Optimization of process parameters in Turning operation by using taguchi method

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Abstract - *Machining is the process of removing undesired material from the workpiece. While machining various process parameters influence the surface finish and rate of metal removed from the work piece (MRR).In this experiment work investigation has been carried out to study the influence of process parameters in turning operation (i.e; cutting speed ,feed ,depth of cut).The Taguchi method L9 is used to analyze the maximizing metal removal rate and analysis of variance technique to find the effect of individual factors which provides optimal results under varying conditions.*

Key Words: Taguchi, ANOVA, surface roughness, MRR.

1.INTRODUCTION

One of the most common metal cutting operations is turning process. In turning process, a workpiece is rotated about its axis and a single-point cutting tools are fed into it, removing unwanted material and creating the desired part. Turning can occur on both internal and external surfaces to produce an axially-symmetrical contoured part. The three key parameters determine productivity and part quality are feed rate, speed and depth of cut. The feed rate is the rate at which the tool is fed into the work. The speed is the rotational frequency of the spindle of the machine, measured in revolutions per minute (RPM). The depth of cut is the amount of material removed as the work revolves on its axis.

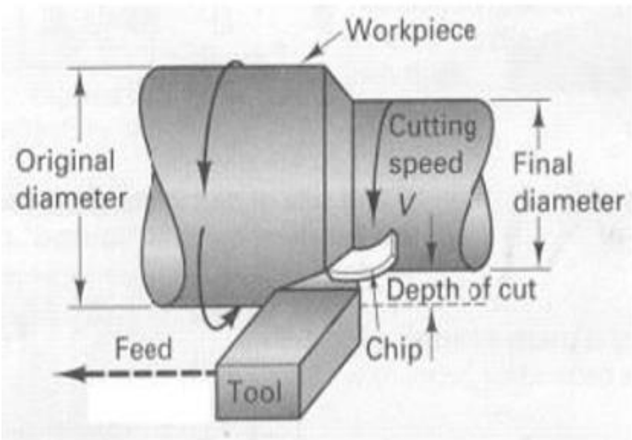


Fig: Turning process

The above parameters affect the important aspects of machining which determines the quality of the product i.e. Surface roughness and Material removal rate.

1.1 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.

$$F = f \times N \text{ mm/min.}$$

1.2 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 turning operation is the surface speed, or the speed at which the work piece material is moving past the cutting tool. It is simply the product of the rotating speed times the circumference of the work piece before the cut is started. It is expressed in meter per minute (m/min), and it refers only to the work piece. Every different diameter on a work piece will have a different cutting speed, even though the rotating speed remains the same

$$V=\frac{\pi}{1000}\text{mm/min.}$$

Here, v is the cutting speed in turning; D is the initial diameter of the work piece in mm, and N is the spindle speed in RPM.

1.3 Depth of cut

Depth of cut is practically self-explanatory. It is the thickness of the layer being removed (in a single pass) from the work piece or the distance from the uncut surface of the work to the cut surface, expressed in mm. It is important to note, though that the diameter of the work piece is reduced by two times the depth of cut because this layer is being removed from both sides of the work

$$\text{Dcut} =\frac{D-d}{2} \text{ mm.}$$

Here, D is the initial diameter (in mm) of the job and d is the final diameter (in mm) of the job respectively.

1.4 Material Removal Rate (MRR)

The material removal rate (MRR) in turning operation is the volume of material/metal that is removed per unit time in mm3 /min. for each revolution of the workpiece, a ring-shaped layer of material of material is removed.

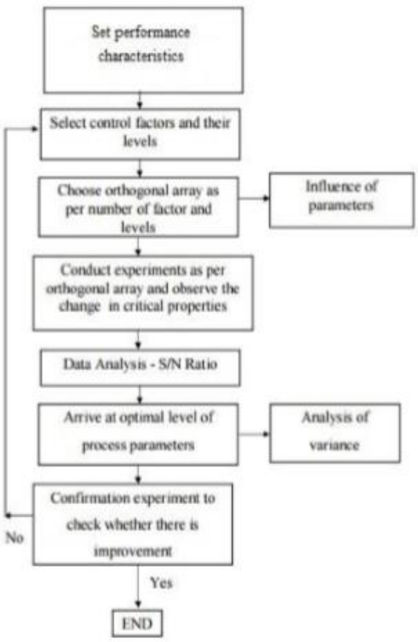
MRR= (initial weight - final weight)/time taken.

1.5 surface roughness

Surface roughness frequently reduced to roughness ad it can be measure by the texture of a surface. It is quantified by the vertical deviations of a real surface from its ideal form. If these deviations are large, the surface is rough, if they are small the surface is smooth.

2. Taguchi method

In industry, design of experiments can be used to systematically investigate the process or product variables that influence the product quality. After you identify the process conditions and product components that influence the product quality, you can direct your efforts to enhance products manufacturability, reliability, quality and field performance. Dr. Genichi Taguchi is regarded as the proponent of robust parameter design, which is an engineering method for product or process design that focuses on minimizing sensitivity to noise or variation. Robust parameter design uses Taguchi designs (orthogonal arrays), which allow you to analyze many factors with few runs. A Taguchi design, or an orthogonal array, is a method of designing experiments, which requires only a fraction of the full factorial combinations. The following steps briefly describe the Taguchi method;



2.1 SELECTION OF AN ORTHOGONAL ARRAY

For conducting experiments appropriate orthogonal array must be selected. This is done by computing the total degree of freedom which determines the minimum number of experiments. For a given set of data, degree of freedom is the amount of information that can be uniquely determined. Once the degree of freedom is determined then next step is to select appropriate orthogonal array. This is obtained by determining the minimum number of experiments by following formula;

Minimum number of experiments = 1 + Number of parameters × (Number of levels - 1)

Since we are using 3 parameters i.e. speed, feed rate, depth of cut and 3 levels of each parameter, then minimum number of experiments that need to be conducted are as follows;

Minimum no. of experiments = 1+ 3× (3-1) = 7

Hence at least 7 experiments need to be conducted. Taguchi experimental design of experiments suggests L9 orthogonal array, where 9 experiments are sufficient to optimize the parameters. Based on these, L9 orthogonal array is selected.

2.2 S/N ratio

The method uses the concept of quadratic quality loss function which is a statistical measure of performance called Signal to Noise (S/N) ratio. The S/N ratio is the ratio of the mean (Signal) to the standard deviation (Noise). The S/N ratio takes both the variability and mean into account. It depends on the quality characteristic of the product or product to be optimized. The standard S/N ratios generally available in Minitab software are described in following table:

Signal-to-noise (S/N) ratio	Goal of the experiment	Data characteristics	Signal-to-noise ratio formulas
Larger-the-better	Maximize the response	Positive	$S/N = -10 * \log(\Sigma(1/Y^2)/n)$
Nominal is best	Target the response and you want to base the signal-to-noise ratio on value of standard deviations only	Positive, zero, or negative	$S/N = -10 * \log(\sigma^2)$
(default) Nominal is best	Target the response variable and you want to base the signal-to-noise ratio on means and standard deviations	Non-negative in which theof standard deviation is zero when the mean is zero	$S/N = 10 \times \log((\bar{Y}^2) \div \sigma^2)$ The adjusted formula is: $S/N = 10 \times \log((\bar{Y}^2 - s^2 \div n) \div s^2)$
Smaller-the-better	Minimize the response variable	Non-negative with a target value of zero	$S/N = -10 * \log(\Sigma(Y^2)/n))$

For Material Removal Rate: - Larger the better type of S/N ratio is selected.

For Surface roughness: - Smaller the better type of S/N ratio is selected.

After all the S/N ratios have been computed for each run of an experiment, Taguchi uses a graphical approach to analyze the data. In this approach, the average responses and S/N ratios are plotted for each factor for each of its levels.

3. Experimentation

The CNC Lathe is used to machining cylindrical shapes from a range of materials including steels and plastics. Many of the components that go together to make an engine work have been machining using lathes. These may be lathes operated directly by people (manual lathes) or computer-controlled lathes (CNC machines) that have been programmed to carry out a task.

FACOTRS	SYMBOLS	LEVEL1	LEVEL2	LEVEL3
SPEED	A	1200	1400	1600
FEED	B	0.08	0.10	0.12
DOC	C	0.3	0.4	0.5

L9 ORTHOGONAL ARRAY FOR EN8 MATERIAL.

SNO	SPEED	FEED	DOC	MRR	SR	Time (sec)
1	1200	0.08	0.3	0.0476	2.6	42
2	1200	0.1	0.4	0.1666	1.2	36
3	1200	0.12	0.5	0.2580	1.2	31
4	1400	0.08	0.4	0.1666	1.3	36
5	1400	0.1	0.5	0.1290	2.0	31
6	1400	0.12	0.3	0.0769	1.4	26
7	1600	0.08	0.5	0.2222	2.1	36
8	1600	0.1	0.3	0.2222	1.5	27
9	1600	0.12	0.4	0.25	1.6	24

L9 ORTHOGONAL ARRAY FOR ALUMINIUM H30 MATERIAL.

SNO	SPEED	FEED	DOC	MRR	SR	Time(sec)
1	1200	0.08	0.3	0.0476	0.4	42
2	1200	0.1	0.4	0.0555	0.4	36
3	1200	0.12	0.5	0.0645	0.6	31
4	1400	0.08	0.4	0.0555	0.8	36
5	1400	0.1	0.5	0.0645	0.8	31
6	1400	0.12	0.3	0.0769	0.6	26
7	1600	0.08	0.5	0.0625	0.6	32
8	1600	0.1	0.3	0.0740	0.8	27
9	1600	0.12	0.4	0.0833	0.8	24

L9 ORTHOGONAL ARRAY FOR STAINLESS STEEL 304 MATERIAL.

SNO	SPEED	FEED	DOC	MRR	SR	Time (sec)
1	1200	0.08	0.3	0.0952	0.6	42
2	1200	0.1	0.4	0.1666	0.6	36
3	1200	0.12	0.5	0.2580	1.0	31
4	1400	0.08	0.4	0.1111	0.6	36
5	1400	0.1	0.5	0.1935	0.7	31
6	1400	0.12	0.3	0.0769	1.0	26
7	1600	0.08	0.5	0.1875	0.4	32
8	1600	0.1	0.3	0.1481	0.6	27
9	1600	0.12	0.4	0.25	0.8	24

3.1 Surface roughness testing

Step:1 position the measurement target

Remove any oil or dust on the measurement target's surface.
If the measurement direction is not indicated, position the

target so that the measurement direction will give the maximum parameters in the height direction (Ra, Rz).

Step:2: visually inspect the surface of the target
Judge whether the surface texture of the target (creases, roughness profile) is periodic or non-periodic.
Step:3: when the sampling length is represented pictorially
When the sampling length is indicated on the figure or in the requirements of the product's technical information, set the cutoff value, λc, to the indicated sampling length.
Step:4: when the roughness profile is periodic
1. For target surfaces that have a periodic roughness profile, estimate parameter RSm from the measured primary profile.
2. Determine the corresponding sampling length (cutoff value λc) from Table 1 by using the estimated RSm.
3. Use the determined sampling length to measure the RSm value.
4. When the measured RSm is within the RSm range estimated from Table 1, use the cutoff value. When the measured result is outside the estimated RSm range, change the cutoff value to the sampling length of the corresponding RSm.
5. Use the sampling length that you have determined with the steps up to this point to measure the required parameters.

Fig: Taylor Hobson Surtronic 3+

3.2 ANOVA

Buying a new product or testing a new technique but not sure how it stacks up against the alternatives? It's an all too familiar situation for most of us. Most of the options sound like each other so picking the best out of the lot is a challenge. Consider a scenario where we have three medical treatments to apply on patients with similar diseases. Once we have the test results, one approach is to assume that the treatment which took the least time to cure the patients is the best among them. What if some of these patients had already been partially cured, or if any other medication was already working on them? In order to make a confident and reliable decision, we will need evidence to support our approach. This is where the concept of ANOVA comes into play.

Source	df	adj ss	adj ms	f-value	p-value	% contribution
Regression	6	1.00000	0.16667	0.40	0.840	54.28
Speed	2	0.04222	0.02111	0.05	0.952	2.29
Feed	2	0.57556	0.28778	0.68	0.594	31.2
Doc	2	0.38222	0.19111	0.45	0.688	20.7
Error	2	0.84222	0.42111			45.7
Total	8	1.84222				99.89

Table 3.1.1: Analysis of variance for surface roughness (EN8).

source	Df	adj ss	adj ms	f-value	p-value	% of contribution
regression	6	0.16000	0.02660	0.86	0.627	72.00
speed	2	0.14222	0.0711	2.29	0.304	63.99
feed	2	0.00888	0.0044	0.14	0.875	4
doc	2	0.00888	0.0044	0.14	0.875	4
error	2	0.06222	0.0311			27.99
total	8	0.2222				99.98

Table 3.1.2: Analysis of variance for surface roughness (AL).

Source	df	adj ss	adj ms	f-value	p-value	% of contri
regression	6	0.313333	0.052222	15.67	0.061	97.91
Speed	2	0.046667	0.023333	7.00	0.125	14.58
Feed	2	0.260000	0.130000	39.00	0.025	81.25
Doc	2	0.006667	0.003333	1.00	0.500	2.08
Error	2	0.006667	0.003333			2.08
Total	8	0.320000				99.99

Table3.1.3: Analysis of variance for surface roughness (SS).

Source	df	adj ss	adj ms	f-value	p-value	% of contri
regression	6	0.035736	0.005956	1.29	0.497	79.52
Speed	2	0.018104	0.009052	1.97	0.337	40.28
Feed	2	0.003687	0.001843	0.40	0.714	8.20
Doc	2	0.013946	0.006973	1.52	0.398	31.03
Error	2	0.009202	0.004601			20.4
Total	8	0.044938				

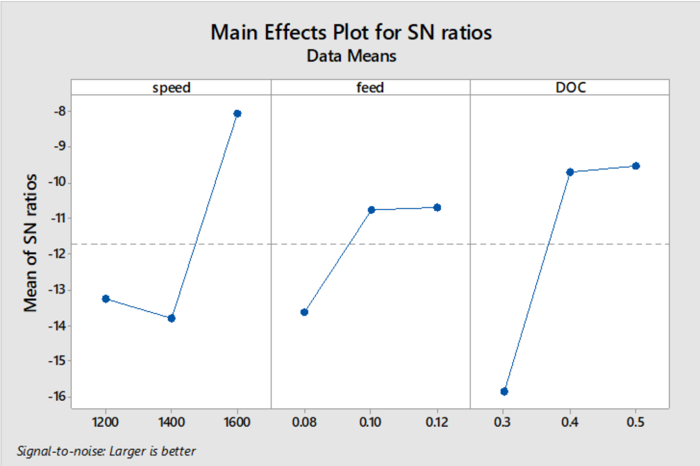
Table3.1.4: Analysis of variance for Metal Removal Rate (EN8).

Source	df	adj ss	adj ms	f-value	p-value	% of contrib
regression	6	0.030853	0.005142	4.75	0.184	93.44
Speed	2	0.007235	0.003617	3.34	0.230	21.9
Feed	2	0.006165	0.003083	2.85	0.260	18.67
Doc	2	0.017453	0.008727	8.06	0.110	52.85
Error	2	0.002166	0.001083			6.5
Total	8	0.033019				

Table 3.1.5: Analysis of variance for MRR (SS).

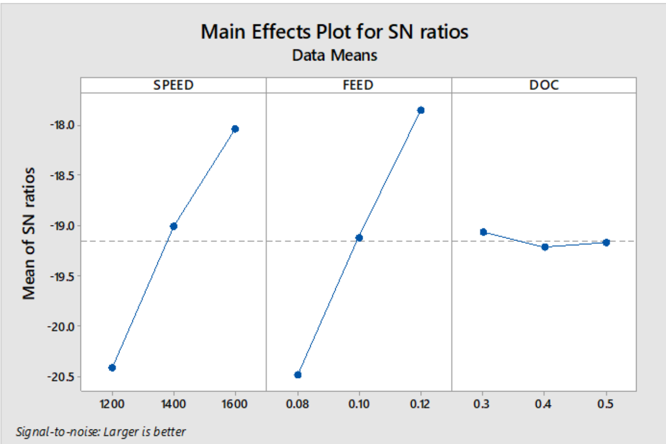
source	df	adj ss	adj ms	f-value	p-value	% of contri
regression	6	0.001047	0.000175	1040.19	0.001	1
speed	2	0.000456	0.000228	1360.18	0.001	43.55
feed	2	0.000582	0.000291	1735.72	0.001	55.58
doc	2	0.000008	0.000004	24.66	0.039	0.764
error	2	0.000000	0.000000			0
total	8	0.001047				

Table 3.1.6: Analysis of variance for MRR (AL).



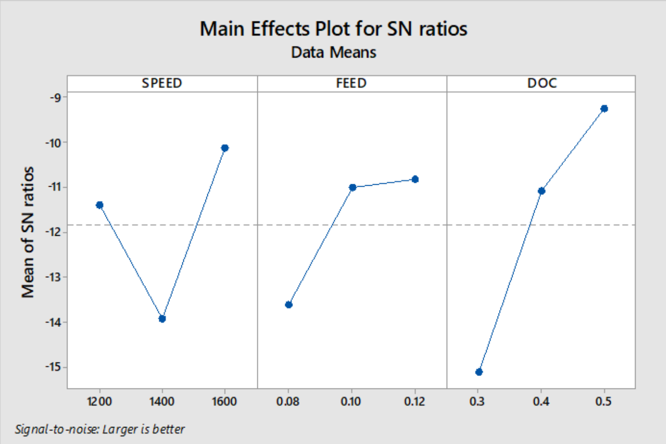
Graph: 3.1 Influence of machine parameters on S/N ratio for MRR of EN8 material.

Optimum parameter settings (A3B3C3) A3=1600rpm, B3= 0.12mm/rev, C3=0.5mm.



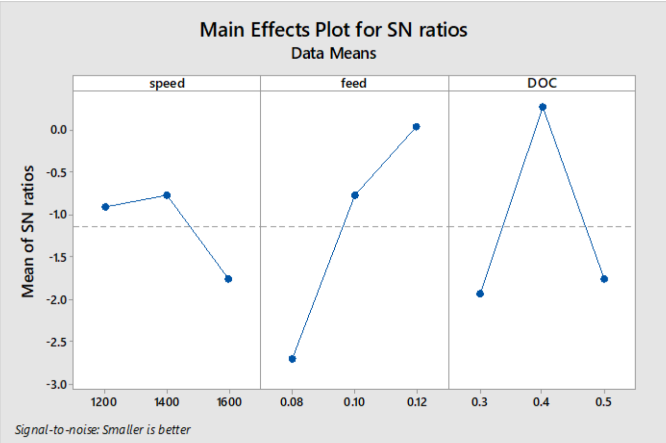
Graph: 3.2 Influence of machine parameters on S/N ratio for MRR of AL material.

Optimum parameter settings (A3B3C1) A3=1600rpm, B3= 0.12mm/rev, C1=0.3mm.



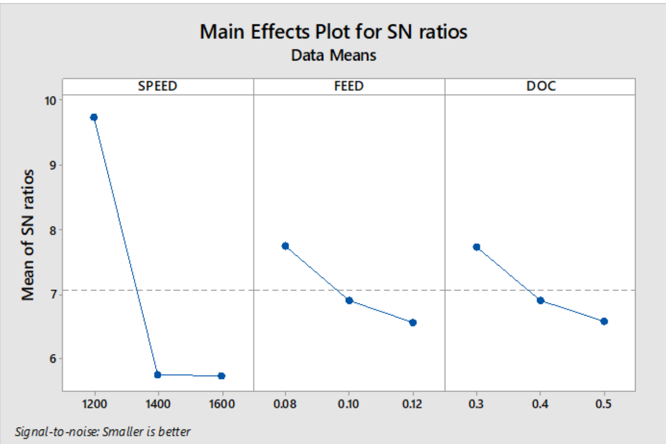
Graph: 3.3 Influence of machine parameters on S/N ratio for MRR of SS material.

Optimum parameter settings (A3B3C3) A3=1600rpm, B3= 0.12mm/rev, C3=0.5mm.



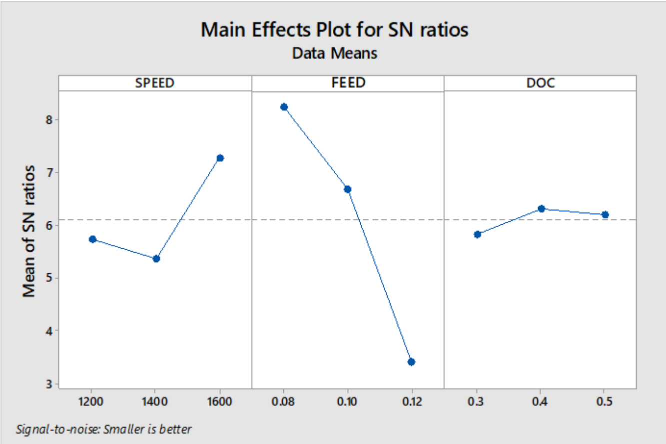
Graph: 3.4 Influence of machine parameters on S/N ratio for surface roughness of EN8 material.

Optimum parameter settings (A3B1C1) A3=1600rpm, B1= 0.08mm/rev, C1=0.3mm.



Graph: 3.5 Influence of machine parameters on S/N ratio for surface roughness of AL material.

Optimum parameter settings (A3B3C3) A3=1600rpm, B3= 0.12mm/rev, C3=0.5mm.



Graph: 3.6 Influence of machine parameters on S/N ratio for SR of SS material.

Optimum parameter settings (A2B3C1) A2=1400rpm, B3= 0.12mm/rev, C1=0.3mm.

4.CONCLUSION

- From Table 3.1.1 Percentage contribution of speed is 2.29%, feed is 31.25%, depth of cut is 20.7%, for surface roughness in EN8.
- From Table 3.1.2 Percentage contribution of speed is 63.99%, feed is 4%, depth of cut is 4%, for surface roughness in AL H30.
- From 3.1.3 Percentage contribution of speed is 14.58%, feed is 81.25%, depth of cut is 2.08% for surface roughness in SS 304.
- From Table 3.1.4 Percentage contribution of speed is 40.28%, feed is 8.20%, depth of cut is % for metal removal rate in EN8.
- From Table 3.1.5 Percentage contribution of speed is 21.9%, feed is 18.67%, depth of cut is 52.85% for metal removal rate in SS 304**.**
- From Table 3.1.6 Percentage contribution of speed is 43.55%, feed is 55.58%, depth of cut is 0.764% for metal removal rate in AL H30.

FROM GRAPH 3.1 The process parameters considered in the experiments are optimized to attain maximum metal removal rate. The best combination of process parameters for turning within the selected range is Cutting Speed 1600 rpm, Feed 0.12 mm/rev Depth of cut 0.5 mm for EN8 material.

FROM GRAPH 3.2 The process parameters considered in the experiments are optimized to attain maximum metal removal rate. The best combination of process parameters for turning within the selected range is Cutting Speed 1600 rpm, Feed 0.12 mm/rev Depth of cut 0.3 mm for AL H30 material.

FROM GRAPH 3.3 The process parameters considered in the experiments are optimized to attain maximum metal removal rate. The best combination of process parameters for turning within the selected range is Cutting Speed 1600 rpm, Feed 0.12 mm/rev Depth of cut 0.5 mm for SS 304 material.

FROM GRAPH 3.4 The process parameters considered in the experiments are optimized to attain minimum surface roughness. The best combination of process parameters for turning within the selected range is Cutting Speed 1600 rpm, Feed 0.08 mm/rev Depth of cut 0.3 mm for EN8 material.

FROM GRAPH 3.5 The process parameters considered in the experiments are optimized to attain minimum surface roughness. The best combination of process parameters for turning within the selected range is Cutting Speed 1600 rpm, Feed 0.12 mm/rev Depth of cut 0.5 mm for AL material.

FROM GRAPH 3.6 The process parameters considered in the experiments are optimized to attain minimum surface roughness. The best combination of process parameters for turning within the selected range is Cutting Speed 1400 rpm, Feed 0.12 mm/rev Depth of cut 0.3mm for Stainless steel material.

REFERENCES

1. Dr.S.S.Chaudhari, S.S. Khedkar, N.B. Borkar, “Optimization of process parameters using Taguchi approach withm inimum quantity lubrication for turning” International Journal of Engineering Research and Applications ISSN: 2248-9622 Vol. 1, Issue 4, pp.1268-1273

2. E. Daniel Kirby, “ A Parameter design study in a Turning operation using the Taguchi Method ,” the Technology Interface/Fall; PP 1 - 14 , 2006

3. Hemant Kumar Agarwal “study of surface roughness in turning of aisi1050 mild steel” international journal of research in Aeronautical and mechanical engineering Vol.2 Issue.1, pg no. 105-111, January 2014

4. Krishankant, Jatin Taneja, Mohit Bector, Rajesh Kumar, “Application of Taguchi Method for Optimizing Turning Process by the effects of machining Parameters” International Journal of Engineering and Advanced TechnologyISSN:2249–8958, Volume- 2, Issue-1, October 2012.

5. Mohamad Syahmi Shahrom, Nafrizuan Mat Yahya and Ahmad Razlan Yusoff, “Taguchi Method Approach on Effect of Lubrication Condition on Surface Roughness in Milling Operation” Malaysian Technical Universities Conference on Engineering & Technology 2012.

6. Mohd Naiim B Yusoff “Application of Taguchi Method in the optimization of Cutting Parameters for Surface Roughness In Turning” Faculty of Mechanical Engineering University Malaysia Pahang. feb2001

7.Resit unal and edwin b. Dean, “Taguchi approach to design optimization for quality and cost:An overview” annual conference Of the international society of parametric analysts, 1991

8.Moaz H. Alia,Basim A. Khidhir, M.N.M. Ansari, and Bashir Mohamed,” FEM to predict the effect of feed rate on surface roughness with cutting force during face turning of alloy”, HBRC Journal, 2013.

9. Lou MS, Chen JC, Li CM. Surface roughness prediction technique for lathe turning operation. J Ind Techno 1998; 15(1): 1-6.

10. Lou MS, Chen JC. In-process surface roughness recognition system in turning operations. Int J Adv Manuf Technol1999; 15: 200-209.

11. Y. Mustafa1 and T. Ali,” Determination and optimization of the effect of cutting parameters and work piece length on the geometric tolerances and surface roughness in turning operation”, International Journal of the Physical Sciences Vol. 6(5), pp. 1074-1084, 4 March, 2011.

12. Dr. M. Naga PhaniSastry, K. Devaki Devi, Dr, K. Madhava Reddy,” Analysis and Optimization of Machining Process Parameters Using Design of Experiments”, ISSN 2224-6096 (Paper) ISSN 2225-0581 (online) Vol 2, No.9, 2012.