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Optimization of Process Parameters for Superior Surface Roughness and Higher Mrr of Al Alloy by Using Taguchi Technique and Regression Analysis

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Abstract

In this thesis experiments are conducted to get the superior surface finish quality and higher material removal rate of a component by using carbide tips. Multiple experiments are performed by varying the milling parameters such as spindle speed, cut feed and step over for roughing and finishing operations. Experiments are performed on 9 components by selecting the parameters as per Taguchi method. After machining, surface roughness values are observed and the parameters are optimized from the observations for the least value for both roughing and finishing operations. Material Removal Rates are also determined and optimized for higher values. Taguchi method and Regression Analysis are used for the optimization of spindle speeds, cut feed and step over.

Cut Feed – 2000mm/min, 2500mm/min, 3000mm/min, Spindle Speed – 1000rpm, 1500rpm, 2000rpm, Step Over – 20mm, 25mm, 30mm and depth of cut – 0.5mm are the machining parameters used in roughing operation. The machining parameters used for finishing operation are Spindle Speed – 2000rpm, 2200rpm, 2500rpm, Cut Feed – 1000mm/min, 1200mm/min, 1500mm/min , Step Over – 5mm, 10mm, 12mm and depth of cut – 0.3mm.

The milling process is conducted on a CNC Vertical milling machine.

Key words: Surface Roughness, Finishing,MRR, Depth of Cut, Spindle speed, Step over

I.INTRODUCTION

Milling is the process of continuous material removing by using rotary cutting tool.Milling could be a cutting method that uses an edge cutter to get rid of material from the surface of a work- piece. The edge cutter could be a rotary-cutting tool, usually with multiple cutting points. As against drilling, wherever the tool is advanced on its rotation axis, the cutter in edge is typically touched perpendicular to its axis so cutting happens on the circumference of the cutter. it's one amongst the foremost ordinarily used processes in trade and machine outlets these days for machining elements to express sizes and shapes.

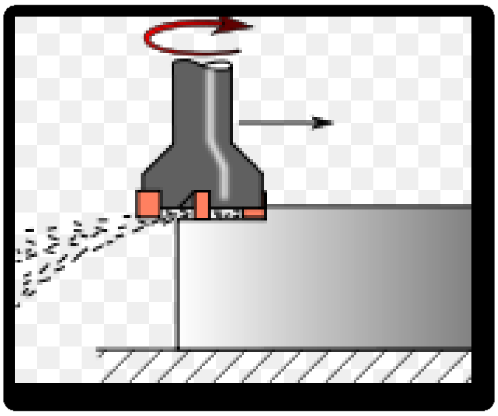

Fig-1 – Cutting Tool Translator and Rotational Motion

GENERAL METHOD FOR CHOOSING SUITABLE PARAMETERS

The choice of cutting parameters is dependent on numerous criteria:

- Productivity
- Surface condition
- Cost of the part
- Machine characteristics
- Part/machine/tool rigidity

The selection method takes these criteria into account, together with the adjustment of the following parameters:

- Forces / power
- Cutting speed
- Feed
- Engagements
- Machining direction
- Lubrication
- Range / strategies
- Vibrations
- Balancing

CHOICE OF OPERATING CONDITIONS

- Cutting speed parameter
- Feed Rate Parameter
- Cutting conditions
- Stages in metal cutting
- Computer Numerical Control

MRR in milling

It is an instantaneous indicator of however expeditiously you're cutting, and the way profitable you're. MRR is that the volume of fabric removed per minute. the upper your cutting parameters, the upper the MRR. MRR in milling: Depth of cut (D), mm.

SURFACE ROUGHNESS

Surface roughness, sometimes shortened to roughness, is also a live of the texture of a surface. it's quantified by the vertical deviations of a real surface from its ideal kind. If these deviations unit of measurement huge, the surface is rough; if they are small the surface is sleek. Roughness is sometimes thought-about to be the high frequency, short wavelength part of a measured surface (see surface metrology). However, in apply it has always necessary to know every the amplitude and frequency to verify that a surface is appropriate purpose.

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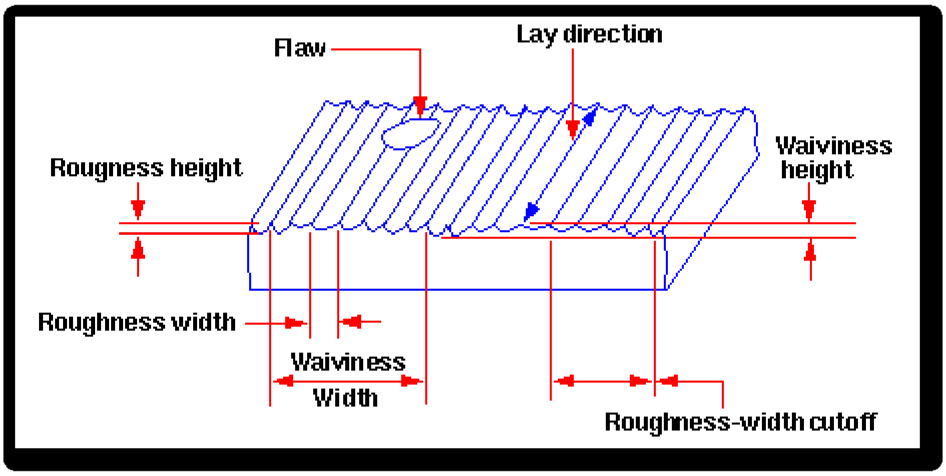

Fig-2 – Surface Roughness Characteristics

II.LITERATURE REVIEW

This paper described by yang [1], prediction of surface roughness in end milling with gene expression programming. In this paper, a method supported organic phenomenon programming (gep) has been projected to construct the prediction model of surface roughness. Gep combines the benefits of the genetic algorithmic rule (ga) and genetic programming (gp). In this paper done by M.S. Sukumar[2], optimization and prediction of parameters in face milling of al-6061 using taguchi and ANN approach . In this paper, taguchi methodology has been accustomed establish the optimum combi nation of influential factors within the edge method. Edge experiment has been performed on al 6061.during this paper done by Liang Gao [3], Application of Free Pattern Search on the surface roughness prediction in finish edge. Experiments area unit conducted to verify the performance of independent agency and independent agency obtains sensible results compared with alternative algorithmic program.

III.EXPERIMENTAL SETUP AND PROCEDURE

Roughing:-50R6 bull nose cutter

Fig-3 – Cutter used for Roughing

New Insert used for this cutter is R6 carbide insert, HITACHI

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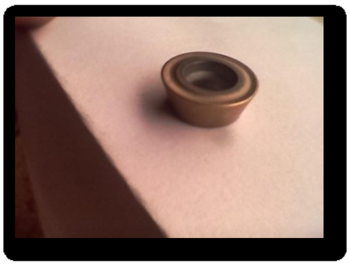


Fig-4 – Insert used for Roughing

Finishing: - 20R5 tip radius cutter

New Insert used for this cutter is R5 carbide insert, TACOTECH

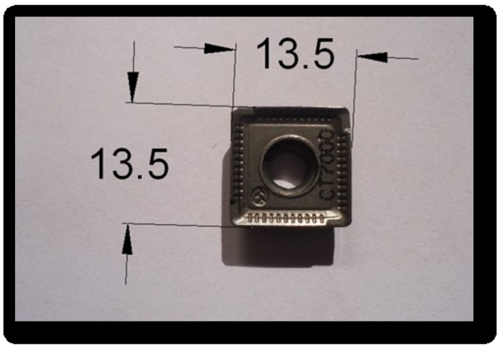


Fig-5 – Insert used for finishing

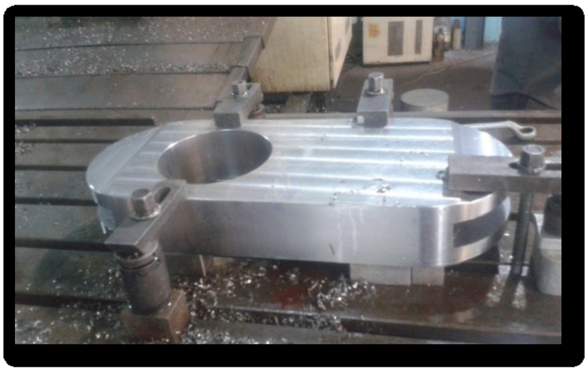


Fig-6 – The component in consideration for experiment

IV.EXPERIMENTAL INVESTIGATION

- **CNC MACHINING DATA FOR ROUGHING**

The machining parameters used for finishing operation square measure Spindle Speed – 2000rpm, 2200rpm, 2500rpm, Cut Feed – 1000mm/min, 1200mm/min, 1500mm/min , Step Over – 5mm, 10mm, 12mm and depth of cut – zero.3mm.

TYPE OF OPERATION		**FACING**
CUTTER		50R6
MATERIAL	**WORK PIECE**	Mn Steel
	CUTTER	CARBIDE
TIME (hrs)		9
NO.OF INSERTS CHANGED		9
Spindle Speed (rpm)		1000
Feed (mm/min)		2000
Step Over (mm)		20
Depth of cut (mm)		0.5

Table-1 – Machining Parameters used for facing operations for component 1 – Roughing

OBSERVATION OF EXPERIMENT

The following tables shows the surface roughness and MRR values determined after machining.

ROUGHING OPERATION

Component	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	STEP OVER (mm)	Surface finish (R_a) µm	MRR (cm^3/sec)
1	1000	2000	20	0.705	1.512
2	1000	2500	25	1.454	1.723
3	1000	3000	30	2.55	2.05
4	1500	2000	25	1.67	2.47
5	1500	2500	30	2.17	2.78
6	1500	3000	20	2.39	2.69
7	2000	2000	30	2.25	1.94
8	2000	2500	20	1.86	1.85
9	2000	3000	25	2.41	2.88

Table-2– Surface Roughness and MRR values observed for roughing operations

FINISHING OPERATION

Component	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	STEP OVER (mm)	Surface finish (R_a) µm	MRR (cm^3/sec)
1	2000	1000	5	2.25	0.149
2	2000	1200	10	2.64	0.155
3	2000	1500	12	3.36	0.331
4	2200	1000	10	2.71	0.448
5	2200	1200	12	2.89	0.617
6	2200	1500	5	3.15	0.553
7	2500	1000	12	2.97	0.273
8	2500	1200	5	2.81	0.21
9	2500	1500	10	3.32	0.671

Table-3– Surface Roughness values observed for finishing operations

V.OPTIMIZATION OF PROCESS PARAMETERS USING TAGUCHI TECHNIQUE

Worksheet 1 ***

↓	C1	C2	C3	C4	C5
	SPINDLE SPEED	CUT FEED	STEP OVER	SURFACE ROUGHNESS	SNRA1
1	1000	2000	20	0.705	3.03622
2	1000	2500	25	1.454	-3.25129
3	1000	3000	30	2.550	-8.13080
4	1500	2000	25	1.670	-4.45433
5	1500	2500	30	2.170	-6.72919
6	1500	3000	20	2.390	-7.56796
7	2000	2000	30	2.250	-7.04365
8	2000	2500	20	1.860	-5.39026
9	2000	3000	25	2.410	-7.64034

Fig-7-The above table shows the calculated S/N Ratio values for Surface Roughness after analyzing in Taguchi.

TAGUCHI ANALYSIS: SURFACE ROUGHNESSversus SPINDLE SPEED, CUT FEED, STEP OVER

↓	C1	C2	C3	C4	C5
	SPINDLE SPEED	CUT FEED	STEP OVER	SURFACE ROUGHNESS	SNRA1
1	2000	1000	5	2.25	-7.0437
2	2000	1200	10	2.64	-8.4321
3	2000	1500	12	3.36	-10.5268
4	2200	1000	10	2.71	-8.6594
5	2200	1200	12	2.89	-9.2180
6	2200	1500	5	3.15	-9.9662
7	2500	1000	12	2.97	-9.4551
8	2500	1200	5	2.81	-8.9741
9	2500	1500	10	3.32	-10.4228

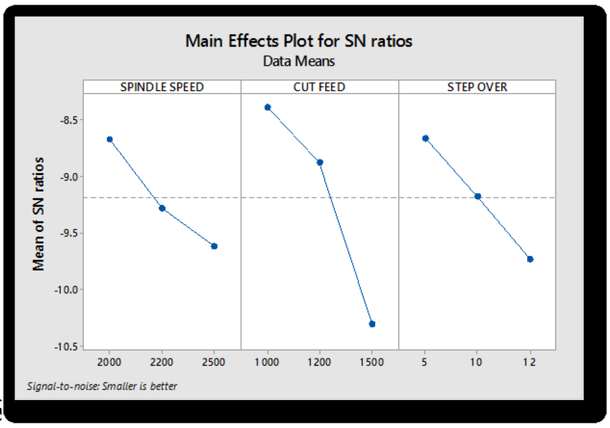
Fig-8– Results of S/N Ratio

TAGUCHI ANALYSIS: MRRversus SPINDLE SPEED, CUT FEED, STEP OVER

Worksheet 1 ***

↓	C1	C2	C3	C4	C5
	SPINDLE SPEED	CUT FEED	STEP OVER	MRR	SNRA2
1	1000	2000	20	1.512	3.59104
2	1000	2500	25	1.723	4.72571
3	1000	3000	30	2.050	6.23508
4	1500	2000	25	2.470	7.85394
5	1500	2500	30	2.780	8.88090
6	1500	3000	20	2.690	8.59505
7	2000	2000	30	1.940	5.75603
8	2000	2500	20	1.850	5.34343
9	2000	3000	25	2.880	9.18785

Fig-9-the calculated S/N Ratio values for MRR after analyzing in Taguchi.



SURFACE ROUGHNESS

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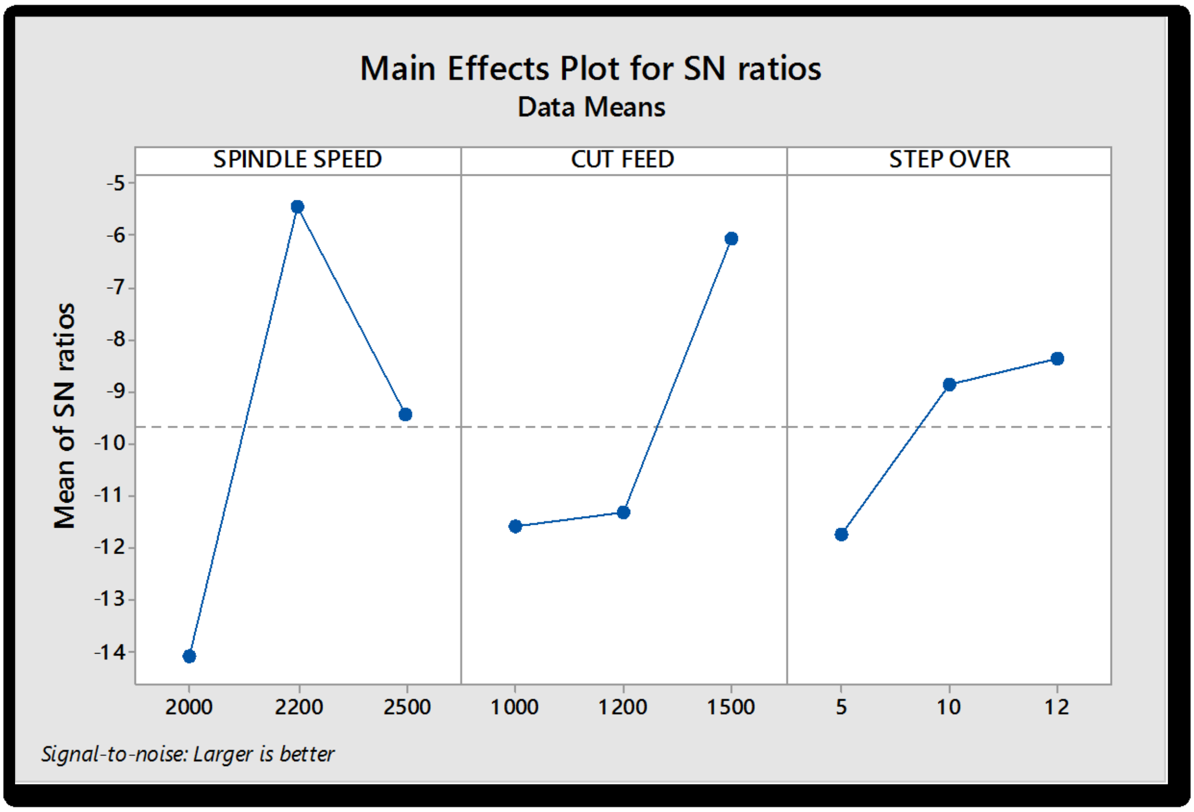
Graph-1 - Effect of milling parameters on surface finish for S/N ratio



Graph-2 - Effect of milling parameters on MRR for S/N ratio

VI.OPTIMIZATION USING REGRESSION ANALYSIS

ROUGHING

Enter Process Parameters Spindle Speed, Cut Feed and Step Over and Results Surface Roughness and MRR in the table.

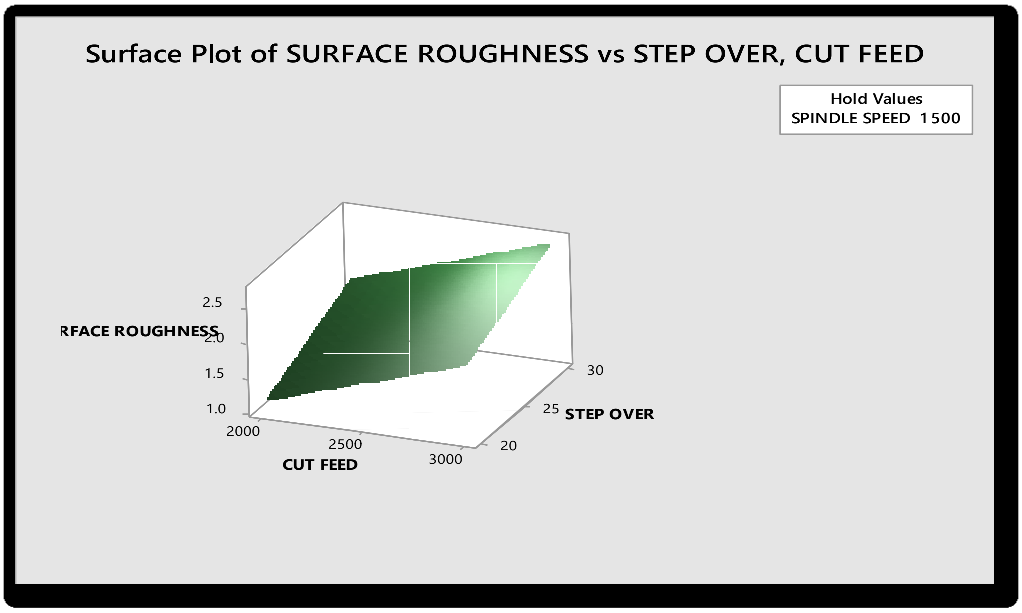
Worksheet 1 ***

↓	C1	C2	C3	C4	C5
	SPINDLE SPEED	CUT FEED	STEP OVER	SURFACE ROUGHNESS	MRR
1	1000	2000	20	0.705	1.512
2	1000	2500	25	1.454	1.723
3	1000	3000	30	2.550	2.050
4	1500	2000	25	1.670	2.470
5	1500	2500	30	2.170	2.780
6	1500	3000	20	2.390	2.690
7	2000	2000	30	2.250	1.940
8	2000	2500	20	1.860	1.850
9	2000	3000	25	2.410	2.880

Fig-10 – Parameters and Responses

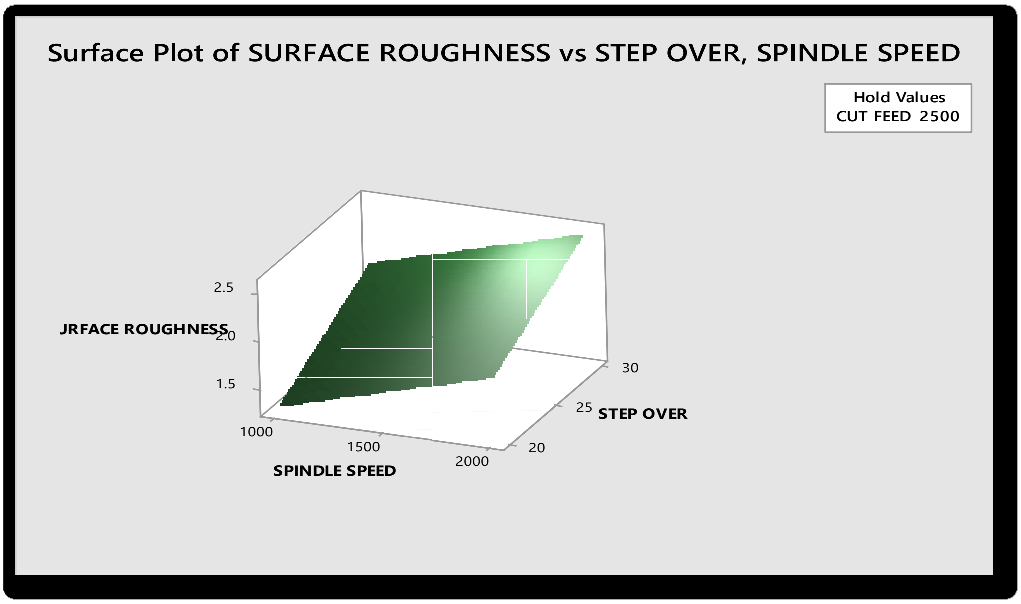
SURFACE ROUGHNESS

The 3D response surface plot may be a graphical illustration of the equation. it's aforethought to grasp the interaction of the variables and find the optimum level of every variable for maximal response.



Graph-3 – Surface Plot of Surface Roughness vs Step over, Cut Feed

By observing above graph, to minimize surface roughness, the Cut Feed should be set at 2000mm/min and Step Over at 20mm.



Graph-4 – Surface Plot of Surface Roughness vs Step over, Spindle Speed

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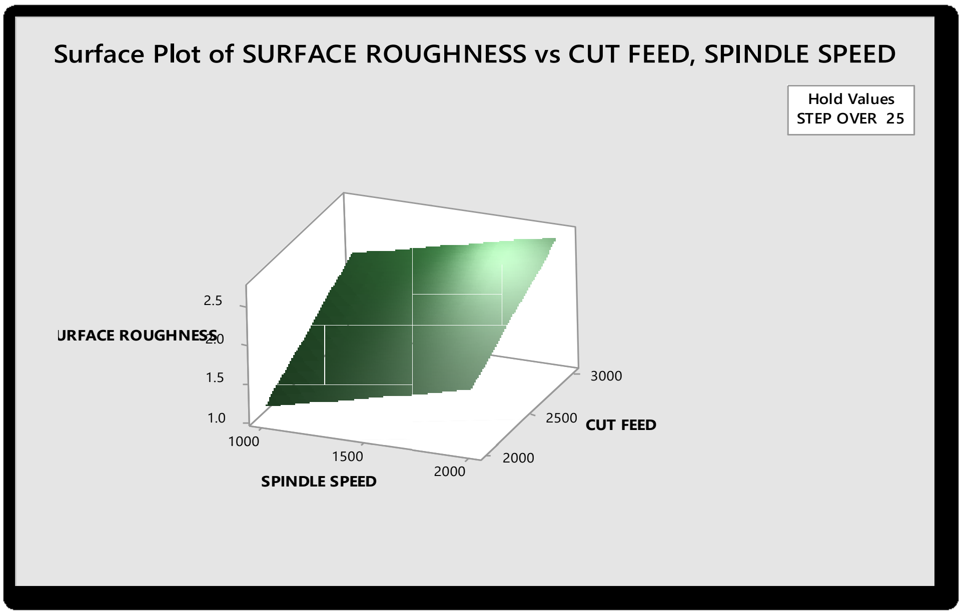
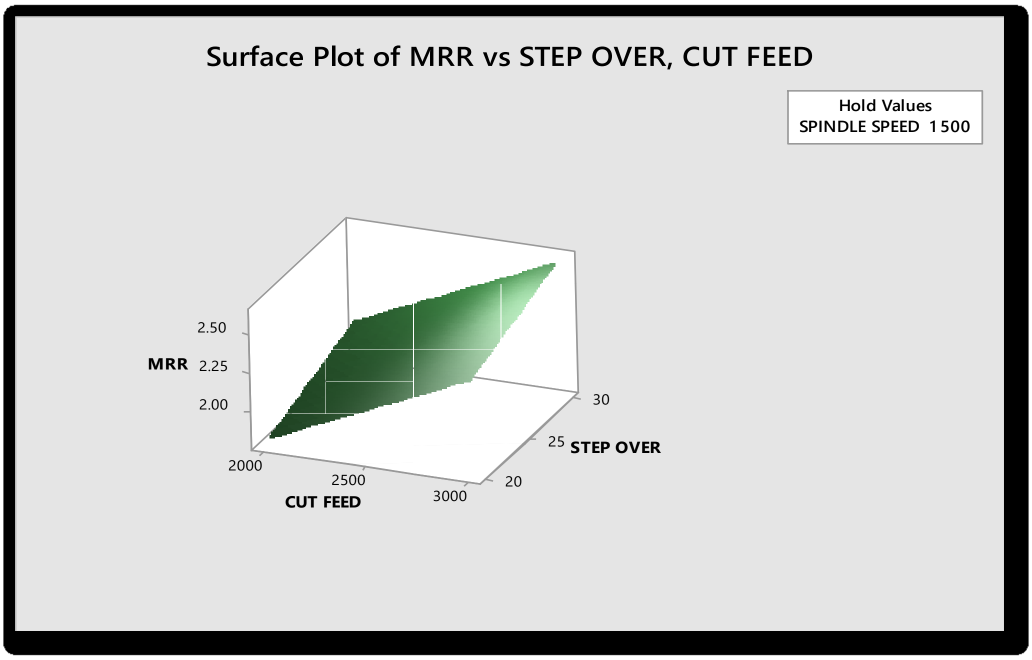
By observing above graph, to minimize surface roughness, the Spindle Speed should be set at 1000rpm and Step Over at 20mm.



Graph-5 – Surface Plot of Surface Roughness vs Cut Feed, Spindle Speed

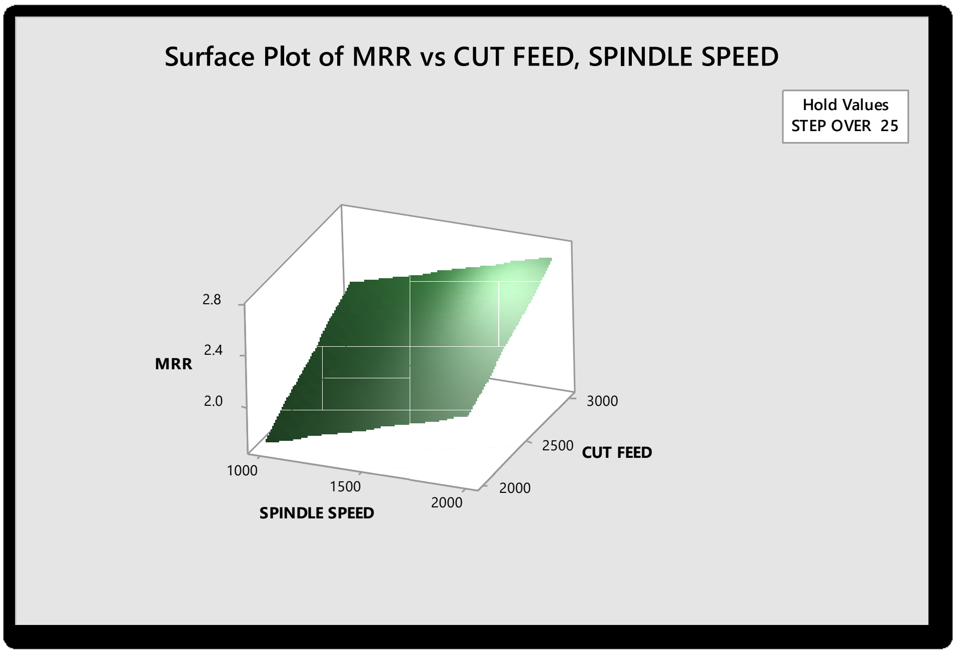
MATERIAL REMOVAL RATE

The 3D response surface plot is a graphical representation of the regression equation. It is plotted to understand the interaction of the variables and locate the optimal level of each variable for maximal response.



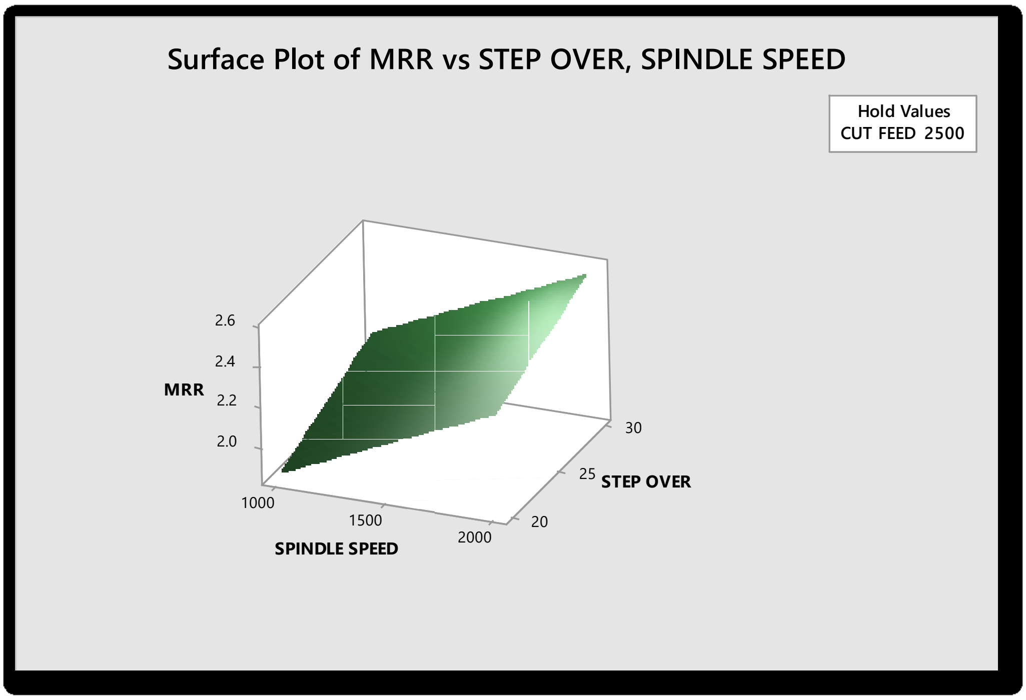
Graph-6 – Surface Plot of Surface Roughness vs Step over, Cut Feed

By observing above graph, to maximize MRR, the Cut Feed should be set at 3000mm/min and Step Over at 30mm.



Graph-7 – Surface Plot of Surface Roughness vs Cut Feed, Spindle Speed

By observing above graph, to maximize MRR, the Cut Feed should be set at 2000mm/min and Spindle Speed at 2000rpm.

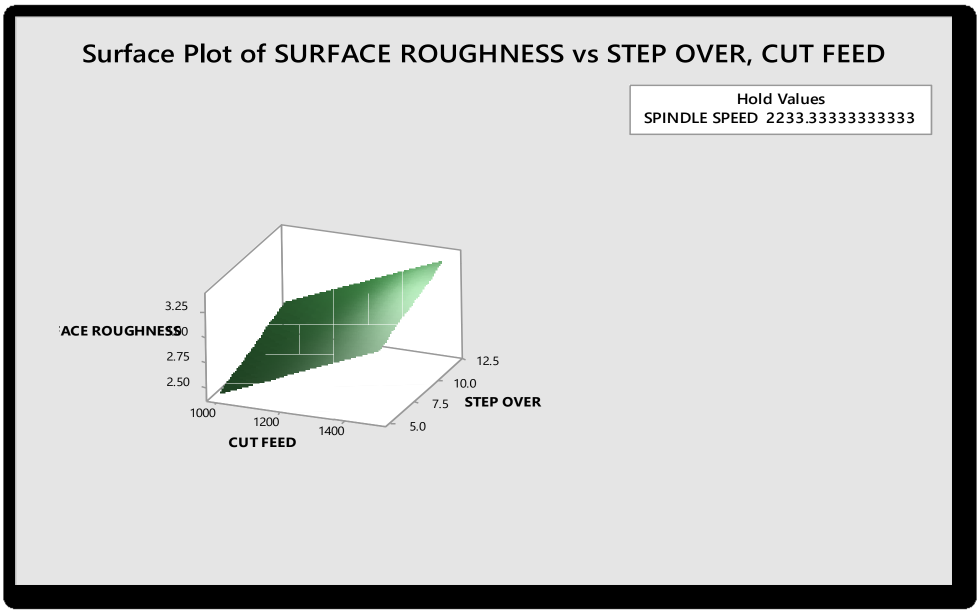


Graph-8 – Surface Plot of Surface Roughness vs Step Over, Spindle Speed

By observing above graph, to maximize MRR, the Step Over should be set at 30mm and Spindle Speed at 2000rpm.

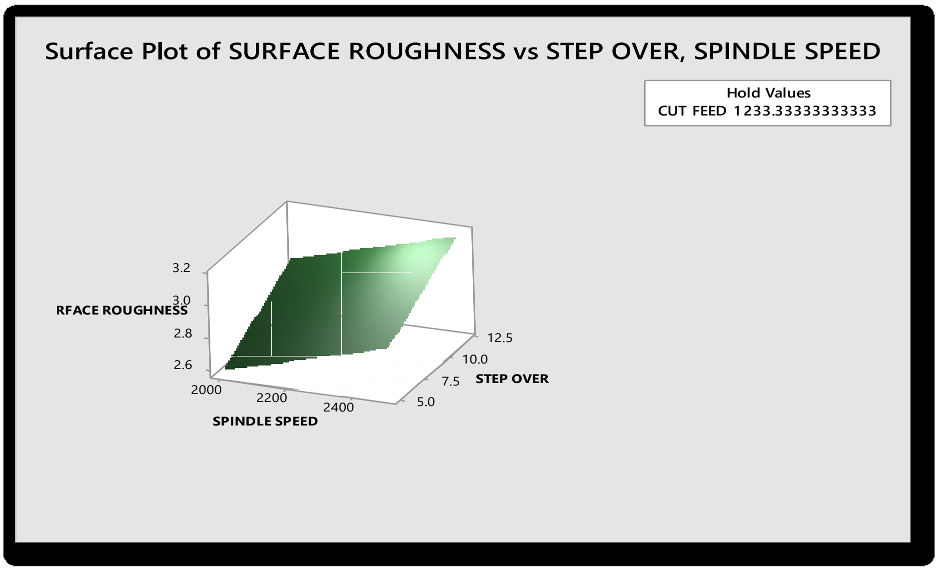
FINISHING

The residual plots indicate that the deterministic portion (predictor variables) of the model Spindle Speed, Cut Feed and Step Over are not capturing some explanatory information that is "leaking" into the residuals. The graph could represent several ways in which the model is not explaining all that is possible.



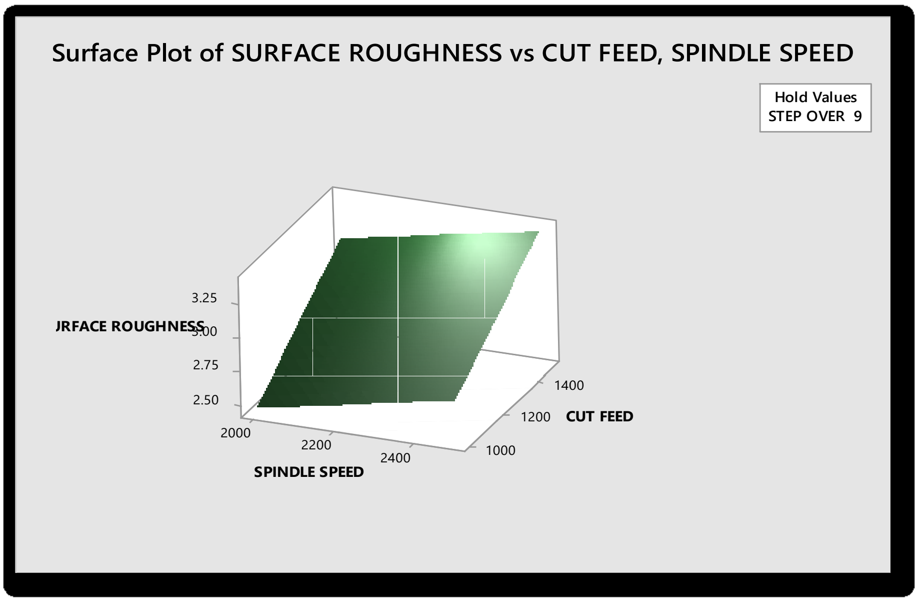
Graph-9 – Surface Plot of Surface Roughness vs Step over, Cut Feed

By observing above graph, to minimize surface roughness, the Cut Feed should be set at 1000mm/min and Step Over at 5mm.



Graph-10 – Surface Plot of Surface Roughness vs Step over, Spindle Speed

By observing above graph, to minimize surface roughness, the Spindle Speed should be set at 2000rpm and Step Over at 5mm.



Graph-11 – Surface Plot of Surface Roughness vs Cut Feed, Spindle Speed

By observing above graph, to minimize surface roughness, the Cut Feed should be set at 1000mm/min and Spindle Speed to 2000rpm.

MATERIAL REMOVAL RATE

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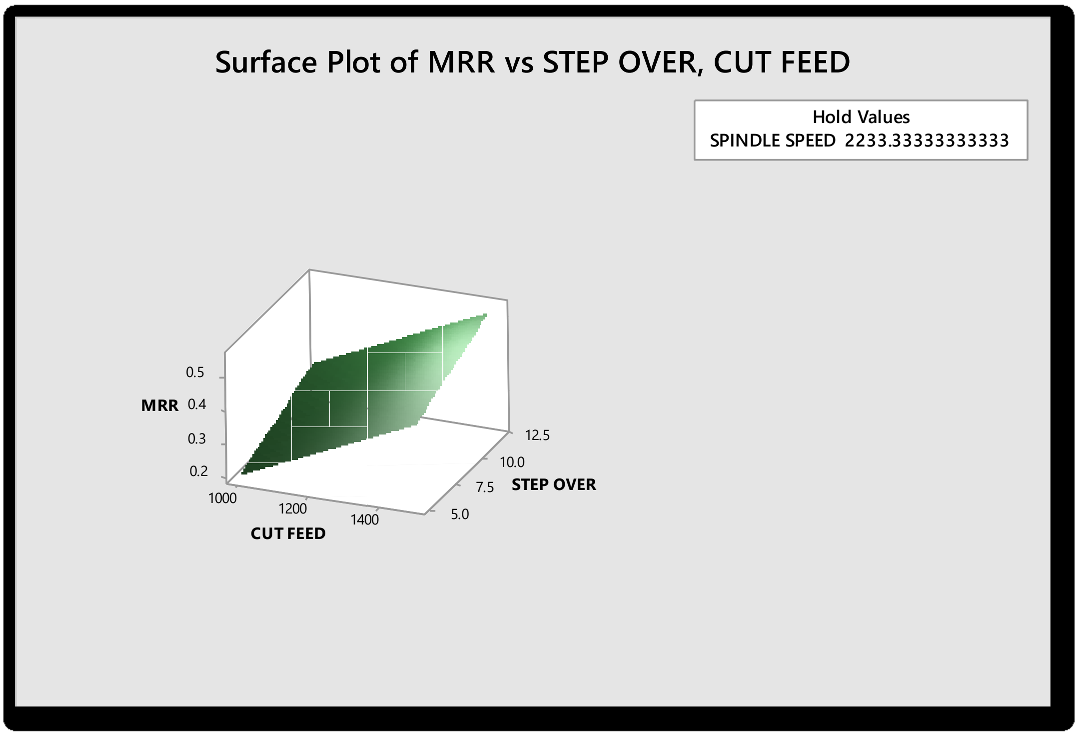
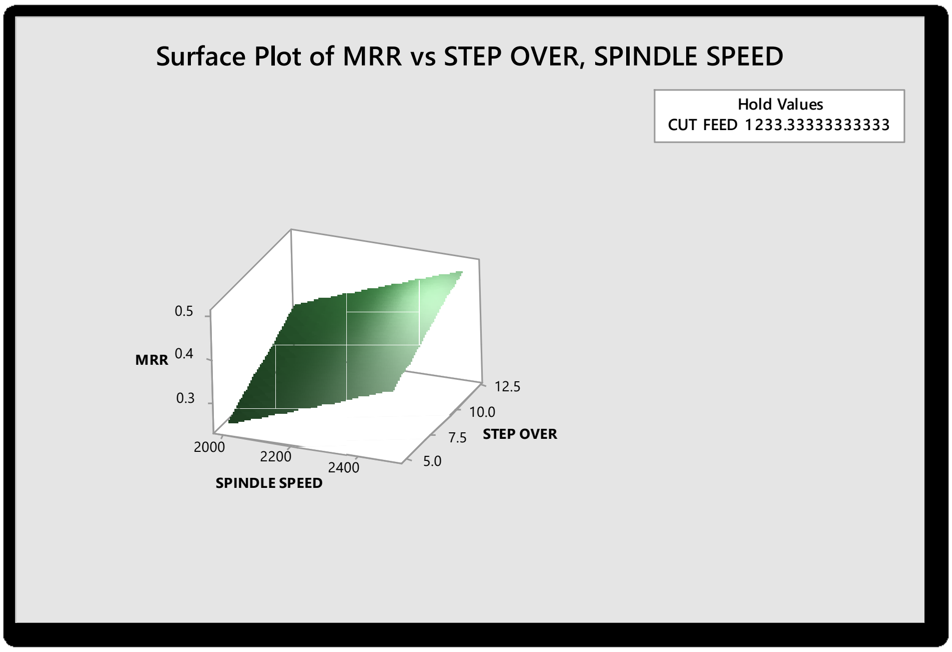


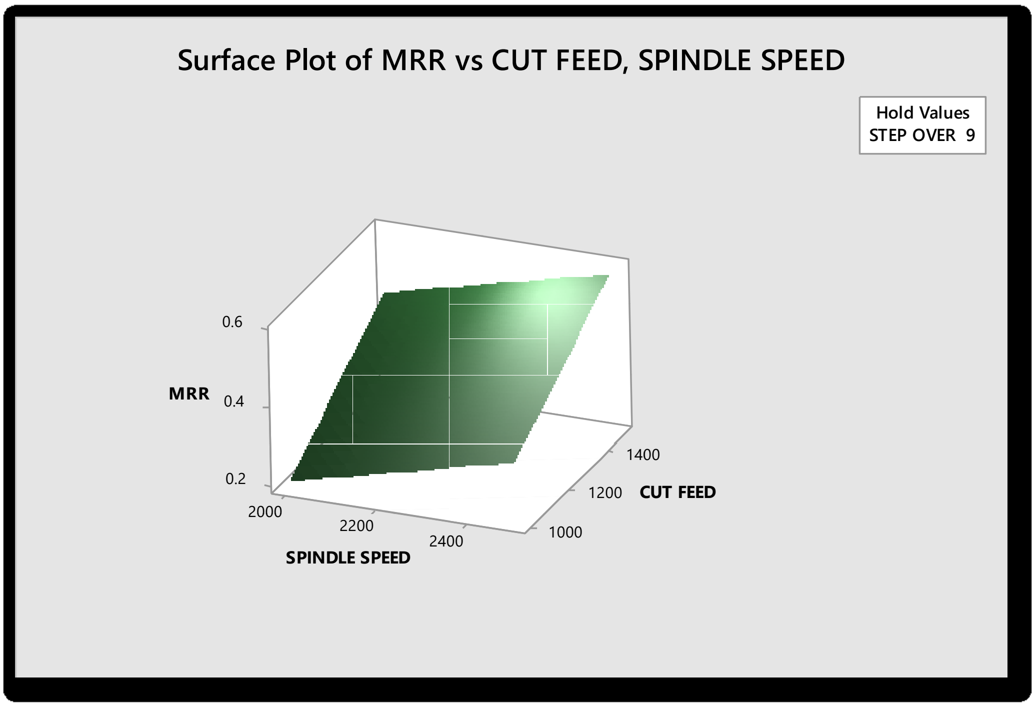
Graph-12 – Surface Plot of MRR vs Step over, Cut Feed

By observing above graph, to maximize MRR, the Cut Feed should be set at 1400mm/min and Step Over at 12.5mm.



Graph-13 – Surface Plot of MRR vs Step over, Spindle Speed

By observing above graph, to maximize MRR, the Step Over should be set at 12.5mm and Spindle Speed at 2400rpm.



Graph-14 – Surface Plot of MRR vs Cut Feed, Spindle Speed

By observing above graph, to maximize MRR, the Cut Feed should be set at 1400mm/min and Spindle Speed at 2400rpm.

CONCLUSION

In this thesis, the parameters spindle speeds, cut feed and step over are optimized determined using Taguchi Method and Regression Analysis.

From the **Taguchi Method,** the following conclusions can be made:

- In roughing operations, to minimize surface roughness, the optimized values are spindle speed 1000 rpm, Cut Feed 2000 mm/min, Step Over 20 mm. To maximize MRR, spindle speed 1500 rpm, Cut Feed 3000 mm/min, Step Over 25 mm.
- In finishing operations, to minimize surface roughness, the optimized values are spindle speed 2000 rpm, Cut Feed 2000 mm/min, Step Over 5 mm. To maximize MRR, spindle speed 2200 rpm, Cut Feed 1500 mm/min, Step Over 12 mm.

From the **Regression Analysis,** the following conclusions can be made:

- In roughing operations, to minimize surface roughness, the optimized values are spindle speed 1000 rpm, Cut Feed 2000 mm/min, Step Over 20 mm. To maximize MRR, spindle speed

2000 rpm, Cut Feed 3000 mm/min, Step Over 30 mm.

- In finishing operations, to minimize surface roughness, the optimized values are spindle speed 2000 rpm, Cut Feed 1000 mm/min, Step Over 5 mm. To maximize MRR, spindle speed 2400 rpm, Cut Feed 1400 mm/min, Step Over 12.5 mm.

REFERENCES

[1] DraženBajić, Luka Celent, Sonja Jozić, Modeling of the influence of cutting parameters on the surface roughness, tool wear and cutting force in face milling, Journal of Mechanical Engineering 58(2012)11, 673-682, DOI:10.5545/sv-jme.2012.456.

[2] B. Sidda Reddy, J. Suresh Kumar, and K. Vijaya Kumar Reddy, Optimization of surface roughness in CNC end milling using response surface methodology and genetic algorithm, International Journal of Engineering, Science and Technology, Journal Home > Vol 3, No 8 (2011)

[3] Yang Yang, Xinyu Li, Ping Jiang, Liping Zhang Prediction of surface roughness in end milling with gene expression programming, Proceedings of the 41st International Conference on Computers & Industrial Engineering

[4] M.S. Sukumar, Optimization and prediction of parameters in face milling of Al-6061 using Taguchi, Procedia Engineering, Volume 97, 2014, Pages 365-371

[5] Liang Gao, Application of Free Pattern Search on the surface roughness prediction in end milling, Evolutionary Computation (CEC), 2012 IEEE Congress, DOI: 10.1109/CEC.2012.6256605

[6] Abdel BadieSharkawy, Surface roughness prediction in end milling process using intelligent systems: A Comparative Study, Applied Computational Intelligence and Soft Computing, Volume 2011 (2011), Article ID 183764, 18 pages

[7] ArunPremnath, Surface Roughness Prediction by Response Surface Methodology in Milling of Hybrid Aluminium Composites, Procedia Engineering, Volume 38, 2012, Pages 745-752

[8] Sukhdev S. Bhogal, Charanjeet Sindhu, Sukhdeep S. Dhami, Minimization of Surface Roughness and Tool Vibration in CNC Milling Operation, Journal of Optimization, Volume 2015 (2015), Article ID 192030, 13 pages

[9] K. Adarsh Kumar, optimization of surface roughness in face turning operation in machining of EN-8, Volumes/2012_Vol_02_Iss_04/IJESAT_2012_02_04_06

[10] H. K. Dave, S. Patel, h. K. Raval, Effect of machining conditions on MRR and surface roughness during CNC turning of different materials, International Journal of Industrial Engineering Computations, ISSN 1923-2934 (Online) - Volume 3 Issue 5 pp. 925-930 , 2012

[11] P. Sam Paul , A.S. Varadarajan , R. Robinson Gnanadurai , Study on the influence of fluid application parameters on tool vibration and cutting performance during turning of hardened steel, International Journal of Engineering Science and Technology, 19 (2016) 241–253.