and depth of cut is need to select which motivate to investigate the effect of this process parameter on the Quality Characteristics.

In turning process the Machining Parameter such as cuttingvelocity, FeedRate, Depth of cut, workpiece properties and machining conditions highly effect the turning performance and deviates the quality in respect with surface finish and effecting the material Removal Rate,It is very necessary to select most appropriate factors which improve the cutting performance, surface Quality and Reduce undesirable losses and Produce high quality of Products.

Various Investigator conduct the experiment to determine the effect of Machining Parameter such as cuttingvelocity, FeedRate, Depth of cut, Tool Nose Radius, Rake Angle on surface Roughness and tool wear in turning of hard material.In this paper, the Taguchi method with ANNOVAis introducedto optimize the process parameter and investigate the effect of process parameters on the Surface Rouhgness and M.R.R. The experimental details of using the Taguchi method to determine and analyze the optimal cutting parameters are described in this paper.

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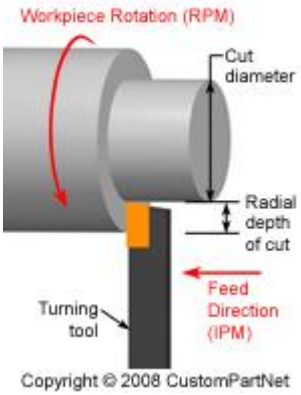

Taguchi method suggest the efficient Design of Experimentfor optimization of Turning Process Parameter using MINITAB 17.Taguchi recommend Signal to Noise Ratio to determine the effect of Parametrs on quality Charcteristics .In Taguchi method ANOVA is use to know the most influence impact of parameter on the Quality Characteristics .

In this Paper Taguchi's Design of Experiment conduct for 9 Trial using Orthogonal Array Design L9 the Parameter are design in coded levels and experiment were conducted according to Orthogonal Array. The Effect of Turing Process Parameters such asCutting velocity, Feed Rate, Depth of cut on hardened IS 2062 Low Carbon Steel of Hardness 64HRB and to obtain the Optimum setting of Parameter that result optimizing Surface Roughness and M.R.R.

2. LITERATURE REVIEW

The survey of Literature indicate that there are vast published work available on the machining of Hardened Material to determine the effect of process parameter on the surface roughness and material removal Rate. However there is no literature available on the study of effect of turning process parameter of IS 2062 .the motive of the selection of this materialis hardened material because of low carbon mild steel vast application in the field of Railways, Marine and Forging Industries.

Supriya Sahu et.al. [1]Optimization of cutting parameters is valuable in terms of providing high precision and efficient machining. Soan attempt is made to optimize machining parameters using coated tools by analysis of surface roughness and tool wear for AISI 4340

Vijay Kumar H.K et.al[2] Taguchi technique is used to find optimum process parameters for turning of hardened AISI 52100 steel under dry cutting conditions Analysis of Variances (ANOVA) for S/N ratio for MRR clearly indicates that the cutting speed is majorly contributing of about 28.33% in obtaining optimal MRR followed by depth of cut 24.3% and feed rate 19.55%. .

Ali Raza Motorcu et.al[3] employed Taguchi method to optimize the machining parameter for Surface Roughness of AISI 8660. They obtained that the feed rate was found to be the dominant factor among controllable factors on the surface roughness, followed by depth of cut and tool's nose radius. However, the cutting speed showed an insignificant effect.

Muhammad Yusuf et.al [4] investigate the optimization of cutting parameter on Turning Process Based on Surface Roughness using Response Surface Methodology under dry cutting condition for Alluminium Alloy 7050 The objective of this research is finding the optimum cutting parameters based on surface roughness. The relation between cutting parameters and surface roughness were discussed.

S.Zhang et.al[5]presented the Taguchi method and ANOVA to optimize the cutting parameter ofHigh-speed Machining Hardened H13 Steel. Taguchi orthogonal arrays, signal-to-noise (S/N) ratio, and Analysis of variance (ANOVA) were used to evaluate the effects of cutting parameters on surface roughness and to find

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the optimal factor/level combination for the better surface roughness. Chinchanikar and Choudhury et.al [5] investigated the effect of workpiece hardness, cutting parameters and type of coated toolduring turning of hardened AISI 4340 steel with different levels of hardness on surface roughness and found better surface finish for harder workpiece and also for PVD applied single-layer TiAlN coated carbide tool. Tugrul et al [8] presented the effects of cutting edge preparation geometry, workpiece surface hardness and cutting conditions on the surface roughness in the finish hard turning of AISI H13 steel. They found that cutting forces are influenced not only by cutting conditions but also the cutting edge geometry and workpiece surface hardness. Chinchanikar and Choudhury [9] investigated the effect of workpiece hardness, cutting parameters and type of coated tool during turning of hardened AISI 4340 steel with different levels of hardness on surface roughness and found better surface finish for harder workpiece and also for PVD applied single-layer TiAlN coated carbide tool.

3.EXPERIMENTAL SETUP

It appears from the literature presented above that not much work has been done to investigate the effect of hardturning parameters on Quality Characteristics (QC) of the machined surface. Keeping this in view, an attempt has been made in this paper to investigate the effect of three cutting parameters (cutting speed, feed rate and depth of cut) on QCduring hardturning of IS2062: 2011 E25 Gr Aalloy steel under dry condition.

The material use for conducting experiment is use IS2062: 2011 E25 GrA Round Bar of Surface Hardness 64 HRB.The size of the workpiece is selected for Sample Test is 37 x 65 mm.

The machine use for the Turning the work piece is Kaushik Make Production Lathe Machine and the experimentation is conducted at M/s Varun Tools, Bhosari, Pune .Precision Instruments such Vernier Calliper use for measurement of Dimension and Surface Roughness is measured with Mitutoyo SJ210 Make Surface Tester. The material Removal Rate is calculated using Equation MRR= f x D_c x V_c.

According Test Report No: NLNJ30Ldated: 02.01.2017conducted at NDT Metal Solution Laboratory, Pune The chemical compositionof selected material IS 2062 (wt%) as shown in Table:

C	**Mn**	**Si**	**S**	**P**
0.21	0.46	0.14	0.028	0.042

Fig 1.Exprimental Setup

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4. DESIGN OF EXPERIMENT

The Taguchi method developed by Genuchi Taguchi is a statistical method used to improve the product quality. It is commonly used in improving industrial product quality due to the proven success [1].With the Taguchi method it is possible to significantly reduce the number of experiments. The Taguchi method is not only an experimental design technique, but also a beneficial technique for high quality system design [7]. Taguchi method is one of the simplest and effective approaches for parameter design and experimental planning (Fisher, 1925). In this method, the term 'signal' represents the desirable value (mean) for the output characteristic and the term 'noise' represents the undesirable value i.e. standard deviation (S.D.) for the output characteristic. Therefore, the S/N ratio is the ratio of the mean to the S.D. There are three types of S/N ratio depending on type of characteristics-the lower-the-better, the higher-the-better, and the nominal-the-better.

According to taguchi method the control Parameters are identify

As per Taguchi technique control parameters were identifies and control limit was set and assign the control factors to the selected orthogonal Matrix design in MINITAB 17 Software

In this investigation three factors were studied and their low level and high level as shown are given in Table 1. The levels are selected according to the recommendation of Manufacture.

The Taguchi method uses a loss function to determine the quality characteristics .Loss Function define by Signal to Noise Ratio .There are three different quality characteristics in S/N Ration Analysis, Namely Nominal is Best, Larger is the better and Smaller is the better For each level of process parameters, signal to noise Ratio is calculated based on S/N Analysis.

4.1 SELECTION OF CONTROL PARAMETER AND THEIR LEVELS

According to Taguchi method the control Parameters are identify

In this experimentation for effective machining cutting Speed, Feed Rate and Depth of Cut is selected as control Parameter and three levels are selected to design orthogonal Array .The next step in Taguchi Method to select the appropriateorthogonal Array .The orthogonal Array is design by using factorial method or using Taguchi method by selecting the control factors. In this work Taguchi Analysis with MINITAB 17 is used to determine the orthogonal Matrix by using Taguchi Method. If the Experiment were conducted without Taguchi method the number of Experiments increases and it is difficult to predict the number also .so Taguchi is effective method to Design orthogonal Matrix. In this present work Design of Experiment is conducted according to the Taguchi Method with L9 Orthogonal Matrix to determine the importance of factor or parameter Nine Experiment with different combination of Process Parameter were conducted.

Table 1: Control ParametersSetting and Their Level

Sr No	***Process Parameter***	***Level 1***	***Level 2***	***Level 3***
1	***Cutting Speed (rpm)***	*300*	*450*	*600*
2	***Feed Rate (mm/rev)***	*0.10*	*0.13*	*0.15*
3	***Depth of Cut(mm)***	*0.5*	*1.0*	*1.5*

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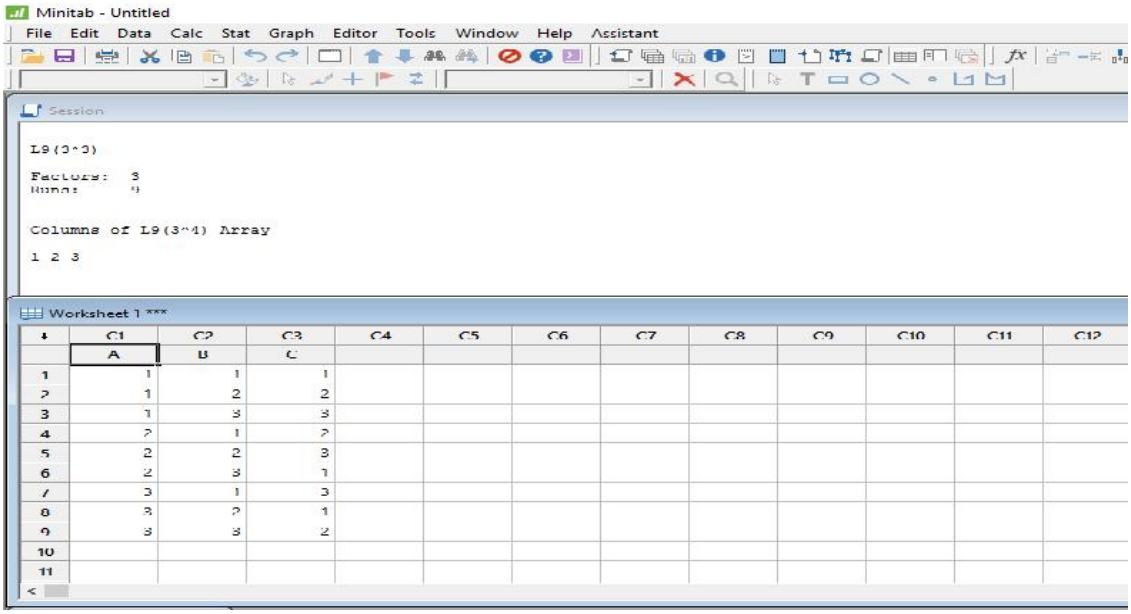
Table 2: L9Orthogonal Array(Coded)



5.EXPERIMENTAL RESULT AND DISCUSSION

Experiments were conducted on Nine Samples using L9 Orthogonal Array Design and the Result were obtain by conducting the trial as shown in Table 3.The surface Roughness measure using MITUTOYO SJ210 Surface Roughness Tester and MRR is calculated by using equation = ΠDtfN

Table 3: Design of Experiment using Orthogonal Array L9 and Their Response

Sr. No.	Uncoded			Control Parameters			Response Results		S/N Ratio	
				Cutting Speed (rpm)	*Feed Rate (mm/rev)*	*Depth of Cut (mm)*	*Surface Roughness(Ra)*	*M.R.R (mm3 /min)*	*S/N Ratio for Surface Roughness*	*S/N Ratio for MRR*
1	1	1	1	300	0.1	0.5	6.54	1742.7	- 16.3	64.82
2	1	2	2	300	0.13	1.0	5.64	4531.0	-15.02	73.12
3	1	3	3	300	0.15	1.5	6.52	7842.1	-16.28	77.88
4	2	1	2	450	0.1	1.0	5.68	5228.1	-15.08	74.36
5	2	2	3	450	0.13	1.5	5.38	10194.79	-14.61	80.16
6	2	3	1	450	0.15	0.5	5.72	3921.0	-15.14	71.86
7	3	1	3	600	0.1	1.5	2.36	10456.2	-7.45	80.38
8	3	2	1	600	0.13	0.5	4.85	4531.02	-13.71	73.12
9	3	3	2	600	0.15	1.0	7.54	10456.2	-17.54	80.38

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6. DETERMINATION OF OPTIMAL CUTTING PARAMETER AND STUDY OF EFFECT OF PROCESS PARAMETER ON QUALITY CHARACTERISTICS.

6.1Effect of Cutting Speed, Feed, Depth of Cut on Surface Roughness

From Response Table no 4. Rank 1 is allotted to Feed so It is observe that feed is most influcing Parameter followed by speed, depth of cut for surface Roughness .It is observe from main effect plot ,the optimum condition S3-F1-D3 i.e. Speed is 600 rpm ,Feed is 0.10 mm/rev and Depth of Cut is 1.5 mm.

Table No 4: Response Table for Signal to Noise Ratios

Smaller is better

Level	Speed(RPM)	Feed(mm/rev)	DOC(mm)
1	-24.00	-21.75	-23.53
2	-23.49	-23.19	-23.99
3	-21.69	-24.24	-21.66
Delta	2.32	2.49	2.34
Rank	3	1	2

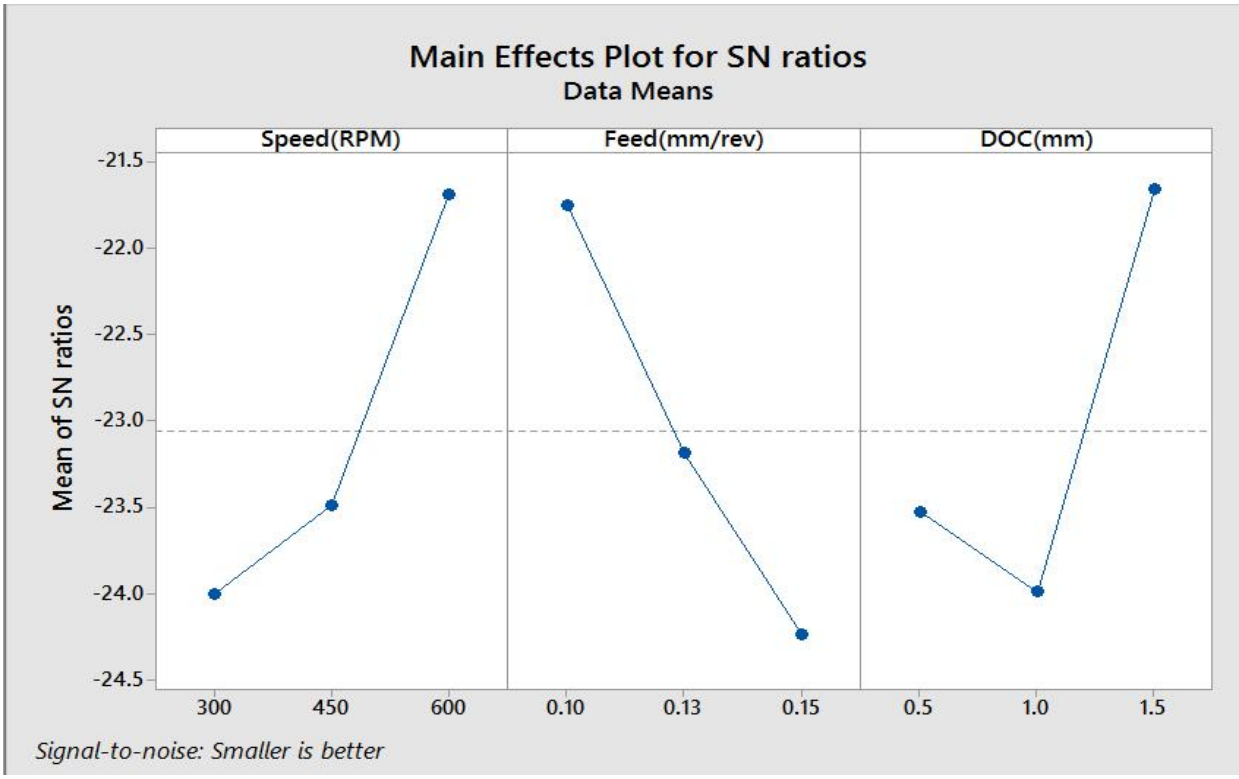

Fig 2 : Main Effect Plots for SN Ratio

6.2 Effect of Cutting Speed, feed Rate and Depth of Cut on MRR.

From Response table No 5 Rank 1 is allotted to the Depth of Cut using Taguchi. It is observe that Depth of cut is most influcing parameter followed by speed and Feed. The optimum condition is S3-F3-D3 i.e. speed is 600rpm, feed is 0.15 mm/rev and Depth of Cut is 1.5 mm.

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Table no: 5Response Table for Signal to Noise Ratios

Larger is better

Level	Speed(RPM)	Feed(mm/rev)	DOC(mm)
1	37.11	37.25	36.88
2	37.55	37.55	37.60
3	37.83	37.69	38.00
Delta	0.71	0.43	1.12
Rank	2	3	1

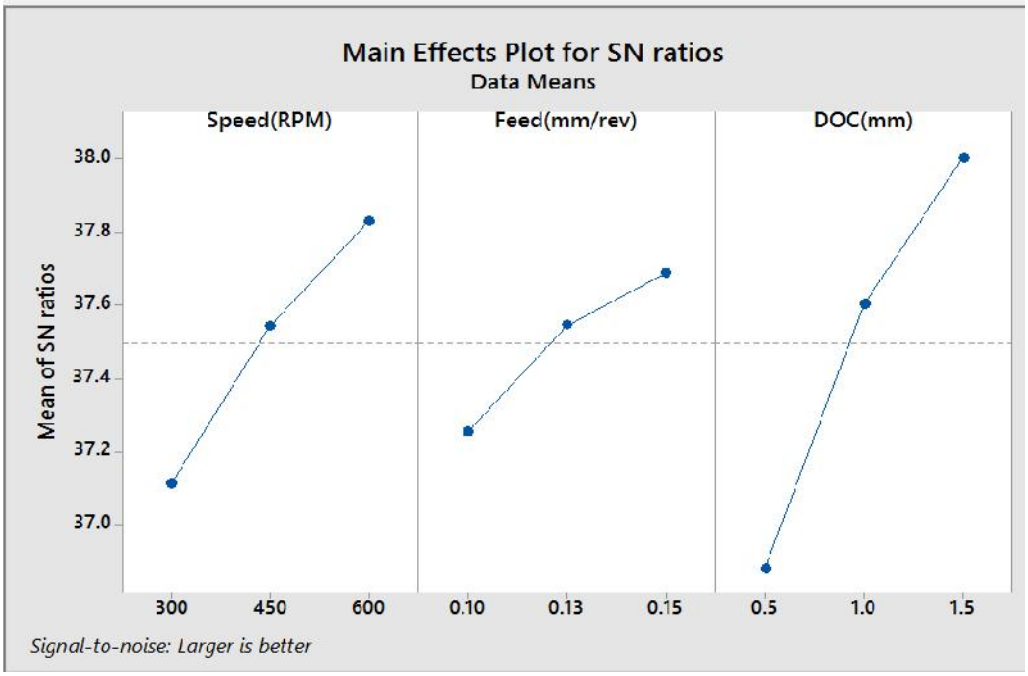

Fig 3: Main Effect plot for SN ratio

7.ANALYSIS OF VARIANCE (ANOVA)

The main purpose of ANNOVA is use to investigate which machining parameter is significantly affected the performance characteristics validate the Result by describing the percentage contribution.UsingMinitab17 software ANOVA module can be employed to investigate effect of parameters.

7.1. ANOVA for S/N Ratio for Surface Roughness

Table No 6 shows the Result of ANNOVA for S/N Ratio for surface Roughness .It is found that feed is most signifantly affecting parameter of turning parameter of hardened material due to its high percentage contribution (25.64%) followed by Speed (20.65%) and Depth of cut amongst the selected parameter is clearly indicate that Feed Rate is majorly contributing.

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Table No:6: ANNOVA FOR S/N Ratio for Surface Roughness

Source	DF	Adj SS	Adj MS	F-Value	P-Value	% Contribution
Speed(RPM)	2	13.83	6.914	0.67	0.597	20.65
Feed(mm/rev)	2	17.17	8.586	0.84	0.544	25.64
DOC(mm)	2	15.45	7.726	0.75	0.570	23.07
Error	2	20.51	10.255			30.63
Total	8	66.96				100

7.2 ANNOVA OR S/N Ratio for MRR

Table No 7 shows the Result of ANNOVA for S/N Ratio for M.R.R .It is found that Depth of cut is most signifantly turning parameter of hardened material affecting material removal rate characteristics due to its high percentage contribution (65.36%) amongst the selected parameter.

Table No:7: ANNOVA FOR S/N Ratio for M.R.R

Source	DF	Adj SS	Adj MS	F-Value	P-Value	% Contribution
Speed(RPM)	2	54.881	27.4404	5.24	0.160	25.68
Feed(mm/rev)	2	19.126	9.5632	0.95	0.512	8.95
DOC(mm)	2	139.642	69.8212	13.68	0.068	65.36
Error	2	0.000	0.0000			
Total	8	213.650				100

8. CONFIRM TEST

After getting optimum Result of Hard Turning Machining Parameter by applying Taguchi and ANOVA, next step to verify the percentage change of surface roughness between predicted and experimental value for this optimal combination .Table 8 shows result of confirmation experiment using optimum condition S3-F1-D3 for Surface Roughness and optimum condition is S3-F3-D3for Material removal Rate.

Table 8: Confirm Test

Sr No	Initial Parameter	Predicted Value	Experimental Value
Level	S1F1D1	S3F1D3	S3F1D3
Surface Roughness	6.54	2.36	1.95
S/N Ratio	-16.3	-7.45	-5.80

After conducting confirm test as shown in Table 8, the S/N Ratio improved from -7.45 to -5.80 due to decrease of surface Roughness which shows that optimal set of parameter (S3F1D3) is enough to improve the surface Roughness parameter.This shows that the process is improved by using Taguchi Method by 22.15 % which shows the optimum utilization of the Resource.

9.CONCLUSION

This paper focused on the application of Taguchi Method for optimization of process parameter of Hard Turning Parameter .As discussed earlier, the parameter design of the Taguchi provides simple and systematic approach for the optimization of cutting parameter.It is observe that feed is most influenced Parameter followed by speed, depth of cut for surface Roughness and Depth of cut is most influenced parameter for material Removal Rate. The optimal combination of the Hard Turning Parameter and their level for the minimum surface Roughness is S3-F1-D3 (i.e.is Speed is 600 rpm, Feed is 0.10 mm/rev and Depth of Cut is 1.5 mm.)As well as the optimal combination of Hard Turning Parameter and their level for maximum material Removal Rate is S3-F3-D3 i.e. (speed is 600rpm, feed is 0.15 mm/rev and Depth of Cut is 1.5 mm.) ANNOVA is applied to know the percentage contribution of process parameters such as feed is 25.64% on Surface Roughness and Depth of Cut is 65.36 % on the material Removal Rate.The significant improvement is about 64.5 % is observe from initial condition to Optimal cutting parameter by using this approach which will helpful for the industry to optimize the machine performance and reduce wastage.

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