CALCULATE THE METAL REMOVING RATE WITH INDIVIDUAL PARAMETERS BY TURNING PROCESS USING TAGUCHI METHOD

[1]T. Naviteja
Holy Mary Institute of Technology and Science.
[3].Mr. N Naresh Head Of the Department, Assistant professor
Holy Mary Institute of Technology and Science.

ABSTRACT: Turning process is one of the most fundamental machining processes used in the manufacturing industry. The process of turning is influenced by many factors such as cutting velocity, feed rate, depth of cut, geometry of cutting tool, and cutting conditions etc., to name a few. In machining operations, achieving the desired surface quality of the machined product is really a challenging job. This is due to the fact that quality is highly influenced by process parameters directly or indirectly. However, the extent of significant influence of the process parameters is different for different responses. In this thesis the effect of insert nose radius and machining parameters including cutting speed, feed rate and depth of cut on surface roughness in a turning operation are investigated by using the Taguchi optimization method. 3D modeling done by CREO parametric software Analysis is done by ANSYS

Keywords:* *MRR surface, CREO, ANSYS, 3D modelling, composite materials.

1. INTRODUCTION

1.1 Turning

Turning is the removal of metal from the outer diameter of a rotating cylindrical work piece. Turning is used to reduce the diameter of the work piece, usually to a specified dimension, and to produce a smooth finish on the metal. Often the work piece will be turned

1.2 Chucking the Work piece we will be working with a piece of 3/4" diameter 6061 Aluminum about 2 inches long. A work piece such as this which is relatively short compared to its diameter is stiff enough that we can safely turn it in the three jaw chuck without supporting the free end of the work

Fig 1 Chucking the Work piece

1.3 Adjusting the Tool Bit

Choose a tool bit with a slightly rounded tip, like the one described above in the tool grinding section. This type of tool should produce a nice smooth finish. For more aggressive cutting, if you need to remove a lot of metal, you might choose a tool with a sharper tip. Make sure that the tool is tightly clamped in the tool holder. Adjust the angle of the tool holder so the tool is approximately perpendicular to the side of the work piece. Because the front edge of the tool is ground at an angle, the left side of the tip should engage the work, but not the entire front edge of the tool. The angle of the compound is not critical; I usually keep mine at 90 degrees so that the compound dial advances the work .001" per division towards the chuck.

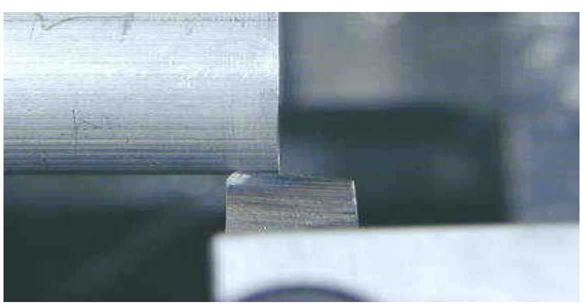


Fig 2 Adjusting the Tool Bit

1.4 Cutting Speeds

If you read many books on machining you will find a lot of information about the correct cutting speed for the movement of the cutting tool in relation to the work piece you must consider the rotational speed of the work piece and the movement of the tool relative to the work piece. Basically, the softer the metal the faster the cutting Don't worry too much about determining the correct cutting speed: working with the 7x10 for hobby purposes, you will quickly develop a feel for how fast you should go. Until you get a feel for the proper speeds, start with relatively low speeds and work up to faster speeds. One of the great features of the 7x10 is that you can adjust the rotational speed without stopping to change belts or gears. Most cutting operations on the 7x10 will be done at speeds of a few hundred RPM - with the speed control set below the 12 O'clock position and with the HI/LO gear in the LO range. Higher speeds, and particularly the HI range, are used for operations such as polishing, not cutting.

1.5 Turning with Power Feed

One of the great features of the 7x10 is that it has a power lead screw driven by an adjustable gear train. The lead screw can be engaged to move the carriage under power for turning and threading operations.

Turning with power feed will produce a much smoother and more even finish than is generally achievable by hand feeding. Power feed is also a lot more convenient than hand cranking when you are making multiple passes along a relatively long work piece.

Fig 3 turning with power feed

1.6 Introduction to EN 31 work tool steel

Tool steel refers to a variety of carbon and alloy steels that are particularly well-suited to be made into tools. Their suitability comes from their distinctive hardness, resistance to abrasion, their ability to hold a cutting edge, and/or their resistance to deformation at elevated temperatures (red-hardness). Tool steel is generally used in a heat-treated state.

With carbon content between 0.7% and 1.5%, tool steels are manufactured under carefully controlled conditions to produce the required quality. The manganese content is often kept low to minimize the possibility of cracking during water quenching. However, proper heat treating of these steels is important for adequate performance, and there are many suppliers who provide tooling blanks intended for oil quenching.

2. OBJECTIVES

To **calculate the Metal Removal Rate (MRR)** in a **turning process** using the **Taguchi method**, you need to follow a structured approach involving both **experimental design** and **statistical analysis**. Let's break it down step by step, including the objectives and calculations.

Objectives of Using Taguchi Method in Turning Process (for MRR)

1. **Optimize process parameters** (like cutting speed, feed rate, depth of cut) to **maximize MRR**.
2. **Determine the most influential parameters** on MRR.
3. **Minimize variability** and ensure robustness of the process.
4. **Use fewer experiments** compared to full factorial design while maintaining statistical integrity.

3. RELATED STUDY

3.1 Vijay Kumar H.K1, Aboobaker Siddiq1 and Muhammed Sinan1 Vol. 4, Issue 5(Version 6), May 2014, p

In this paper, Taguchi technique is used to find optimum process parameters for turning of hardened AISI 52100 steel under dry cutting conditions. A L9 orthogonal array, signal-to-noise(S/N) ratio and analysis of variances (ANOVA) are applied with the help of Minitab.v.16.2.0 software to study performance characteristics of Machining parameters namely cutting speed, feed rate and depth of cut with consideration of Material Removal Rate (MRR) and surface roughness. The results obtained from the experiments are changed into signal-to-noise ratio(S/N) ratio and used to optimize the value of MRR and surface roughness. The ANOVA is performed to identify the importance of parameters. The final results of experimental study are presented in this paper. The conclusions arrived at are significantly discussed at the end.

4. METHODOLOGY

Problem Definition

- Objective: Maximize MRR in the turning process.
- Approach: Use Taguchi Method to identify and optimize key parameters.
- Output: MRR (mm^3/min)

4.1 introductions to cutting forces and surface finish

Knowing the magnitude of the cutting forces in the turning process as function of the parameters and conditions of treatment is necessary for determining of cutting tool strength, cutting edge wearing, limit of the maximum load of the cutting machine and forecasting the expected results of the processing. In particular, during machining with high cutting speed, using modern materials and modern cutting machines imposes the necessity of studying physical phenomena in the cutting process and their mathematical modeling. Moreover, analysis of physical phenomena has shown that conditions are created for processing by material removal, in substantially different conditions, primarily due to the use of larger cutting speeds. In such circumstances the creation of possibilities for identification of physical phenomena in the cutting process allows: the creation of the basis for selection of optimal processing parameters, forecasting the process of wear of the cutting edge, determination of time to change the cutting tools, quality management of work piece surface layer, optimization of cutting tool stereometry, chip shape and removal conducting, upgrading the technology of production of cutting tool inserts and their properties. During intensive machining conditions, monitoring of the cutting forces is possible only with the use of computer aided research systems. Experiences show that the determination of cutting forces in an analytical way not fully reflects the real situation. Basis of mathematical models for cutting forces obtained in an analytical way are spreadsheet data obtained in surveys, conducted in certain treatment conditions that can be changed. From here emerges the justification for carrying out research activities for the determination of mathematical models to describe the change of cutting forces as a function of processing parameters. Surface finish, also known a surface texture or surface topography, is the nature of a surface as defined by the 3 characteristics of lay, surface roughness, and waviness. It comprises the small local deviations of a surface from the perfectly flat ideal (a true plane). Surface texture is one of the important factors that control friction and transfer layer formation during sliding. . Sometimes, stick-slip friction phenomena can be observed during sliding depending on surface texture.

4.2 Different modules in pro/engineer

- Part design
- Assembly
- Drawing
- Sheet metal
- Manufacturing

3D models

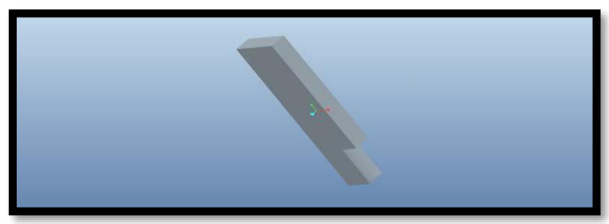


Fig 4 Cutting tool

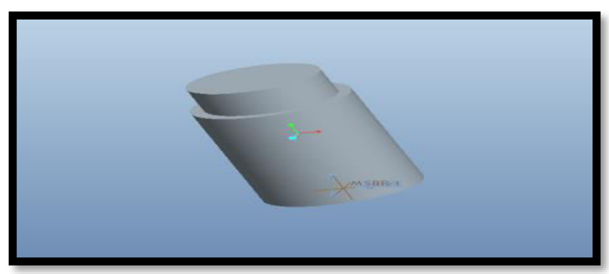


Fig 5 Work piece

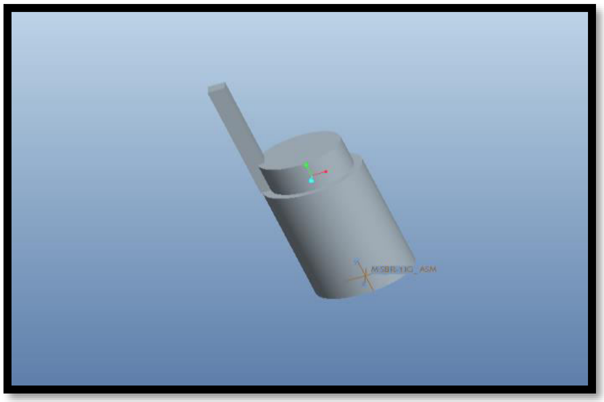


Fig 6 assembly

4.3 STRUCTURAL ANALYSIS

FORCE -1150N

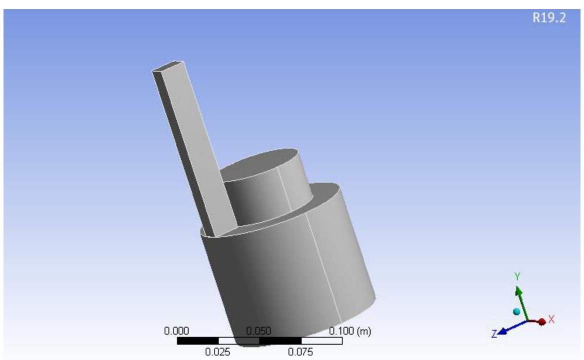


Fig 7 import geometry

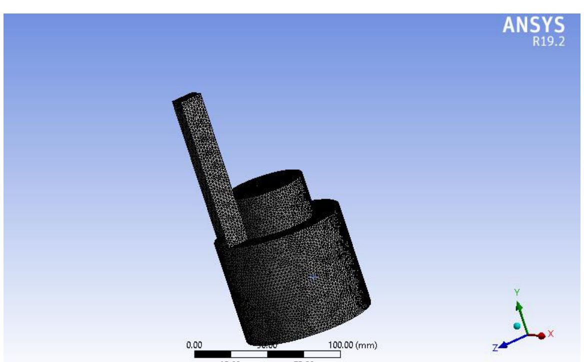


Fig 8 Meshing

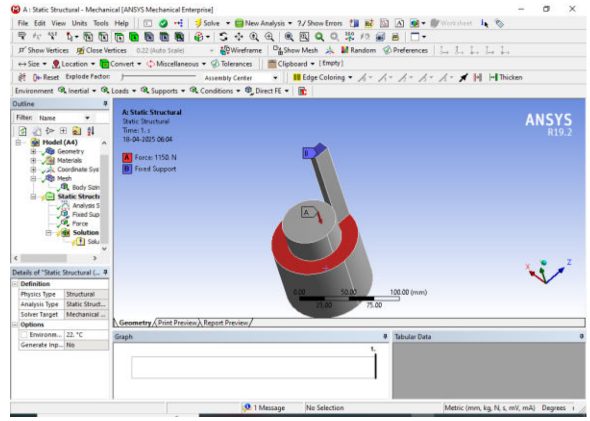


Fig 9 boundary conditions

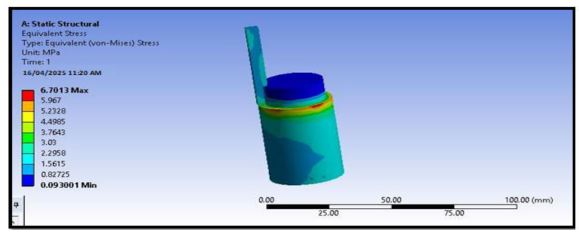


Fig 10 total deformation

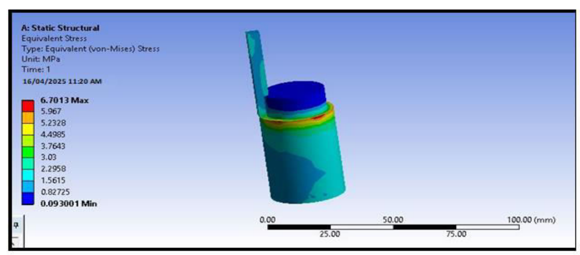


Fig 11 Stress

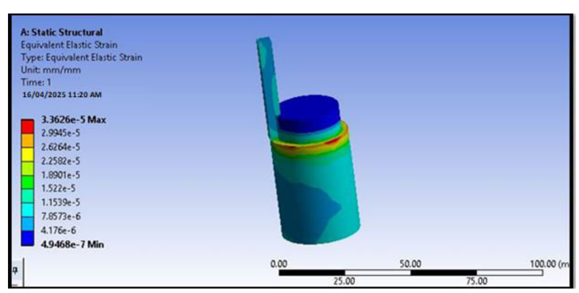


Fig 12 Strain

4.4 FORCE -688N

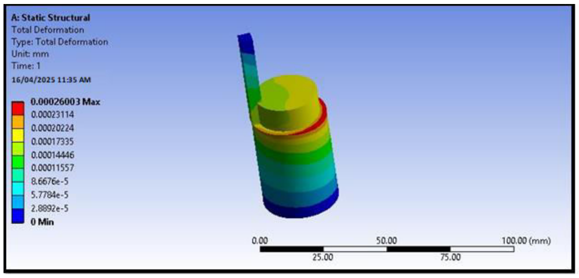


Fig 13 Total deformation

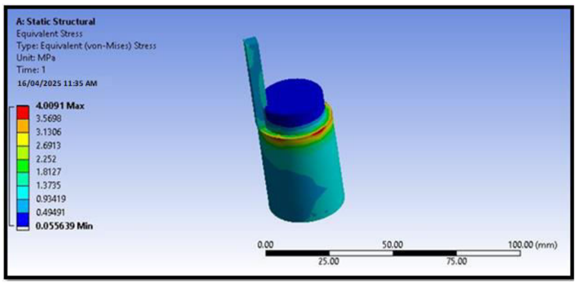


Fig 14 stress

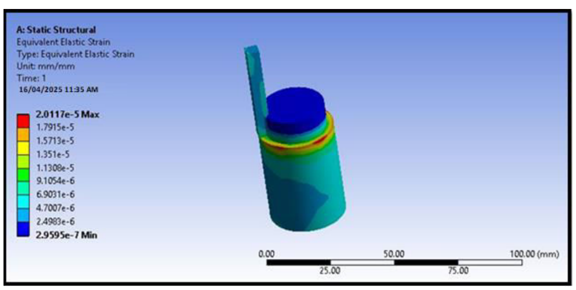


Fig 15 Strain

5. Result table

FORCE(N)	Total deformation(mm)	Stress (N/mm^2)	Strain
1150	0.0004346	6.23	3.01e-05
992	0.0003749	5.78	2.90e-05
688	0.0002600	4.00	2.01e-05
550	0.00020787	3.20	1.608e-05
375	0.00014173	2.18	1.096e-05
270	0.00010205	1.57	7.89e-06
465	0.00017515	2.70	1.35e-05
297	0.00011225	1.73	1.42e-05
206	7.785e-5	1.20	6.0235e-06

5.1 experimental investigations

The experiments are done on the CNC turning machine with the following parameters:

Cutting tool material –cemented Carbide Tool

Work piece material – EN 31Tool Steel

Feed – 200mm/min, 250mm/min, 300mm/min

Cutting speed – 600rpm, 1200rpm, 1800rpm,

Depth of cut – 0.4mm, 0.5mm, 0.6mm

Experimental photos

Fig 16 machine

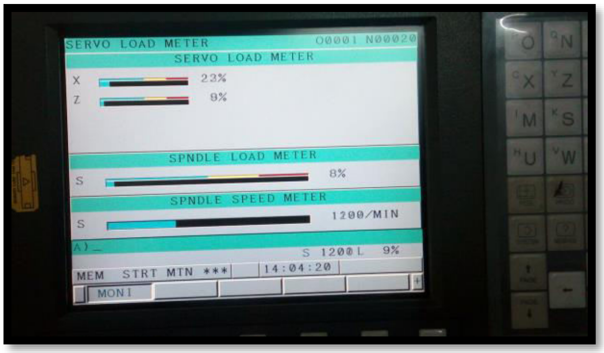


Fig 17 coding

Fig 18 tool set

Fig 19 lubrication

Fig 20 work piece

PROCESS PARAMETERS	LE VEL1	LEVEL2	LEVEL3
CUTTING SPEED(rpm)	600	1200	1800
FEED RATE (mm/rev)	200	250	300
DEPTH OF CUT(mm)	0.4	0.5	0.6

6. Result table

JOB NO.	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)
1	600	200	0.4
2	600	250	0.5
3	600	300	0.6
4	1200	200	0.4
5	1200	250	0.5
6	1200	300	0.6
7	1800	200	0.4
8	1800	250	0.5
9	1800	300	0.6

6.1 Surface finish value

JOB NO.	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)	Surface finish (R_a) µm
1	600	200	0.4	0.62
2	600	250	0.5	0.78
3	600	300	0.6	0.91
4	1200	200	0.4	1.21
5	1200	250	0.5	1.46
6	1200	300	0.6	1.94
7	1800	200	0.4	2.41
8	1800	250	0.5	2.84
9	1800	300	0.6	3.12

6.2 Introduction to taguchi technique

- Taguchi defines Quality Level of a product as the Total Loss incurred by society due to failure of a product to perform as desired when it deviates from the delivered target performance levels.
- This includes costs associated with poor performance, operating costs (which changes as a product ages) and any added expenses due to harmful side effects of the product in use.

6.3 Taguchi Methods

- Help companies to perform the Quality Fix!
- Quality problems are due to Noises in the product or process system
- Noise is any undesirable effect that increases variability
- Conduct extensive Problem Analyses
- Employ Inter-disciplinary Teams
- Perform Designed Experimental Analyses
- Evaluate Experiments using ANOVA and Signal-to noise techniques

6.4 Taguchi orthogonal array

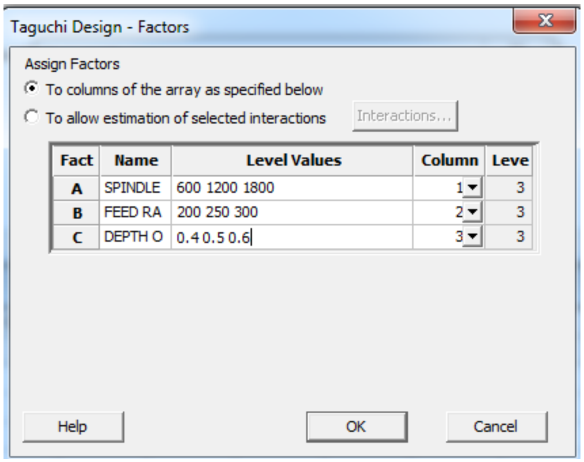
JOB NO.	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)
1	600	200	0.4
2	600	250	0.5
3	600	300	0.6
4	1200	200	0.4
5	1200	250	0.5
6	1200	300	0.6
7	1800	200	0.4
8	1800	250	0.5
9	1800	300	0.6

Surface finish (R_a) µm
0.62
0.78
0.91
1.21
1.46
1.94
2.41
2.84

6.5 OPTIMIZATION OF SURFACE FINISH USING MINITAB SOFTWARE

6.6 Design of Orthogonal Array

First Taguchi Orthogonal Array is designed in Minitab15 to calculate S/N ratio and Means which steps is given below:

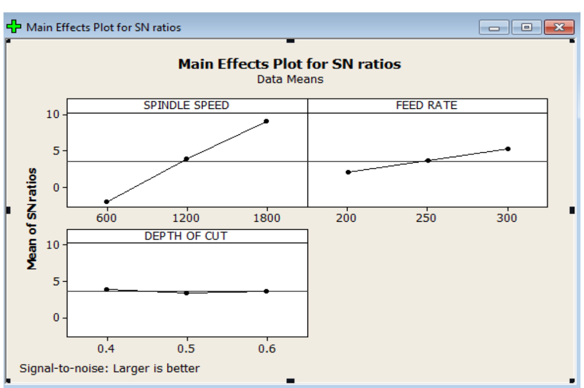


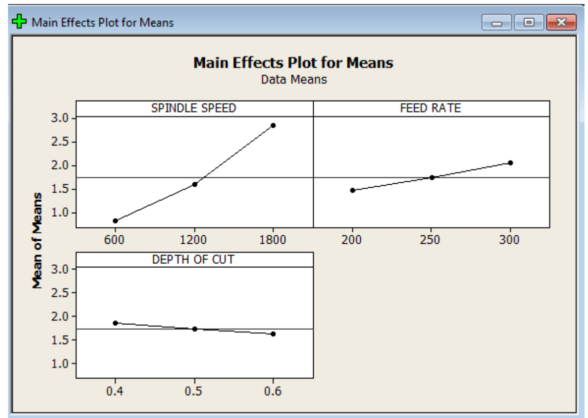
Worksheet 2 ***

↓	C1	C2	C3
	SPINDLE SPEED	FEED RATE	DEPTH OF CUT
1	600	200	0.4
2	600	250	0.5
3	600	300	0.6
4	1200	200	0.5
5	1200	250	0.6
6	1200	300	0.4
7	1800	200	0.6
8	1800	250	0.4
9	1800	300	0.5

Worksheet 1 ***

↓	C1	C2	C3	C4	C5
	SPINDLE SPEED	FEED RATE	DEPTH OF CUT	SURFACE FINISH	SURFACE FINISH 2
1	600	200	0.4	0.62	0.70
2	600	250	0.5	0.78	0.85
3	600	300	0.6	0.91	0.99
4	1200	200	0.5	1.21	1.30
5	1200	250	0.6	1.46	1.55
6	1200	300	0.4	1.94	2.10
7	1800	200	0.6	2.41	2.50
8	1800	250	0.4	2.84	2.93
9	1800	300	0.5	3.12	3.20





7. RESULTS

Taguchi method stresses the importance of studying the response variation using the signal–to–noise (S/N) ratio, resulting in minimization of quality characteristic variation due to uncontrollable parameter. The cutting force is considered as the quality characteristic with the concept of "the smaller-the-better". The S/N ratio for the smaller-the-better is:

$$S/N = -10 * \log(\Sigma(Y^2)/n))$$

Where n is the number of measurements in a trial/row, in this case, n=1 and y is the measured value in a run/row. The S/N ratio values are calculated by taking into consideration above Eqn. with the help of software Minitab 17. The force values measured from the experiments and their corresponding S/N ratio values are listed in Table

Worksheet 1 ***

↓	C1	C2	C3	C4	C5	C6	C7
	SPINDLE SPEED	FEED RATE	DEPTH OF CUT	SURFACE FINISH	SURFACE FINISH 2	SNRA1	MEAN1
1	600	200	0.4	0.62	0.70	-3.65701	0.660
2	600	250	0.5	0.78	0.85	-1.80088	0.815
3	600	300	0.6	0.91	0.99	-0.46863	0.950
4	1200	200	0.5	1.21	1.30	1.95612	1.255
5	1200	250	0.6	1.46	1.55	3.53908	1.505
6	1200	300	0.4	1.94	2.10	6.08659	2.020
7	1800	200	0.6	2.41	2.50	7.79665	2.455
8	1800	250	0.4	2.84	2.93	9.19975	2.885
9	1800	300	0.5	3.12	3.20	9.99165	3.160

8. CONCLUSION

The cutting parameters are cutting speed, feed rate and depth of cut for turning of work piece EN 31 tool steel. In this work, the optimal parameters of cutting speed are 600rpm, 1200rpm and 1800rpm, feed rate are 200mm/min, 250mm/min and 300mm/min and depth of cut are 0.4mm, 0.5mm and 0.6mm. Experimental work is conducted by considering the above parameters. Cutting forces, surface finish and cutting temperatures are validated experimentally. By observing the experimental results and by taguchi, the following conclusions can be made: To minimize the cutting forces, the optimal parameters are spindle speed – 600rpm, feed rate – 200mm/min and depth of cut – 0.4mm. To get better surface finish, the optimal parameters are spindle speed – 1800rpm, feed rate – 300mm/min and depth of cut – 0.6mm. To maximize material removal rate, the optimal parameters are spindle speed – 600rpm, feed rate – 200mm/min and depth of cut – 0.6mm. The effects of these parameters on the cutting forces are calculated using theoretical calculations and using the forces stresses and displacements are analyzed using Ansys. 3D modeling is done in Pro/Engineer. By observing the analysis results, the stress values are less than the yield stress values.

REFERENCES

1. Using the Response Surface Method to Optimize the Turning Process of AISI 12L14 Steel
2. Optimization of Process Parameters of Turning Parts: A Taguchi Approach by Neeraj Sharma, Renu Sharma
3. The Effect of Tool Construction and Cutting Parameters on Surface Roughness and Vibration in Turning of AISI 1045 Steel Using Taguchi Method by Rogov Vladimir Aleksandrovich, Ghorbani Siamak
4. Parametric investigation of turning process on mild steel aisi 1018 material by J. M. Gadhiya, P. J. Patel
5. Evaluation and Optimization of Machining Parameter for turning of EN 8 steel by Vikas B. Magdum, Vinayak R. Naik
6. Analyses of surface roughness by turning process using Taguchi

method by S. Thamizhmanii, S. Saparudin, S. Hasan

7. Application of Taguchi Method for Optimizing Turning Process by the effects of Machining Parameters by Krishankant, Jatin Taneja, Mohit Bector, Rajesh Kumar
8. Multi-Objective Optimization of the Cutting Forces in Turning Operations Using the Grey-Based Taguchi Method by Yigit
9. Experimental investigation of Material removal rate in CNC turning using Taguchi method by Kamal, Anish and M.P.Garg
10. Optimization of Cutting Parameters of Composite Materials using Genetic Algorithm by Dhavamani and Alwarsamy
11. Arbizu and Prez,Puertas. I. Arbizu, C.J. Prez L. (2003), "Surface roughness prediction by factorial design of experiments in turning processes". Journal of Materials Processing Technology, 143- 144, 390-396.
12. Akhyar G., Che Haron C. H. and Ghani J. A. (2008), "Application of Taguchi Method in the Optimization of Turning Parameters for Surface Roughness; International Journal of Science Engineering and Technology," Vol. 1, No. 3, 60-66.
13. Asilturk I. and Akkus H. (2011), "Determining the effect of cutting parameters on surface roughness in hard turning using the Taguchi method", Measurement 44,1697–1704.