International Journal On Engineering Technology and Sciences – IJETS™
ISSN(P): 2349-3968, ISSN (O): 2349-3976
Volume III, Issue IV, April- 2016

OPTIMIZATION OF CNC TURNING PROCESS PARAMETERS ON ALUMINIUM 6063 USING RESPONSE SURFACE METHODOLOGY

N.Muthu prakash	*M.Dhineswaran*	*T.Nateshasundharan*	*R.Venkatramanan*
Assistant Professor	Assistant Professor	Assistant Professor	Assistant Professor
Coimbatore Institute of Engineering and Technology	Coimbatore Institute of Engineering and Technology	Coimbatore Institute of Engineering and Technology	Coimbatore Institute of Engineering and Technology
prakash1988cbe@gmail.com	dhines.kavi@gmail.com	tnsundharan@gmail.com	tnsundharan@gmail.com

ABSTRACT

This project presents the effect of process parameter in turning operation to predict surface roughness. The turning process by using CNC turning lathe is widely used in industry because of its versatility and efficiency. Applications of the turning process can be found in many industries ranging from large engine manufactures to small die shops. The parameters that affect the turning operation are vibration, tool wear, surface roughness etc. Among this surface roughness is an important factor that affects the quality in manufacturing process. The main objective of this project is to predict the surface roughness on aluminium 6063, by optimizing the input parameters such as spindle speed, feed rate and depth of cut by using coated carbide tool. A second order mathematical model is developed using regression technique and optimization is carried out using Box-Behnken of response surface methodology. The application of response surface methodology for optimizing the input parameters such as spindle speed (rpm), feed rate (mm/min) and depth of cut (mm), the output parameter surface roughness can also be optimized for economical production. Therefore, this study attempts the application of response surface methodology to find the optimal solution of the cutting conditions for giving the minimum value of surface roughness using design- expert 8.0 software

***Key words:* Optimization, RSM, Surface roughness**

1. INTRODUCTION

1.1 TURNING:

Turning is the process whereby a single point cutting tool is parallel to the surface. It can be done manually, in a traditional form of lathe, which frequently requires continuous supervision by the operator,or by using a computer controlled and automated lathe which does not. This type of machine tool is referred to as having computer numerical control, better known as CNC, and is commonly used with many other types of machine tool besides the lathe.

When turning, a piece of material (wood, metal, plastic even stone) is rotated and a cutting tool is traversed along 2 axes of motion to produce precise diameters and depths. Turning can be either on the outside of the cylinder or on the inside and produce tubular components to various geometries. Although now quite rare, early lathes could even be used to produce complex geometric figures, even the platonic solids; although until the advent of CNC it had become unusual to use one for this purpose for the last three quarters of the twentieth century. It is said that the lathe is the only machine tool that can reproduce itself.

The turning processes are typically carried out on a lathe, considered to be the oldest machine tools, and can be of four different types such as straight turning, taper turning, profiling or external grooving. Those types of turning processes can produce various shapes performance measures surface roughness and flank wear were investigated. The relationship between the machining input parameters of materials such as straight, conical, curved, or grooved work piece. In general, turning uses simple single-point cutting tools. Each group of work piece materials has an optimum set of tools angles which have been developed through the years

2. LITERATURE REVIEW

1. K.Saravanakumar, Dr.A.K.ShaikDawood, (ESTIJ),(August 2012)This paper is aimed at conducting experiments on Inconel 718 and investigation the influence of

machining process parameters such as cutting speed (X1, m/min), feed rate(X2, mm/rev), and depth of cut (X3, mm) on the output parameters such as material removal rate and surface roughness. By optimizing input parameters such as cutting speed, feed rate, and depth of cut, etc., the output parameters like surface finish and metal removal rate can also be optimized for economical production. Number of experiments had been conducted with suitable combinations of input parameters. Relationship between material removal rate and input parameters and between surface roughness and input parameters are arrived through Design expert software. These regression equations are solved using genetic algorithm tool.

2. Mr.Ch.Madhu.V.N, .Prof., A.V.N.L. Sharma, Dr.K.VenkataSubbiah, (April 2012) The main objective of this paper is to predict the surface roughness on Work piece material – TITANIUM. In machining process, Surface roughness is an important index to evaluate cutting performance. The influence of cutting speed, feed rate and depth of cut on the surface roughness is examined. The model for the surface roughness, as a function of cutting parameters, is obtained using ANN in MATLAB7.This research is to carry out the experiments by selecting different variables and their levels, applying artificial neural network (ANN) and then analyzing the results obtained.

3. J.S.Senthilkumaar,P.Selvarani, R.M.Arunachalam, (November 2010)Inconel 718 is widely used in aerospace industries because of their ability to withstand excessive loads even at elevated temperature. This property makes it, one of the most difficult to machining the material with inferior surface quality and rapid tool wear. Cutting experiments were conducted as per the full factorial design under dry cutting conditions. The effects of the machining parameters on these studies show that cutting conditions, tool wear, the material properties of tool and work piece, as well as cutting speed 'V' (m/min), feed rate 'f' (mm/rev) and depth of cut 'a' (mm) and Surface roughness 'Ra' (μ m) Flank wear 'VB' (mm) Surface roughness 'Ra' (μ m) Flank wear 'VB' (mm) the performance measures were established using the nonlinear regression analysisfactors level, its significance to influence the surface roughness and flank wear for the tuning and facing processes.

3. PROBLEM IDENTIFICATION AND METHODOLOGY

3.1 PROBLEM IDENTIFICATION:

Turning is the process whereby a single point cutting tool is parallel to the surface. It can be done manually, in a traditional form of lathe, which frequently requires continuous supervision by the operator, or by using a computer controlled and automated lathe which does not. This type of machine tool is referred to as having computer numerical control, better known as CNC, and is commonly used with many other types of machine tool besides the lathe. When turning, a piece of material (wood, metal, plastic even stone) is rotated and a cutting tool is traversed along 2 axes of motion to produce precise diameters and depths. Turning can be either on the outside of the cylinder or on the inside and produce tubular components to various geometries. Although now quite rare, early lathes could even be used to produce complex geometric figures, even the platonic solids; although until the advent of CNC it had become unusual to use one for this purpose for the last three quarters of the twentieth century. It is said that the lathe is the only machine tool that can reproduce itself.

Traditionally, the selection of cutting conditions for machining was left to the machine operator. In such cases, the experience of the operator plays a major role, but even for a skilled operator it is very difficult to attain the optimum values each time. Thus the selection of cutting parameters such as cutting speed, feed rate and depth of cut for machining became difficult and it created great impact in product quality.

This trend toward automation has created a need in industry for a comprehensive approach to product quality. To realize successfully full automation in machining, approaches and devices to predict and monitor continuously and reliably the machining process are needed. These will allow quality assurance to be merged with manufacturing processes, with the goal of approaching Zero defect production. A large number of theoretical and experimental studies on surface profile and roughness of machined products have been reported. Cutting/process parameters (including cutting speed, depth of cut, feed rate, and tool geometry) significantly influence the surface finish of machined parts.

IJETS

3.2.Methodology

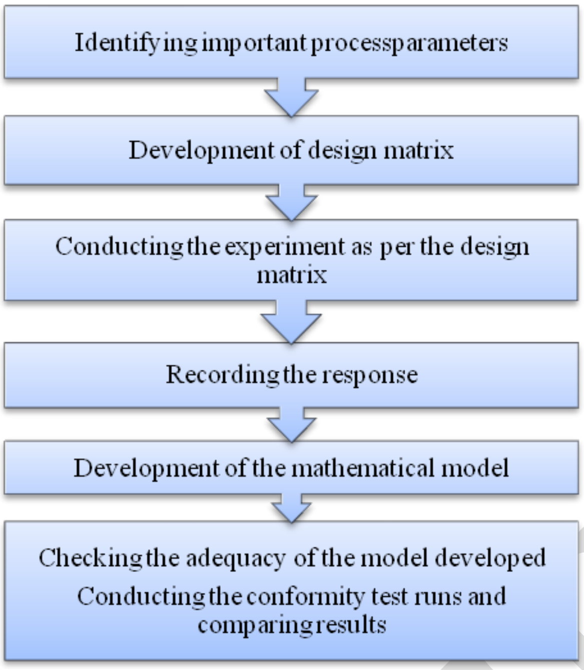


figure.1 Methodology flow chart

4. EXPERIMENTAL METHODOLOGY

4.1 INTRODUCTION

The second phase of design of experiments is conducting phase. In conducting phase experiment are conducted for the selected process parameter combinations at a random order. The conducting phase involves the following tasks.

1. Preparation of work piece.
2. Conducting experiments.
3. Measuring surface roughness.
4. Developing a mathematical model.

The work piece selected **Aluminum 6063** is still not given consideration by researchers and suitable for most engineering applications such as

- Aircraft and aerospace components
- Marine fittings
- Transport
- Bicycle frames
- Camera lenses
- Driveshafts
- Electrical fittings and connectors
- Couplings

Figure 4.1 Aluminium 6063

i)Composition of Aluminium 6063:

the material Aluminum 6063 for ease of machinability is a subset of tool steels, commonly used in tool bits and cutting tools. It is superior to the older high carbon steel tools used extensively through the 1940s in that it can withstand higher temperatures without losing its temper (hardness).AK10 Carbide Inserts for Turning Ground and Polished for AluminiumUni-tip was used for turning.

4.2 WORK MATERIAL PREPARATION

Specification:

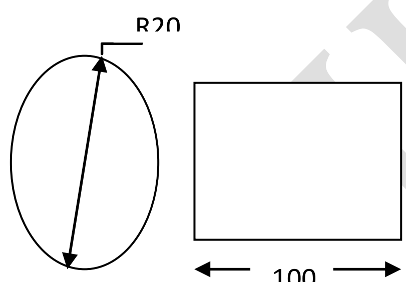
Control system-fanuc emulated
Spindle power-1Hp
Spindle speed-100 to 3000 rpm
Max. Turning dia-32mm
Rapid traverse rate-1.2m/min

IJETS

Cutting parameter	Units	Levels		
		-1	0	1
Spindle Speed (X1)	Rpm	1000	1500	2000
Feed Rate (X2)	mm/min	0.06	0.08	0.1
Depth of Cut (X3)	Mm	0.4	0.6	0.8

Table 4.1 Composition of Aluminium 6063

(ii)Work material specification:



5.1 Regression equation:

Computer-generated experimental designs, such as the D-optimal design, have some advantages over traditional response surface designs such as the central composite design .One major advantage is much greater flexibility in selecting response surface model types and the number of experimental runs. For example, for a three-factor and one response surface experiment, the following

5.4 ANOVA

ANOVA: Analysis of Variance

The tests we have learned up to this point allow us to test hypotheses that examine the difference between only

S. NO	Spindle speed X1 (rpm)	Feed rate X2 (mm/min)	Depth of cut X3 (mm)	Experimental surface roughness (μm)	predicted surface roughness (μm)
1	1000	0.1	0.6	0.623	0.66
2	2000	0.1	0.6	0.687	0.64
3	1000	0.08	0.8	0.638	0.65
4	1500	0.06	0.4	0.641	0.66
5	1500	0.06	0.8	0.678	0.66
6	1500	0.08	0.6	0.661	0.64
7	1500	0.08	0.6	0.663	0.66
8	1500	0.08	0.6	0.653	0.67
9	1000	0.06	0.6	0.646	0.66
10	1500	0.1	0.4	0.661	0.66
11	2000	0.08	0.4	0.695	0.65
12	2000	0.06	0.6	0.697	0.69
13	1000	0.08	0.4	0.638	0.66
14	1500	0.08	0.6	0.659	0.68
15	2000	0.08	0.8	0.689	0.67
16	1500	0.08	0.6	0.667	0.68
17	1500	0.1	0.8	0.658	0.66

Table 5.3 Development design matrix

second-order model is the standard model for box benkhenRegression equations were formed using software for surface roughness.

The regression equation for Surface Roughness Ra (**Y**) is

Y=0.50527 –– 005 * XI + 1.37625 * X2+ 0.23025 * X3 + 3.25000E- 004 * XIX2 -1.50000 E - 005* XIX3 - 2.50000* X2 X3 + - 008* XI^2 - 3.56250* X28.12500E-003* $X3^2$

Where,

X1- refers of input parameters spindle speed.
X2 -refers of input parameters feed rate.
X3-refers of input parameters depth of cut.
Y-refers of output parameters surface roughness

5. OPTIMIZATION METHODOLOGY

two means. Analysis of Variance or ANOVA will allow us to test the difference between 2 or more means. ANOVA does this by examining the ratio of variability between two conditions and variability within each condition.An ANOVA test, on the other hand, would

IJETS

compare the variability that we observe between the two conditions to the variability observed within each condition. Recall that we measure variability as the sum of the difference of each score from the mean. When we actually calculate an ANOVA we will use a short-cut formula Thus, when the variability that we predict (between the two groups) is much greater than the variability we don't predict (within each group) then we will conclude that our treatments produce different

Weight (%)	6063
Al	Bal
Si	0.40-0.80
Fe	0.70 max
Cu	0.15-0.40
Mn	0.15
Mg	0.8-1.2
Cr	0.04-0.35
Zn	0.25 max
Ti	0.15 max
Others each	0.05 max
Others each	0.15 max

Table 5.2 Factors and Levels tabulation

results.

5.5Results and discussion: Response surface methodology:

5.5.1 Interaction effect of spindle speed,

The interaction and direct effect of spindle speed on surface roughness is discussed below.Fig.5.9.1, shows the interaction and direct effect of feed rate and spindle speed on surface roughness. The above interaction figure evidenced that the spindle speed and feed rate on the surface roughness of turning process has a significant effect.

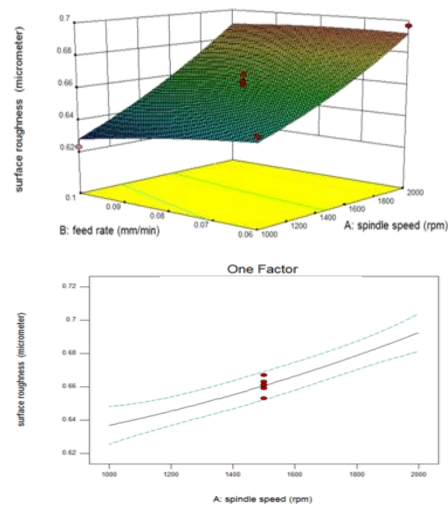


Figure. 5.5.1, Surface interaction dimensional views and direct effect views of spindle speed and feed rate over surface roughness.

As the spindle speed increases from 1000 rpm to 2000 rpm the surface roughness value is reduced from 0.68 to 0.62 µm, where feed rate has the inverse relationship on surface roughness compared to the spindle speed. From the result it is concluded that the change in feed rate (0.06-0.08 mm/min) has significant effect on surface roughness (0.64-0.680.66µm) at higher spindle speed (2000rpm) whereas the change in feed rate (0.06-0.08 mm/min) has no significant effect on surface roughness (0.67-0.68µm) at lower spindle speed (1000 rpm). The conclusion can also be verified from the ANOVA.

5.5.2 Interaction effect of feed rate

The interaction and direct effect of spindle speed on surface roughness is discussed below. Surface roughness is discussed below

IJETS

International Journal On Engineering Technology and Sciences – IJETS™
ISSN(P): 2349-3968, ISSN (O): 2349-3976
Volume III, Issue IV, April- 2016

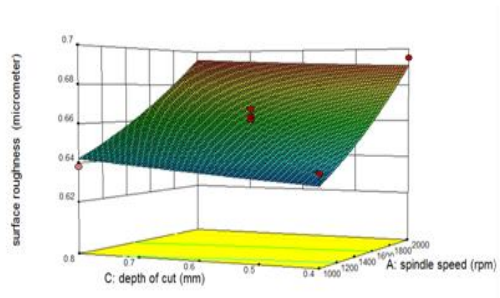


Fig.5.5.2, Surface interaction and direct dimensional views and direct effect views of feed rate and depth of cut over surface roughness

Fig.5.5.2shows the interaction and direct effect of feed rate and depth of cut on surface roughness. The above interaction figure evidenced that the feed rate and depth of cut on the surface roughness of turning process has a significant effect. From the Fig.8 it has been concluded that higher feed rate and depth of cut was increase the surface roughness whereas lower feed rate and depth of cut decrease the surface roughness. To obtain the quality surface of Ra between 0.62 and 0.64 feed rate less than 0.06 and depth of cut less than 0.70 should be preferred.

5.5.3 Interaction effect of Depth of cut:

The interaction and direct effect of Depth of cut on surface roughness is discussed below.

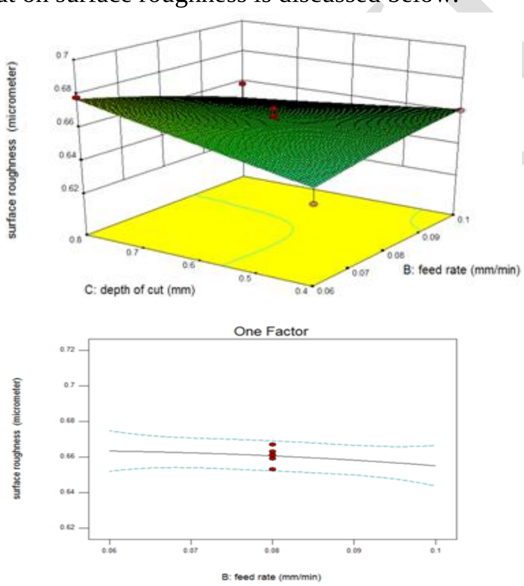


Fig.5.5.3, Surface interaction and direct dimensional views and direct effect views of spindle speed and depth of cut over surface roughness

Fig.5.5.3 shows the interaction and direct effect of depth of cut and spindle speed on surface roughness. The above interaction figure evidenced that the spindle speed and depth of cut on the surface roughness of turning path of cutrsm process has a significant effect. From the Fig.10 it has been concluded that the lower spindle speed (1000 rpm) with the increase in depth of cut (0.7 to 0.8 mm) has a significant effect on surface roughness (0.62-0.67µm) at higher spindle speed (2000rpm) whereas the increase in depth of cut (0.4 to 0.5 mm) has no significant effect on surface roughness (0.65 to 0.64µm) at lower spindle speed (1000 rpm).

5.5.4Prediction Vs Actual

Fig. 4 revealed that they have no obvious pattern and unusual structure. This implies that the models proposed are adequate and there is no reason to suspect any violation of the independence or constant variation assumption

- has no significant effect on surface roughness (0.67-0.69µm) at lower spindle speed (1000 rpm).

A feed rate less than 0.08 and depth of cut less than 0.60 have been preferred for obtaining good surface finish

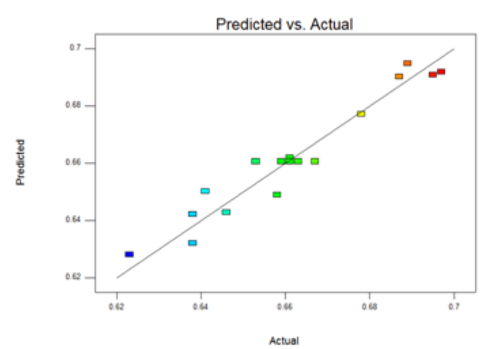


Fig.5. 5.4 Prediction Vs Actual

6. CONCLUSION

6.1 CONCLUSION:

This investigation attempts the application of response surface methodology to find the optimal solution of the cutting conditions such as spindle speed (rpm), feed rate (mm/min) and depth of cut (mm) for giving the minimum value of surface roughness using design of experiment concept. The confirmatory test was conducted and found that the percentage of error within

±1.5%. The following conclusions are obtained by analysis of work are,

The obtained experimental data can be used to predict the surface roughness 'Ra' by developing the regression model using DoE

- A good surface roughness was obtained at the feed rate (0.06-0.07 mm/min) and spindle speed (1700-2000 rpm).
- The change in feed rate (0.06-0.1 mm/min) has a significant effect on surface roughness (0.69-0.66µm) at higher spindle speed (2000rpm).
- The change in feed rate (0.06-0.08 mm/min)

Components in hard turning with CBN tool", Prediction model and cutting conditions Optimization, Measurement 45 (2012),pp.344–353

VII.REFERENCES

[1] Zeelan Basha N, ―Determining the Effect of Cutting Parameters on Surface Roughness Using Genetic Algorithm‖ Science, Technology and Arts Research Journal, pp.98-101, 2013.
[2] Hamdi, A., Mohamed, A.(2011). Analysis of surface roughness and cutting force components in hard turning with CBN tool: Prediction model and cutting conditions optimization. Measurement: 344- 354.
[3] Anil, G., Hari, S., Aman,A.(2010).Taguchi-fuzzy multi output optimization (MOO) in high speed CNC turningof AISI P-20 tool steel.Expert Systems with Applications:.6822-6828.
[4] Amit, S., Vinod, Y.(2011) .Modeling and optimization of cut quality during pulsed laser cutting of thin Al-alloy sheet for straight profile. Optics & Laser Technology: 159-168.
[5] Zeelan Basha N, ―Determining the Effect of Cutting Parameters on Surface Roughness Using Genetic Algorithm‖ Science, Technology and Arts Research Journal, pp.98-101, 2013.
[6] Marks' Standard Handbook for Mechanical Engineers, 8th Ed., McGraw Hill, pp. 6-50 to 6-57
[7] Ilhan , A., Mehmet, Ç.(2010).Modeling and prediction of surface roughness in turning operations using artificial neural network and multiple regression method.Expert Systems with Applications:.5826-5832.
[8] Aman Aggarwal ―Optimizing power consumption for CNC turned parts using response surface methodology and Taguchi's technique—A comparative analysis‖ journal of materials processing technology 2 0 0 (2 0 0 8) 373–384.
[9] P.V.S. Suresh ―A genetic algorithmic approach for optimization of surface roughness prediction model‖ International Journal of Machine Tools & Manufacture 42 (2002) 675–680.
[10] N. Zeelan Basha, ―Optimization of CNC Turning Process Parameters on ALUMINIUM 6061 Using Genetic Algorithm‖, International Journal of Innovative Science and Modern Engineering, pp.43-46, 2013. M. Brezocnik, M. Kovacic, M. Ficko, ―Prediction of surface roughness with Genetic programming‖,Journal of Materials Processing Technology, 2004,pp.28-36
[11] MaciejGrzendaa, Andres Bustillo, ‖The evolutionary development of roughness prediction models‖, Applied Soft Computing (2012), pp.1-10.
[12] S.S.K. Deepak, ―Applications of Different Optimization Methods for Metal Cutting Operation‖–A Review, Research Journal of Engineering Sciences,Vol.1(3),Sept.2012,pp.52-58
[13] HamdiAouici, Mohamed AthmaneYallese, KamelChaoui, TarekMabroukic, JeanFrançois Rigal, ―Analysis of surface roughness and cutting force components in hard turning with CBN tool‖, Prediction model and cutting conditions Optimization, Measurement 45 (2012),pp.344–353.
[14] Arokiadass, K. Palaniradja, N. Alagumoorthi, ―Prediction and Optimization of End Milling Process Parameters Of cast Aluminium Based MMC.‖, Trans. Nonferrous Met. Soc. China, 21 February 2012, pp. 1568-15

IJETS