GRD Journal for Engineering | Volume 2 | Issue 5 | April 2017
ISSN: 2455-5703

Optimization of Lathe Parameters for Minimum Surface Roughness and Maximum MRR

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Abstract

This paper theologies with the Taguchi technique for the optimization of lathe parameters on a cylindrical round workpiece of EN19 steel. In industry main objective is to have a good quality surface or to get a maximum material removal rate. The three significant parameters of lathe which are used are speed, feed and depth of cut. The number of experiments has been carried out using Taguchi's orthogonal array in the design of experiments (DOE).Analysis of Variance is used to identify the effects of parameters on the workpiece. Roughness values are measured using a surface roughness meter. From experimental results the mathematical models were generated for the parameters.
Keywords- Lathe, Annova, Mathematical Modeling, MRR, Taguchi Method, Optimization

I. INTRODUCTION

Lathe is used for different applications in manufacturing industry. Large number of operations can be performed on lathe machine using different tools. In this work, Facing and Turning operations are carried out on lathe machine. In Facing Operation the tool is feed perpendicular to the axis of rotation of the workpiece. Turning is a form of machining, a material removal process, which is utilized to make rotational parts by cutting away unwanted material. Tool used in lathe operation is a single point cutting tool of HSS (High-speed steel) material. Cylindrical round workpiece is used of EN-19 steel grade.EN-19 is an high quality alloy steel which is also known as 709M40.EN-19 steel has good ductility and shock resistant and its resistance to wear properties. It is suitable for applications like gears, spindles, pinion, and shafts. Lathe parameters that affect the tool life are Spindle speed, feed and depth of cut are selected. Feed rate means the speed of the cutting tool's movement relative to the workpiece as the tool makes a cut. Spindle speed is the rotational speed of the spindle and the workpiece in revolutions per minute (rpm). Depth of cut is the depth of the tool along the axis of the workpiece as it makes a cut, as in a facing operation. Optimizing these parameters means reduction in cost, increase in productivity and less machining time. Analysis of variance (Anova) is used, which shows that which cutting parameters is mostly affecting the workpiece. In order to identify reactive and nonreactive effects of experimental parameter ANOVA is used. Design of Experiments using Taguchi approach is used which makes it simple to gather, analyze and further interpret in a convenient manner. The Taguchi method is used to improve the quality of products and processes. Surface roughness tester is used to measure the roughness of the workpiece by using the process parameters. The experimental results were used in analysis of variance (ANOVA) by using MINITAB 17 statistical software.II.

A. Problem Statement

Mathematical Modeling and optimization of lathe parameters for maximum material removal rate and minimum surface roughness

B. Objective

Our aim in this project is to make Mathematical Modeling and Optimization of lathe Parameters for Minimum Surface Roughness and Maximum MRR. Therefore the objectives of the following paper are:-

1) To find the most dominating cutting parameter which affects the value of MRR and also the other parameters which affect the value of MRR.
2) To find the relation between the cutting parameters and MRR.
3) To find the optimal set of cutting parameters for which we get desired value of MRR.
4) To find the desired models for the prescient execution.

C. Methodology

In this current work, attempt is made to find the effect of turning operations on the workpiece and the quality of surface is measured in terms of minimum surface roughness (Ra) during the turning operation for EN19 steel workpiece. Experiments are carried out to find various lathe parameters such as, depth of cut, feed rate, and speed. An experimental design based on Taguchi L9 orthogonal array is used to check the relations between the factors. Roughness is measured by Surface roughness instrument. This instrument has Stylus probe which gives the surface roughness reading on the screen in micrometer. In the present work, exploratory outcomes were utilized to discover the analysis of variance (ANOVA) which clarifies that which cutting parameters is mostly affecting the workpiece. To have a clear idea of the effects, mathematical model is used to find a correlation between lathe parameters and material removal rate (MRR). Finally, the predicted value is validated and compared with experimental result.

II. LITERATURE REVIEW

D.Vishnu Vardhan Reddy (2016), The Taguchi technique and Genetic algorithm (GA) for predicting the responses of turning operation on CNC lathe machine for EN19steel. The number of experiments has been carried out using Taguchi's orthogonal array in the design of experiments (DOE). The cutting parameters are spindle speed, feed rate and depth of cut. The Analysis of Variance (ANOVA) and Signal-to-Noise ratio were used to study the performance characteristics in turning operation. The accurate mathematical model has been developed using genetic algorithm. The genetic algorithm is used to get the optimum cutting parameters by using the regression equations of different parameters. The research showed acceptable prediction results for the developed model. [1]

Gaurav Chaudhary (2014), it is well known that machining process monitoring is a crucial requirement in the successful implementation of the automated / unmanned operation of a plant. In metal cutting procedure, the adequacy of cost-quality-time matrix generally relies on the ideal choice of cutting parameters. In present approach, Taguchi method and analysis of variance (ANOVA) is employed to develop a turning process model in terms of process parameters viz. cutting speed, feed rate and depth of cut for achieving the optimum surface finish .This process model is then verified experimentally by machining EN19 material. In today's competitive environment the need of optimal use of the resources like CNC machines, is the important issue. Cutting parameters such as speed, feed, depth of cut, influence the production rate, quality and cost of component, during a machining operation. The parameters thus selected were generally on the conservative side when compared with optimal parameters. Limited Choice of the cutting parameters with the ventured drives and impediments with respect to cutting devices were the hindrances during the time spent advancement in the old days. With the advent of stepless speed – feed drives on the CNC machine tools (Fig.1) and development of cutting tools capable of cutting at exceedingly high speeds have made rigorous optimization feasible. Further with increase in the level of automation the idle time of operation has drastically fallen down and the index able inserts have reduced the tool setup times considerably and made them comparable with machining time. All these have created tremendous scope in the field of optimization of cutting parameters. [2]

Ravindra Nath Yadav (2016), the optimum condition obtained from Taguchi Methodology has been used as central value in Response Surface Methodology for the modeling and optimization. The result shows the significant improvement in surface finish with hybrid approach as compared to the Taguchi analysis. Machining of the rotating surfaces is basic requirement of the manufacturing industries to get the desired shapes, sizes and surface quality of circular shaft used in various power transmission units. Such desired conditions are achieved by Turning Process, which is performed on the Lathe Machine. Turning Process can be defined as a metal cutting process in which desired depth-of-cut has been removed in form of chips from the rotating surfaces with application of the wedge shaped single point cutting tool penetrates toward the workpiece . It is capable to generate the different profiles such as cylindrical shaft, cone shaft and step shaft turning. It is also applicable to machine several complex surfaces/profiles like key hole, spline shaft, internal holes as well as threading, knurling, gear cut, cam profiles etc. with application of special attachments on Lathe Machine. To improve the productivity with better surface finish, the performance of the turning process were studied by various researchers in different conditions. Sarma and Dixit studied the effect of process parameter during turning of the cast iron in dry and air-cooled conditions with ceramic cutting tool. They found improved surface quality and low tool wear with air cooled turning as compared to the dry turning. The effect of lubricants on surface roughness and tool wear during turning of AISI-4340 steel were studied by Dhar et al. The multi-pass turning is an unique method to achieve the better surface finish in which finish cut turning performed after several rough cut turning. Even though, this process leads to increase in the setting times as a result the overall cast of products are increased. Instead of this, hard turning also comes into existence to get the surface finish upto grinding level with application of ceramic or cubic boron nitride (CBN) cutting tools at high speed on same Lathe Machine. Aslan experimental investigated the performance of the cutting tool during hard turning of the coldwork tool steel. Grzesik studied the effect of tool shapes on the wear and surface roughness in hard turning using different shaped ceramic tools. Asilturk and Akkus analyzed the effect of turning parameters on the surface quality during hard turning with application of Taguchi technique. Even though, machine tool suffers with high wear and tear during hard turning due to high cutting velocity. Therefore, a novel turning operation has been proposed with application of two-single point cutting tools tominimize/eliminate the problems related to the different turning processes (normal turning, multi-pass turning and hard turning). Such developed process is named as Duplex Turning Process. [3]

Dadaso D. Mohite (2016), the ability of a grinding wheel to perform is significantly affected by the way in which the wheel is dressed. The four important parameters of blade type multi point diamond dressing operation are, dressing depth of cut, dressing cross feed rate, drag angle of dresser and number of passes. The effect of these parameters is measured in terms of surface of work piece during subsequent grinding operation. In this work, experimental models are created for surface roughness by considering selected four parameters of dressing as control variables using Taguchi philosophy. .The mathematical models in terms of dressing parameters were developed for surface roughness on the basis of experimental results.[4]

G.M.Sayeed Ahmeda (2015), Efficient turning of high performance Mild Steel material can be achieved through proper selection of turning process parameters to minimize surface roughness, feed and radial forces. In this present paper outlines an experimental study to optimize Feed and Radial forces and study the effects of process parameters in Lathe turning on Mild Steel work material in dry environment conditions using HSS tool. The orthogonal array, signal to noise ratio and analysis of variance are utilized to concentrate the execution qualities in Lathe machine turning operation.. Three machining parameters are chosen as process parameters: Cutting Speed, Feed rate and Depth of cut. The experimentation plan is designed using Taguchi's L9 Orthogonal Array (OA) and Minitab-16 statistical software is used. Optimal values of process parameters for desired performance characteristics are obtained by Taguchi design of experiment. Prediction models are developed with the help of regression analysis method using Minitab-16 software and lastly the ideal and computed results are additionally checked with the help of confirmation examinations. Surface roughness is measured on each run according to Taguchi design of experiment and finally average roughness (Ra) is measures on confirmation experiment to compare with previous given machining parameters according to the Taguchi design of experiment. [5]

III. EXPERIMENTAL DETAILS AND RESULTS

Experiments were conducted on an all-gear lathe machine to find out the surface roughness of workpiece. Table 1 shows control factors and machining parameters with their levels.

Fig. 1: All Geared Lathe Machine

Table 1: Cutting Parameters and their Levels

Control factors	*Depth of cut(mm),D*	*Feed rate(mm/rev),f*	*Spindle speed(rpm),N*
Level 1	*0.5*	*0.1*	*950*
Level 2	*1*	*0.15*	*625*
Level 3	*1.5*	*0.2*	*415*

A. Workpiece Material

EN-19 steel bar was selected as the workpiece material of length 110 mm and diameter 34 mm, then facing and turning operation were performed on that workpiece and the workpiece was brought to length of 105 mm and diameter of 32 mm to obtain bright surface. According to Taguchi L9 orthogonal array method a total of 9 readings were noted down in a table and at the respective conditions in the table, machining were done.

Table 2: Experimental Data for MRR

Expt. No.	*D*	*f*	*N*	*MRR*	*S/N ratio*
1	*0.5*	*0.1*	*950*	*0.36170*	*-8.8330*
2	*0.5*	*0.15*	*625*	*0.20833*	*-13.6250*
3	*0.5*	*0.2*	*415*	*0.29620*	*-10.5683*
4	*1*	*0.1*	*625*	*0.42200*	*-7.4938*
5	*1*	*0.15*	*415*	*0.39470*	*-8.0747*
6	*1*	*0.2*	*950*	*1.72*	*4.710*

7	*1.5*	*0.1*	*415*	*0.625*	*-4.0824*
8	*1.5*	*0.15*	*950*	*1.51250*	*3.5939*
9	*1.5*	*0.2*	*625*	*1.027*	*0.2314*

B. Surface Roughness Instrument

Instrument used to measure surface roughness is MITUTOYO surf test SJ-210.

Fig. 2: MITUTOYO surf test SJ-210

Table 3: Experimental Data for Surface Roughness

Exp. No.	*D*	*f*	*N*	*Ra*	*S/N ratio*
1	*0.5*	*0.5*	*950*	*3.8133*	*-11.6260*
2	*0.5*	*0.5*	*625*	*4.3820*	*-12.8334*
3	*0.5*	*0.5*	*415*	*5.4106*	*-14.6649*
4	*1*	*1*	*625*	*4.2540*	*-12.5759*
5	*1*	*1*	*415*	*3.466*	*-10.7973*
6	*1*	*1*	*950*	*5.1880*	*-14.3000*
7	*1.5*	*1.5*	*415*	*5.6406*	*-15.0265*
8	*1.5*	*1.5*	*950*	*4.4940*	*-13.0527*
9	*1.5*	*1.5*	*625*	*4.4920*	*-13.0488*

C. Mean Effect Plot for S/N Ratio

1) Mean effect plot for S/N ratio for MRR .Signal to noise ratio is by larger is better.

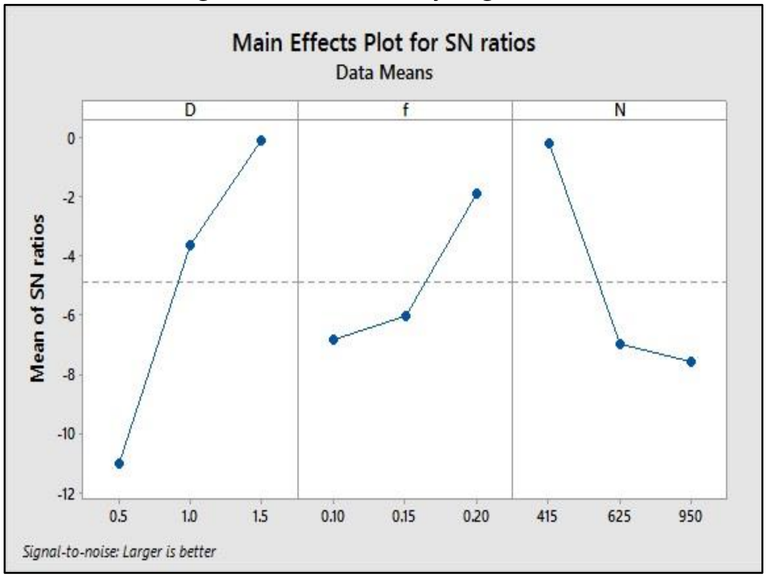

Fig. 3: Mean Effect Plot for MRR

MRR increases with increase in the depth of cut and Spindle speed. Feed rate has least effect on MRR.

2) Mean effect plot for S/N ratio for surface roughness. Signal to noise ratio is by smaller is better.

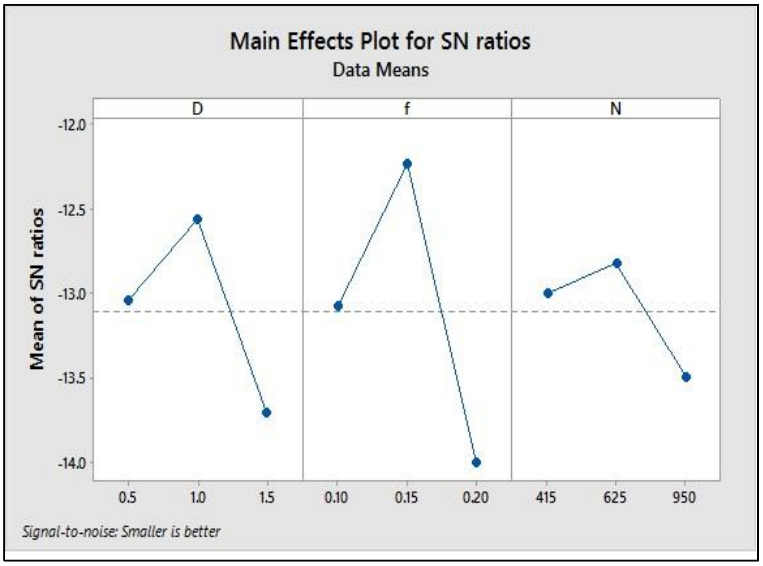

Fig. 4: Main Effect Plot for Ra

Surface roughness decrease with decrease in depth of cut and Spindle speed.

D. Analysis of Variance:-

Result of Anova determines most significant factor for MRR which is depth of cut.

Table 4: Results of the ANOVA

Source	*DF*	*Sum of Square*	*Variance*	*F-Value*	*P-Value*
D	*2*	*0.94074*	*0.47037*	*9.44*	*0.096*
f	*2*	*0.44797*	*0.22399*	*4.49*	*0.182*
N	*2*	*1.00652*	*0.50326*	*10.10*	*0.090*
Error	*2*	*0.09966*	*0.04983*		
Total	*8*	*2.49490*			

IV. INTERACTION PLOT

The result of one parameter depends on the level of the other parameter. An interaction plot is used to envisage possible interactions. Interaction plot between all parameter such as depth of cut, feed rate and Spindle speed is shown in fig

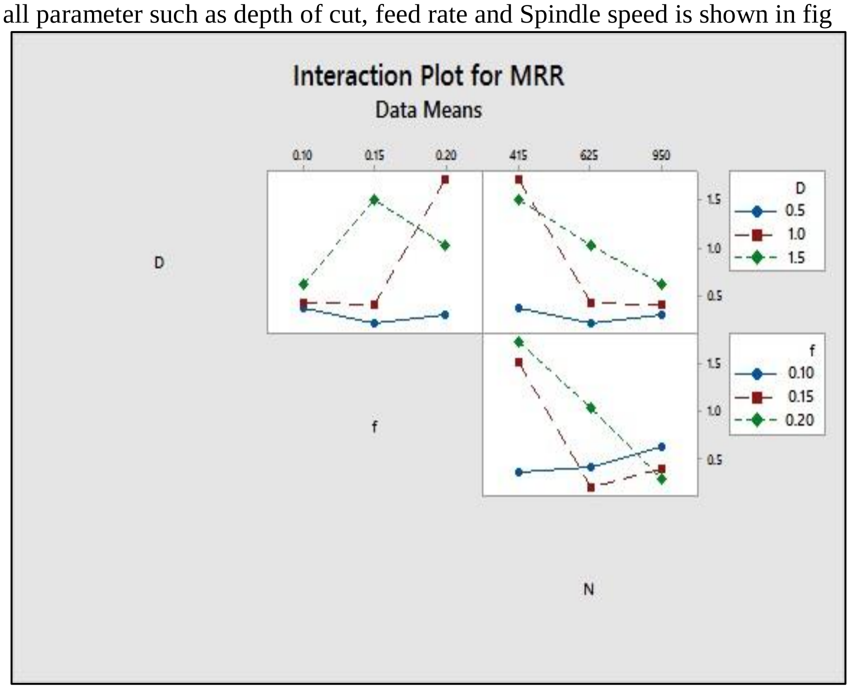

Fig. 5: Interaction Plot for MRR

V. CONTOUR PLOT

A contour plot is a graph that you can use to explore the potential relationship between three variables. A contour plot is like a topographical map in which x-,y-,z- values are plotted. In this plot, depth of cut is plotted on the x- and feed is plotted on y- scales and response values are represented by contours.

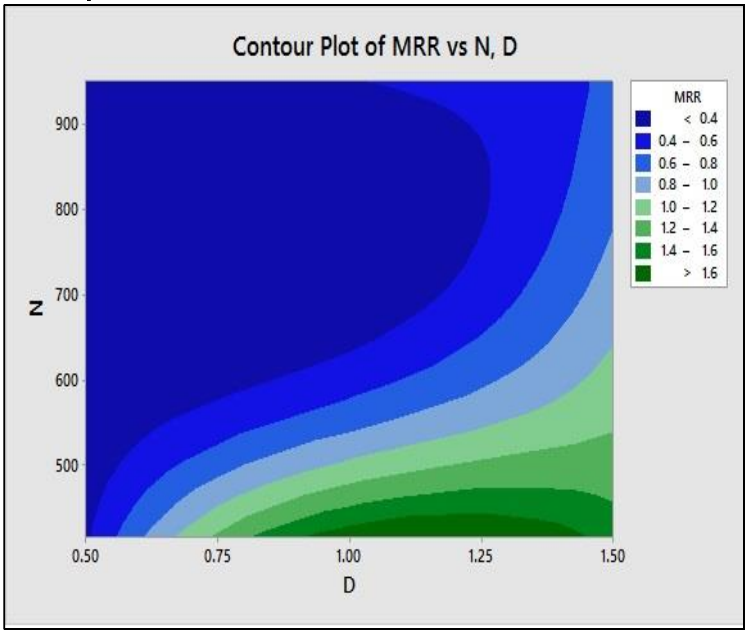

Fig. 6: Contour Plot for MRR

VI. MATHEMATICAL MODELING

The factual instruments in various relapse examination, RSM and Taguchi technique are for the most part utilized for advance of customary prescient displaying. Taguchi is a social affair of numerical and measurable procedures for experimental model building. It is utilized for issues in which the yield parameters are influenced by a few information parameters and the objective is to advance the process. In this work, straight and non-direct scientific model was created by utilizing different relapse investigation keeping in mind the end goal to discover connections between's lathe parameters and MRR.

$$MRR= \phi(D,f,N) \qquad (1)$$

Where MRR is the Material removal rate, ϕ is the response function and D,f,N are lathe variables.
D=Depth of cut; f=feed rate;N=spindle speed.
Eq. (1) can be expressed in non-linear form as,

$$MRR= C\ D^{a1}\ f^{a2}\ N^{a3} \qquad (2)$$

To determine the constant (C) and exponents a1, a2, a3) these mathematical models are converted from non-linear to linear form by performing a logarithmic transformation. Equation (2) can be represented in linear mathematical form as follows:

$$\ln MRR=\ln C+a1 \ln D+a2 \ln f+a3 \ln N \qquad (3)$$

E. Mathematical Modeling of MRR

By the technique of multiple regressions analysis equation (2) understood by utilizing MATLAB 17 statistical software and found values of constants C, a1, a2, a3 and a4. Hence, for developing the MRR mode, only the individual variables D,f,N are considered and the non-linear fit between MRR and lathe parameters is given by:

NON-LINEAR MODEL:-

$$MRR=0.000749D\ 1.0345\ f\ -0.6316\ N\ -0.6316 \qquad (4)$$

LINEAR MODEL:-

$$MRR= -0.6496+0.7815\ D+6.7179\ f\ -0.0006\ N \qquad (5)$$

VII. RESULT

The confirmation experiment is a final step in confirming the conclusions from the past round of experimentation. The optimum conditions are set for the significant parameters and a selected number of tests are run under specified conditions. The confirmation experiment is a crucial step and is much prescribed to check the experimental conclusion. The optimal set of lathe parameters are depth of cut as 1.5 mm, feed rate as 0.2 mm, and spindle speed as 415 rpm. The MRR increases with increase in depth of cut.

VIII. CONCLUSIONS

This paper has displayed utilization of Taguchi technique to choose the ideal procedure parameters for pounding wheel dressing process. The idea of ANOVA and S/N ratio has been utilized to decide the impact of process parameters on material removal rate. From research comes about the accompanying conclusions were:

1) The Depth of cut (D) is the most dominating factor on material removal rate (MRR) of work piece followed by Spindle speed while feed rate has relatively weak effect on MRR.
2) The MRR depends on depth of cut. Larger the depth of cut larger the MRR.
3) The optimal set of lathe parameters are depth of cut as 1.5 mm, feed rate as 0.2 mm, and spindle speed as 415 rpm.
4) Among every scientific model, the linear and nonlinear models were observed to be better as far as the prescient execution.

ACKNOWLEDGMENT

It is indeed a great pleasure and moment of immense satisfaction for we to present a project report on “OPTIMIZATION OF LATHE PARAMETERS FOR TURNING OPERATION ON LATHE MACHINE” amongst a wide panorama that provided us inspiring guidance and encouragement, we take the opportunity to thanks to thanks those who gave us their indebted assistance.

We wish to extend our cordial gratitude with profound thanks to our internal guide Prof. S.M.JADHAV for his everlasting guidance. It was his inspiration and encouragement which helped us in completing our project.

Our sincere thanks and deep gratitude to Head of Department, Prof. M. M. Joshi and other faculty member; but also to all those individuals involved both directly and indirectly for their help in all aspect of the project.

At last but not least we express our sincere thanks to our Institute’s Principal Dr. R. S. Prasad, for providing us infrastructure and technical environment.

REFERENCES

[1] D.Vishnu Vardhan Reddy, N. Jaya Krishna, N.Bhaskar,"Optimization of Cutting Parameters in Turning of En-19 by using Taguchi and Genetic Algorithm" International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 5 Issue 01, January-2016.

[2] Gaurav Chaudhary," Optimization Of Turning parameters by using taguchi method for optimum surface finish "International Journal of Mechanical And Production Engineering, ISSN: 2320-2092, Volume- 2, Issue- 5, May-2014.

[3] Mustafa Gunaya,Emre Yucel "Application of Taguchi method for determining optimum surface roughness in turning of high alloy white cast iron" Measurement 46 (2013) 913–919.

[4] Dadaso D. Mohite "An Investigation of Effect of Dressing Parameters for Minimum Surface Roughness using CNC Cylindrical Grinding Machine "International Journal of Research in Engineering and Applied Sciences (ISSN 2249-3905) VOLUME 6, ISSUE 6 (June, 2016)

[5] Ashish Kabra" Study on Parametric Optimization & Modeling for Surface Roughness, Feed and Radial Force of EN-19/ANSI-4140 Steel in CNC Turning Using Taguchi and Regression Analysis Method" Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol.3,Issue 1, January -February 2013, pp.1537-1544.

[6] G.M.Sayeed Ahmed S. Sibghatullah Hussaini Quadri Md Sadiq Mohiuddin "Optimization of Feed and Radial Force in Turning Process by using Taguchi Design Approach" G.M. Sayeed Ahmed et al. / Materials Today: Proceedings 2 (2015) 3277 – 3285.

[7] R. Nath Yadav, A Hybrid Approach of Taguchi-Response Surface Methodology for Modeling and Optimization of Duplex Turning Process, Measurement (2016).

[8] D. Sai Chaitanya Kishore, , K. Prahlada Rao, A. Ramesh."Optimization of machining parameters for improving cutting force and surface roughness in turning of Al6061-TiC in-situ metal matrix composites by using Taguchi method".

[9] Kant G, Sangwan KS, Prediction and optimization of machining parameters for minimizing power consumption and surface roughness in machining, Journal ofcleanerProduction(2014).

[10] Bilga PS, Singh S, Kumar R, Optimization of energy consumption response parameters for turning operation using Taguchi method, Journal of Cleaner Production (2016).

[11] Dinesh Kumar Kasdekar,Vishal Parashar2, Jasveer singh, M.K.Gour4 "Taguchi Method and ANOVA: An Approach for Selection of Process Parameters of EDM of EN-353 Steel"(ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 4, Issue 6, June 2014).

[12] Natarajan N Arunachalam RM," Optimization with micro EDM with multi performance characterstics using taguchi method and grey relational analysis" Journal of sci.Ind Research 2011;70:500-5.