Gujarat Technical University

Smt. S. R. PATEL ENGINEERING COLLEGE

Multi-Response Optimization of Turning parameters using Gray Relational Analysis on Al alloy

Under The Valuable Guidance of
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Content

Introduction

- Quality and productivity are two important but conflicting criteria in any machining operations. In order to ensure high productivity, extent of quality is to be compromised. It is, therefore, essential to optimize quality and productivity simultaneously.
- Productivity can be interpreted in terms of material removal rate in the machining operation and quality represents satisfactory yield in terms of product characteristics as desired by the customers.
- Dimensional accuracy, form stability, surface smoothness, fulfilment of functional requirements in prescribed area of application etc. are important quality attributes of the product.

Cont.…

- Increase in productivity results in reduction in machining time which may result in quality loss. On the contrary, an improvement in quality results in increasing machining time there by, reducing productivity. Therefore, there is a need to optimize quality as well as productivity.

- Optimizing a single response may yield positively in some aspects but it may affect adversely in other aspects. The problem can be overcome if multiple objectives are optimized simultaneously.

Project definition

- It is therefore required to maximize material removal rate (MRR), and surface roughness to improve product quality simultaneously by selecting an appropriate (optimal) process environment. Hence, we are planning multi-objective optimization philosophy based on Taguchi method applied in turning operation.

Objectives of the Present Investigation

- To conduct experiments in turning process using Taguchi L_9 single level orthogonal array design under coolant on and the coolant off condition.

- Study on the effect of process parameters on turning performance, which is measured in terms of material removal rate and surface roughness.

- Design of experiment and statistical methods have been performed for analysis, prediction and optimization.

- To determine the optimum machining parameters in order to obtain desired surface roughness and higher MRR.

- To analyze analysis of variance and GRA whether the selected parameters value is correct or not.

Taguchi Method

- Taguchi’s philosophy, developed by Dr. Genichi Taguchi, is an efficient tool for the design of high quality manufacturing system which gives minimum no. Of experiments to be performed.

- Taguchi’s Orthogonal Array (OA) provides a set of well-balanced experiments (with less number of experimental runs), and Taguchi’s signal-to-noise ratios (S/N), which are logarithmic functions of desired output; serve as objective functions in the optimization process.

- Taguchi method uses a statistical measure of performance called signal-to-noise ratio. The S/N ratio takes both the mean and the variability into account. The S/N ratio is the ratio of the mean (Signal) to the standard deviation (Noise).

- Taguchi method Traditional experimental design methods are very complicated and difficult to use. Additionally, these methods require a large number of experiments when the number of process parameters increases.

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- In order to minimize the number of tests required, Taguchi experimental design method, a powerful tool for designing high-quality system, was developed by Taguchi. This method uses a design of orthogonal arrays to study the entire parameter space with small number of experiments only.
- The Taguchi Method is applied in four steps.

1. Brainstorm the quality characteristics and design parameters important to the product/process.
2. Design and conduct the experiments.
3. Analyse the results to determine the optimum conditions.
4. Run a confirmatory test using the optimum conditions.

Advantages

1. The main advantage of using Taguchi method is that it gives more importance to the mean performance characteristic value which is very close to the target value than the value within a definite specification limits, thus improves the quality of the product.
2. Taguchi's method is a powerful simple tool and easy to apply to many engineering processes for experimental design.
3. The Taguchi method is used to narrow down the scope of a research project or to know the problems in a manufacturing process from existence data.

Literature reviews

Literature Review

[1]

Sr.	Title	Investigator	Remarks
1	Experimental investigation of Material removal rate in CNC turning using Taguchi method.	Kamal Hassana, Anish Kumar, M.P.Garg	The Material removal rate is mainly affected by cutting speed and feed rate. With the increase in cutting speed the material removal rate is increases & as the feed rate increases the material removal rate is increases.

Literature Review

[2]

Sr.	Title	Investigator	Remarks
2	Optimization of Machining Parameters for Turning using Taguchi Approach	Anand S.Shivade, Shivraj Bhagat, Suraj Jagdale, Amit Nikam, Pramod londhe	This paper presents the application of single characteristics optimization approaches for turning processes. These approaches utilized in many fields to optimize the single and multi performance characteristics efficiently.

Literature Review

[3]

Sr.	Title	Investigator	Remarks
3	Analysis of Influence of Turning Process Parameters on MRR & Surface Roughness Of AA7075 Using Taguchi's Method and Rsm	S.V.Alagarsamy, N.Rajakumar	In the study, the Taguchi method and Response surface methodology was applied for analyzing to get a minimum surface roughness and maximum material removal rate for turning process of Aluminum Alloy 7075 using CNC machine via considering three influencing input parameters- Speed, Feed and Depth of Cut.

Literature Review

[4]

Sr.	Title	Investigator	Remarks
4	Optimization of cutting parameters in multipacks turning operation using ant colony algorithm	Vaibhav B. Pansare, Mukund V. Kavade	In this work, non-conventional method of optimization ACO was studied. ACO is used to find optimum cutting parameters in turning operation. It requires less number of iteration to reach to optimal solution. It can be used for other machining process like milling, drilling etc.

Literature Review

[5]

Sr.	Title	Investigator	Remarks
5	Influence of cutting parameters on cutting force and surface finish in turning operation	Dr. C. J. Raoa , Dr. D. Nageswara Raob, P. Sriharic	The feed rate has significant influence on both the cutting force and surface roughness. Cutting Speed has no significant effect on the cutting force as well as the surface roughness. Depth of cut has a significant influence on cutting force, but has an insignificant influence on surface roughness.

Literature Review

[6]

Sr.	Title	Investigator	Remarks
6	Parametric Optimization for Improved Tool Life and Surface Finish in Micro Turning using Genetic Algorithm	M. Durairaja, S. Gowri	In this study, statistical modeling and optimization of process parameters has been done using the multi objective genetic algorithm to obtain the optimized cutting conditions for both surface roughness and tool wear.

Literature Review

[7]

Sr.	Title	Investigator	Remarks
7	Optimisation of machining parameters for turning operations based on response surface methodology	Ashvin J. Makadia , J.I. Nanavati b	For the surface roughness, the feed rate is the main influencing factor on the roughness, followed by the tool nose radius and cutting speed. Depths of cut have no significant effect on the surface roughness

Literature Review

[8]

Sr.	Title	Investigator	Remarks
8	optimizing surface roughness in turning operation using taguchi technique and anova	H.M.somashekara	This research gives us how to use Taguchi’s parameter design to obtain optimum condition with lowest cost, minimum number of experiments and Industrial Engineers can use this method.

Literature Review

[9]

Sr.	Title	Investigator	Remarks
9	Experimental study on the effect of cutting parameters on surface finish obtained in cnc turning operation	B.tulasiramarao, Dr.k.srinivas,Dr. p ram reddy, A.raveenda, Dr.b.v.r.ravi kumar	We have arrived on a conclusion that the minimum surface roughness in stainless steel is obtained when the Spindle speed is (1200 rpm approx.), Depth of cut and Feed Rate are minimum (i.e 0.2 mm and 0.15 mm respectively). In case of aluminum the minimum surface is obtained when the spindle speed is (800 rpm approx), Depth of cut and Feed Rate are minimum (i.e 0.3 mm and 0.15 respectively).

Literature Review

[10]

Sr.	Title	Investigator	Remarks
10	Multi-objective optimization of the cutting forces in turning operations using the grey-based taguchi method	Yigit Kazancoglu, Ugur Esme, Melih Bayramo glu, Onur Guven	A grey relational analysis of the material-removal rate, the cutting force and the surface roughness obtained from the Taguchi method reduced from the multiple performance characteristics to a single performance characteristic which is called the grey relational grade. Therefore, the optimization of the complicated multiple performance characteristics of the processes can be greatly simplified using the Grey-based taguchi method

Literature Review

[11]

Sr.	Title	Investigator	Remarks
11	Multi-Objective Optimization of Machining Parameters During Dry Turning of AISI 304 Austenitic Stainless Steel Using Grey Relational Analysis	Shreemoy Kumar Nayak, Jatin Kumar Patro, Shailesh Dewangan.	The current study aims at investigating the influence of different machining parameters such as cutting speed (Vc), feed (f) and depth of cut (t). The recommended parametric combination based on the studied performance criteria (i.e. MRR, Fc and Ra) was found to be Vc =45m/min, f=0.1mm/rev, t=1.25mm. A confirmatory test was also carried out to support the analysis and an improvement of 88.78% in grey relational grade (GRG) was observed

Literature Review

[12]

Sr.	Title	Investigator	Remarks
12	Optimization of Machining Parameters for End Milling of Inconel 718 Super Alloy Using Taguchi Based Grey Relational Analysis	Lohithaksha M Maiyara, Dr.R.Ramanujamb, K.Venkatesanc, Dr.J.Jeraldd.	This study investigated the parameter optimization of end milling operation for Income 718 super alloy with multi-response criteria based on the taguchi orthogonal array with the grey relational analysis. Nine experimental runs based on an L9 orthogonal array of Taguchi method were performed. Cutting speed, feed rate and depth of cut are optimized with considerations of multiple performance characteristics namely surface roughness and material removal rate.

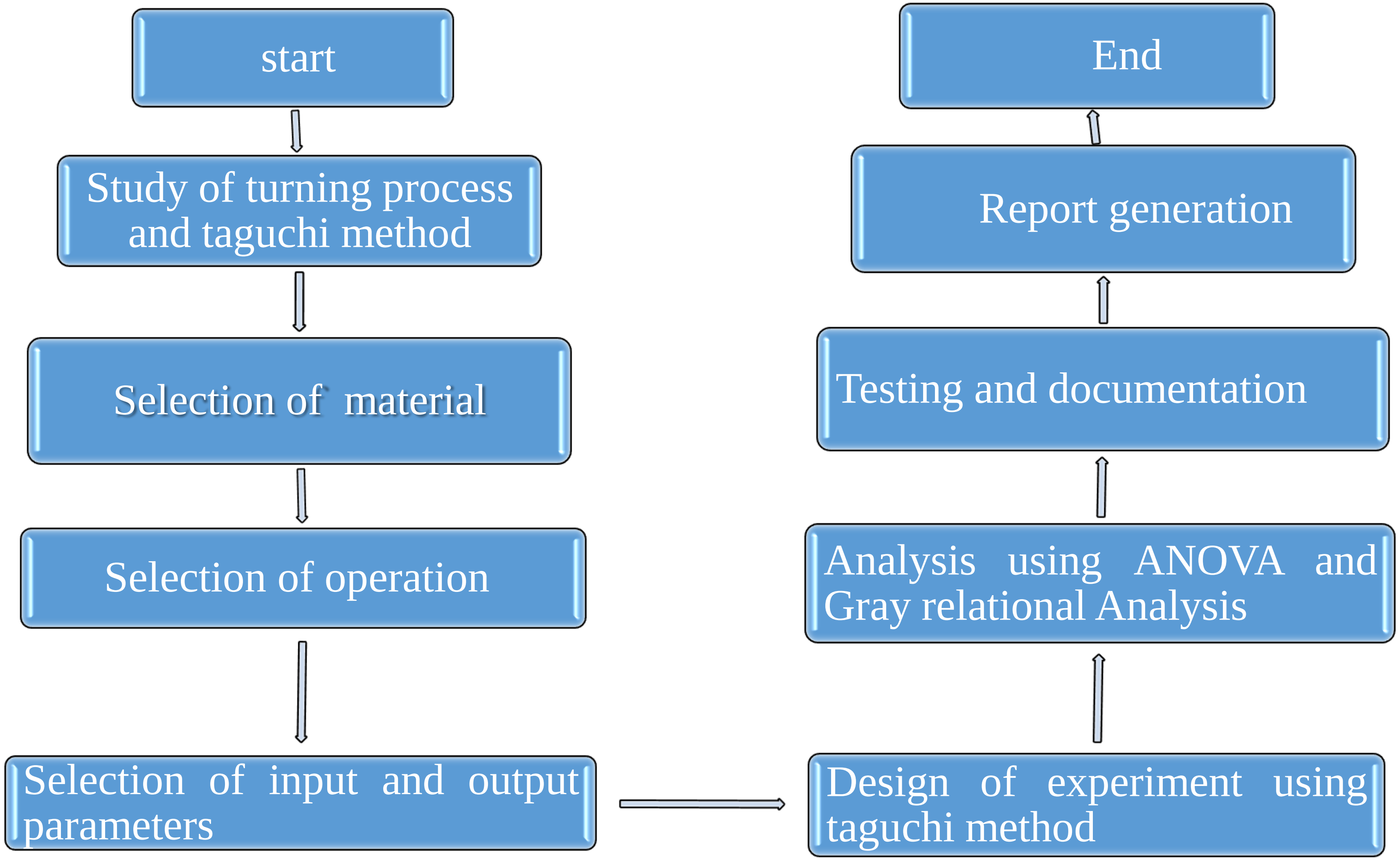
Literature Review Conclusion

- The Material removal rate is mainly affected by cutting speed and feed rate.
- The surface roughness is mainly affected by feed rate but no more effect on depth of cut.
- Taguchi method and surface response method is best suited for al alloy.
- Taguchi method give lowest cost, minimum number of experiments and Industrial Engineers can use this method compare with other.

Work flow

7th sem

8th sem



Work plan for project work

	July	August	Sept.	October	November	January	Feb.	March
1.Definition of project								
2.Literature review								
3.Selection of material								
4.selection of Input Parameters and output parameters								
5. Experimentation on conventional lathe								
6. Design of experiment using tag chi method								
7. Analysis using ANOVA and GRA								
8. report generation								

Selection of material

TURNING MATERIAL

- In turning, the raw form of the material is a piece of stock from which the work pieces are cut. This stock is available in a variety of shapes such as solid cylindrical bars and hollow tubes.
- Common materials that are used in turning include aluminum, brass, magnesium, nickel, steel, thermoplastics, titanium and zinc.
- Results in a good surface finish.
- Promotes long tool life.
- Requires low force and power to turn.

Cont…

- **Aluminum Alloy (6063)**

- Aluminum is a soft, lightweight, malleable metal with appearance ranging from silvery to dull gray, depending on the surface roughness. It is ductile, and easily machined, cast, and extruded.

- Aluminum alloy 6063 is a medium strength alloy commonly referred to as an architectural alloy.

- Aluminum alloy 6063 is typically used in:

- Architectural applications.

Experimentation

- The experiment is performed on AL-6063 work piece of cross section 38mm diameter and 475mm length. The cutting tool for turning process in AL-6063 work piece is cobalt bonded cemented carbide tool have been used for experiment. The different sets of turning experiments are performed using a lathe machine.

Experimental details

- Al alloy (6063) of Ø: 38 mm, length: 475 mm were used for the turning experiments in the present study.

- MACHING PARAMETERS

  Input parameter

  Feed
  Depth of cut
  Speed

  Output parameter

  Material removal rate
  Surface roughness

Taguchi Design and formula

Taguchi Orthogonal Array Design
L9(3**3)
Factors: 3
Runs: 9
Columns of L9(3**4) Array
1 2 3

- **Calculation of material removal rate**

MRR= (1000*f*D*N) /60 mm^3/min

Where, f = Feed rate in mm/rev,
D = Depth of cut in mm
N= Speed in m/min,

Al bar after experiment

Experimental result

Sr no	Speed(rpm)	Speed(mm/min)	Feed Rate(mm/rev)	Depth of cut(mm)	MRR(mm^3/min)	Surface roughness(μm)
1	625	74.61	0.5	1	621.75	2.222
2	625	74.61	0.7	2	1740.90	2.196
3	625	74.61	0.9	3	3339.45	1.754
4	720	85.95	0.5	2	1432.50	1.625
5	720	85.95	0.7	3	3008.25	2.772
6	720	85.95	0.9	1	1289.25	2.600
7	800	95.50	0.5	3	2387.50	3.343
8	800	95.50	0.7	1	1114.56	3.723
9	800	95.50	0.9	2	2865.00	6.784

Data analysis by Anova

Analysis of variance (ANOVA) is the most powerful conventional tool to identify the main and interaction effects. ANOVA is a used as a tool to divide the total variation in sub category the data into usable and meaningful component of variation. In compare to orthogonal array experiments, ANOVA is a tool used to sub-divide the total variation into following categories such as variation caused by main effect, variation caused by interaction effects and variation caused by error. So, mathematically, we can write total variation as the following way,

Total variation=V_m +V_i +V_e

Where

V_m= variation caused by main effect,

V_i= variation caused by interaction effective Error variation. (Antony and Kaye; 2000)

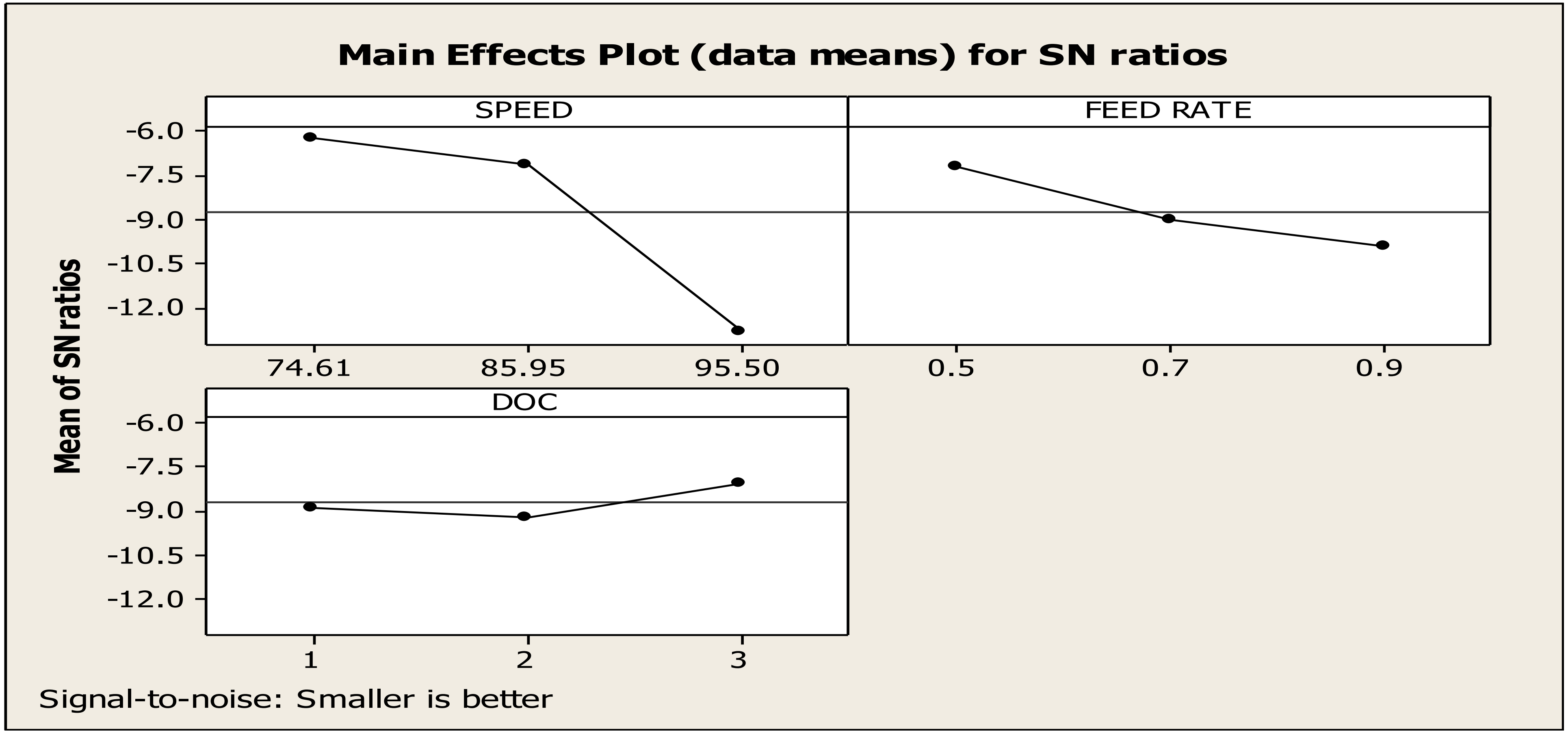
ANOVA Table for MRR

Source	DF	Sum of squre	ss/Total ss	% Value
Speed	2	94311	0.0129	1.29
Feed	2	1554804	0.2134	21.34
Depth of cut	2	5438880	0.7468	74.68
Error	2	194530	0.02671	2.671
Total	8	7282525		

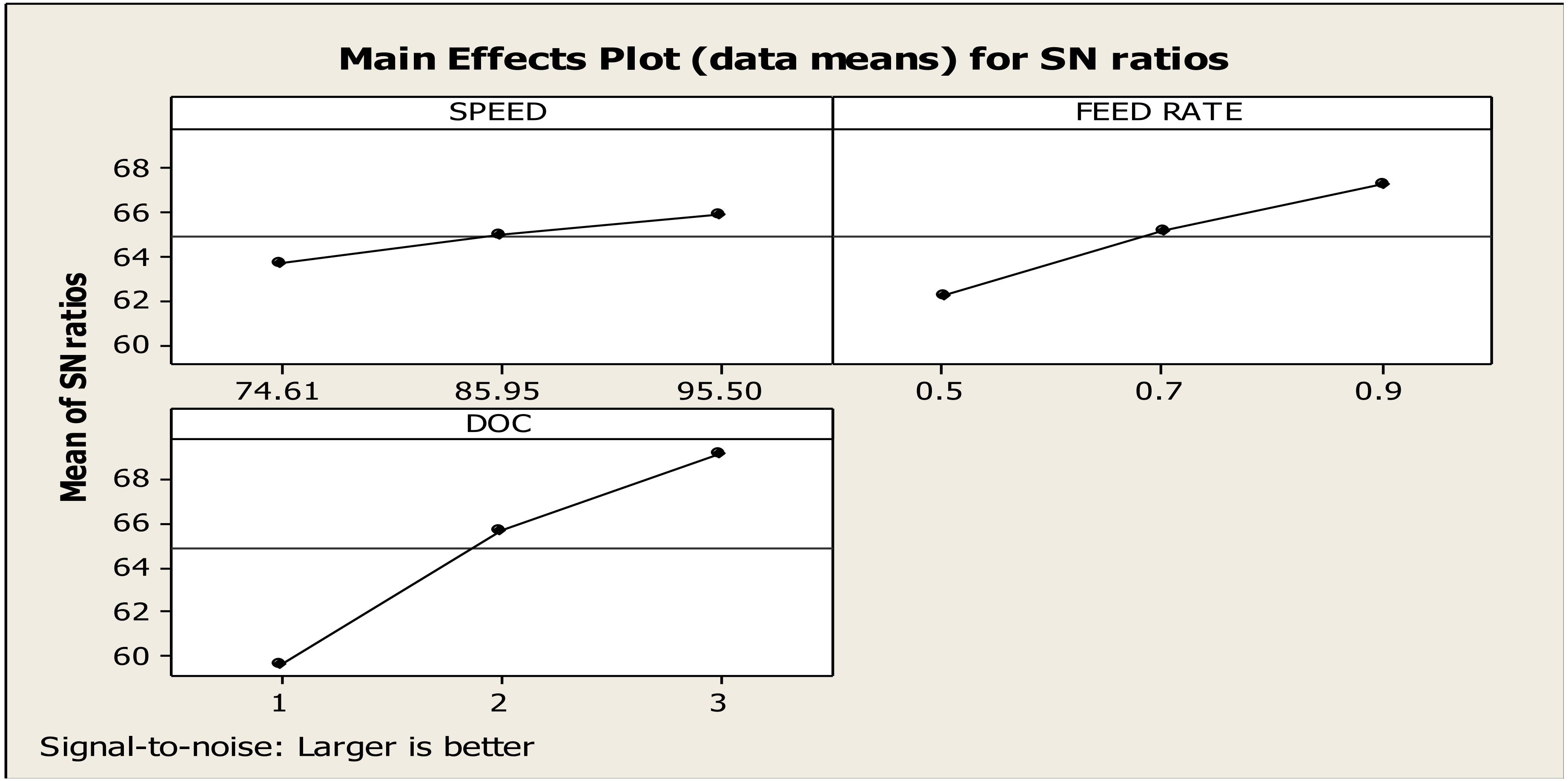
ANOVA Table for surface roughness

Source	DF	Sum of squre	Ss/Total ss	% Value
Speed	2	11.844	0.5955	59.55
Feed	2	2.648	0.1349	13.49
Depth of cut	2	1.354	0.06815	6.815
Error	2	4.020	0.2023	20.23
Total	8	19.866.		

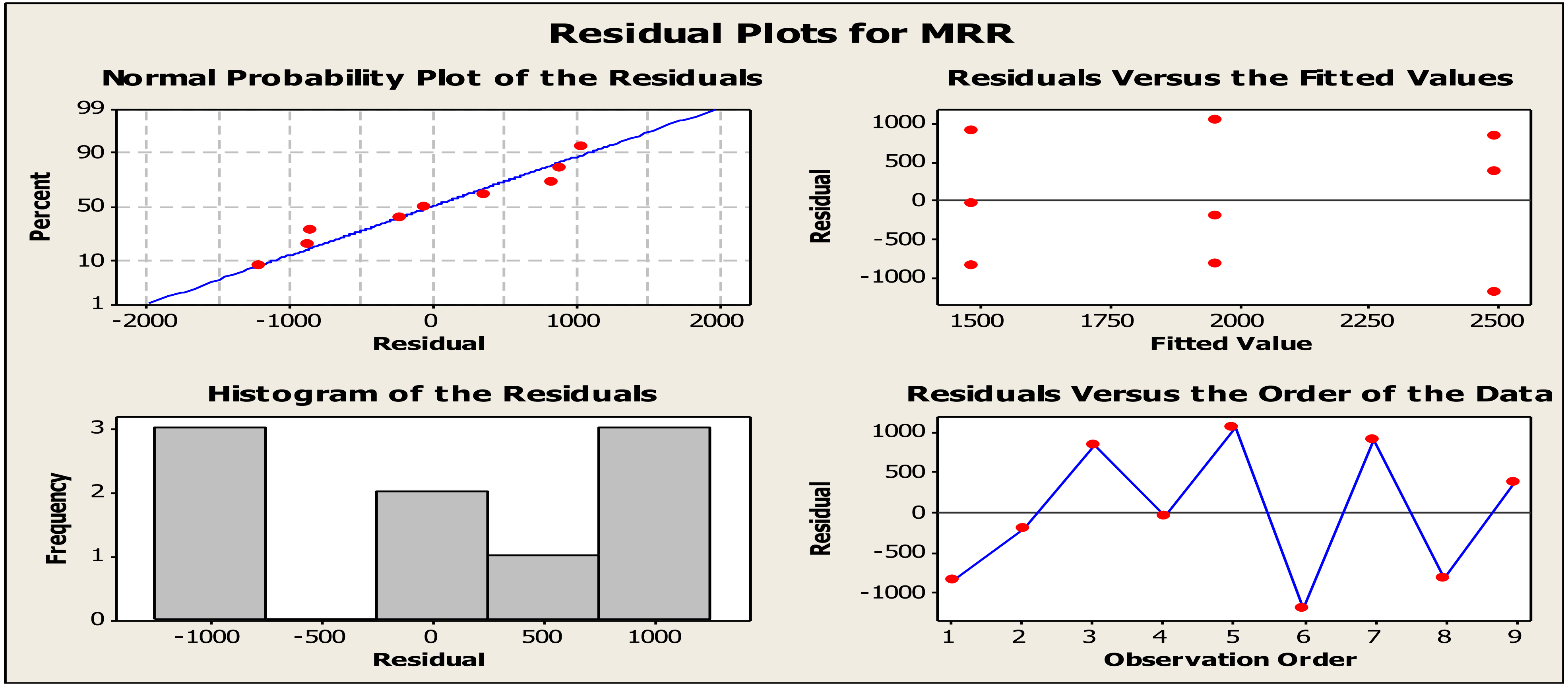
Main Effect Plot for S/N Ratio of Ra



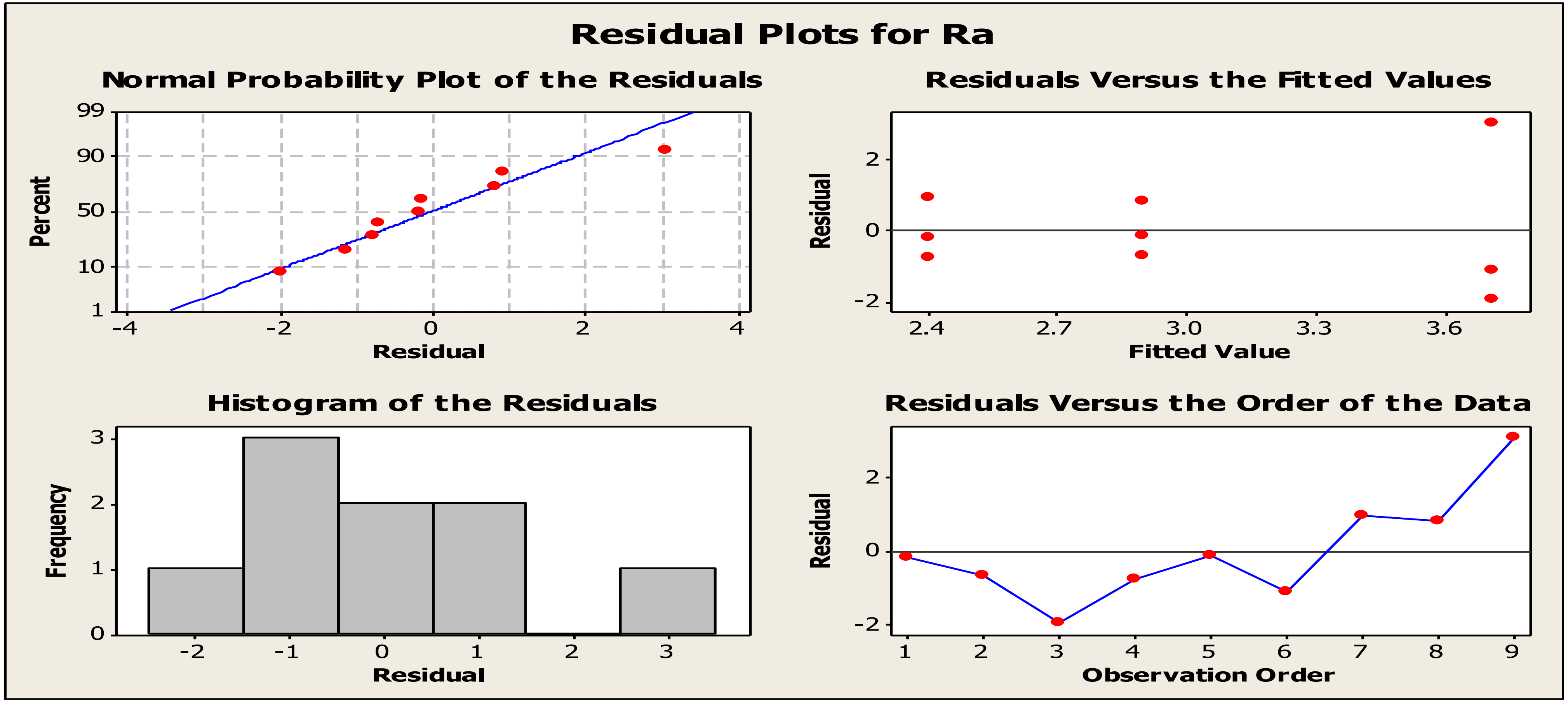
Main Effect Plot for S/N Ratio of MRR



Residual plots of ANOVA for MRR



Residual plots for surface Roughness



Gray Relational Analysis

- Grey relational analysis is used to solve interrelationships among the multiple responses. It was introduced by Deng [5]. In this approach a grey relational grade is obtained for analyzing the relational degree of the multiple responses. Lin et al. (2002) have attempt grey relational based approach to solve multi-response problems in the Taguchi method. The first step in the grey relational analysis is to pre process data in order to normalize the raw data for the analysis. This process is knows is grey relational generation. In the present study a linear normalization of the experimental result for the surface roughness and MRR were performed in range between 0 to 1.

- This the equestion used for S/N ration with larger the better case and smaller the better case respectively.

Cont…

$$Z_{ij} = \frac{y_{ij} - min.(y_{ij}, i=1,2,....n)}{max(y_{ij}, i=1,2,....n) - min\ (y_{ij}, i=1,2....)} \qquad Z_{ij} = \frac{max.(y_{ij}, i=1,2,....n) - y_{ij}}{max(y_{ij}, i=1,2,....n) - min\ (y_{ij}, i=1,2....)}$$

➢ The following steps are followed in GRA:

- Experimental data are normalised in the range between zero and one.
- Next, the grey relational coefficient is calculated from the normalised experimental data to express the relationship between the ideal (best) and the actual experimental data.
- Grey relational grade is then computed by averaging the weighted grey relational coefficients corresponding to each performance characteristic.
- Statistical analysis of variance (ANOVA) is performed for the input parameters with the GRG and the parameters significantly affecting the process are found out.
- Optimal levels of process parameters are then chosen.

Normalized value of MRR and Ra

S.NO	Surface roughness(μm)	MRR(mm^3/min)	Normalized- MRR	Normalized-Ra
1	2.222	621.75	0	0.8842
2	2.196	1740.9	0.4118	0.8893
3	1.754	3339.45	1	0.9749
4	1.625	1432.5	0.2983	1
5	2.772	3008.25	0.8781	0.7776
6	2.6	1289.25	0.2456	0.811
7	3.343	2387.5	0.6497	0.6669
8	3.723	1114.56	0.1813	0.5933
9	6.784	2865	0.8254	0

Deviation sequence of MRR and Roughness

S.NO	Normalized- MRR	Normalized-Ra	Δ- MRR	Δ -Ra
1	0	0.8842	1	0.1158
2	0.4118	0.8893	0.5882	0.1107
3	1	0.9749	0	0.0251
4	0.2983	1	0.7017	0
5	0.8781	0.7776	0.1219	0.2224
6	0.2456	0.811	0.7544	0.189
7	0.6497	0.6669	0.3503	0.3331
8	0.1813	0.5933	0.8187	0.4067
9	0.8254	0	0.1746	1

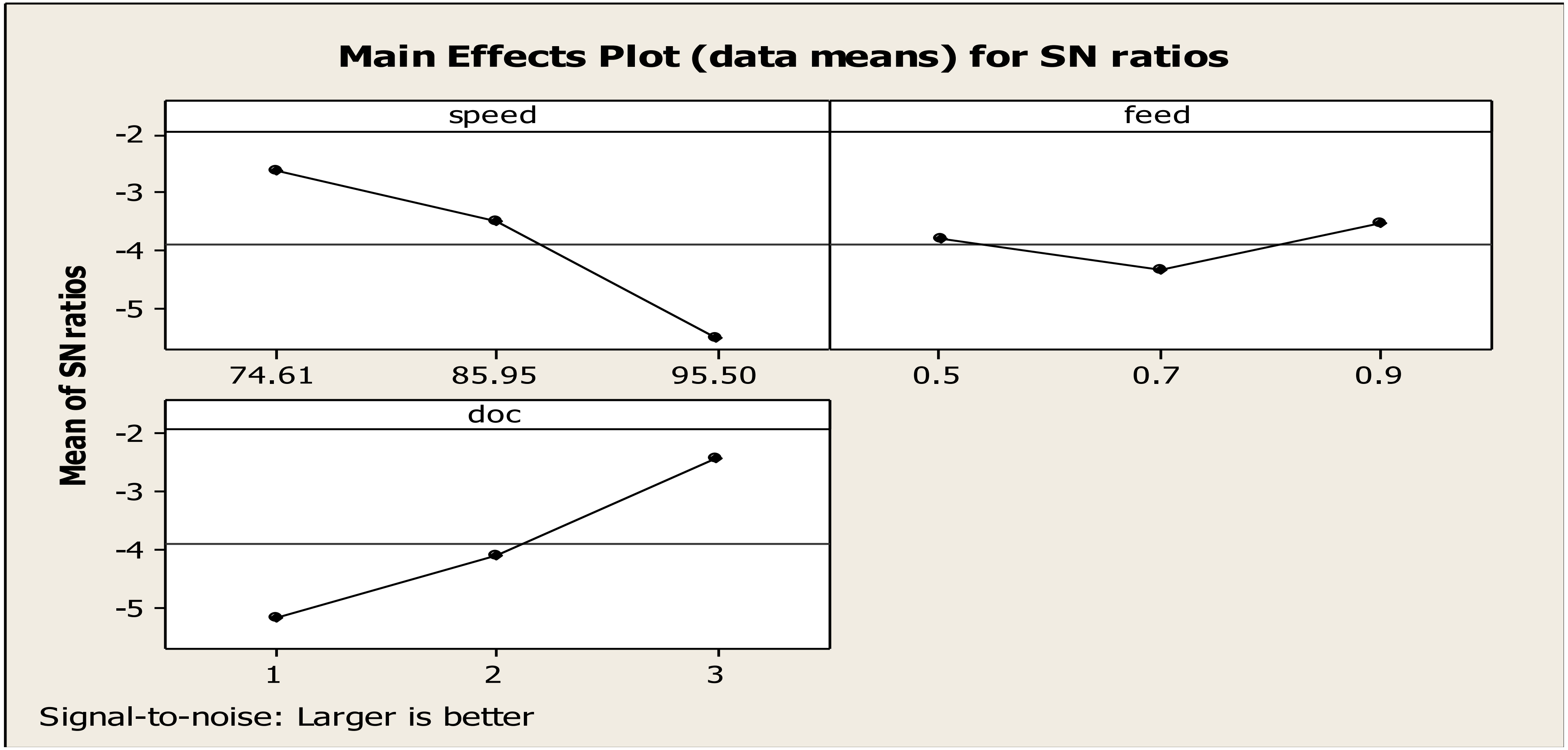
GRC,GRG and Rank

S.NO	GRC MRR	GRC Ra	GRG	RANK
1	0.4761	0.8119	0.644	4
2	0.4607	0.8187	0.6397	5
3	1	0.9521	0.97605	1
4	0.416	1	0.708	3
5	0.8039	0.6921	0.748	2
6	0.3985	0.7256	0.56205	7
7	0.588	0.6	0.594	6
8	0.3791	0.5514	0.46525	9
9	0.7411	0.3333	0.5372	8

ANOVA Table for Gray relational grade

Source	DF	Sum of squre	Ss/Total ss	% Value
Speed	2	13.137	0.4739	47.39
Feed	2	1.042	0.0375	3.75
Depth of cut	2	11.436	0.4125	41.25
Error	2	2.107	0.0760	7.600
Total	8	.27.721		

Main Effect Plot for S/N Ratio of GRG



Optimal level factor for responses

- The optimal factor levels obtain from main effects plot of S/N Ratio of MRR.

S.NO	FACTOR	OPTIMUM LEVEL	OPTIMUM VALUE
1	SPEED (m/min)	3	95.50
2	FEED (mm/rev)	3	0.9
3	DEPTH OF CUT (mm)	3	3

Cont…..

- The optimal factor levels obtain from main effects plot of S/N Ratio of surface roughness.

S.NO	FACTOR	OPTIMUM LEVEL	OPTIMUM VALUE
1	SPEED (m/min)	1	74.61
2	FEED (mm/rev)	1	0.5
3	DEPTH OF CUT (mm)	3	3

Cont…..

- The optimal factor levels obtain from main effects plot of S/N Ratio of Gray relational grade..

S.NO	FACTOR	OPTIMUM LEVEL	OPTIMUM VALUE
1	SPEED (m/min)	1	74.61
2	FEED (mm/rev)	3	0.9
3	DEPTH OF CUT (mm)	3	3

Conclusion

- In this study the optimization of turning parameters with multiple performance characteristics (high MRR and minimum Ra) for the machining of Al-6063 was carried out.

- In case of MRR, it was found that the Coolant employment “off” spindle speed with 95.50 m/min , 0.9 mm/rev of feed rate and 3mm Depth of cut can reach the maximum value of MRR. Feed rate and depth of cut are main affecting parameters of MRR.

- In case of surface roughness it was found that the spindle speed with 74.61 m/min , 0.5 mm/rev of feed rate and 3mm Depth of cut can reach the minimum value of surface roughness. Feed rate is main affecting parameters of surface roughness.

- It is found that the multi performance characteristics of the turning process such as MRR improved together by this approach

References

1. Kamal Hassana, Anish Kumar, M.P.Garg, "Experimental investigation of Material removal rate in CNC turning using Taguchi method" Vol. 2, Issue 2,Mar-Apr 2012

2. Anand S.Shivade, Shivraj Bhagat, Suraj Jagdale, Amit Nikam, Pramod londhe , "Optimization of Machining Parameters for Turning using Taguchi Approach" ISSN: 2277-3878, Volume-3, Issue-1, March 2014

3. S.V.Alagarsamy, N.Rajakumar "Analysis of Influence of Turning Process Parameters on MRR & Surface Roughness Of AA7075 Using Taguchi's Method and Rsm" ISSN: 2278-9480 Volume 3, Issue 4 (Apr - 2014)

4. Vaibhav B. Pansare, Mukund V. Kavade "optimization of cutting parameters in multipass turning operation using ant colony algorithm" Volume-2, Issue-4, 955 – 960 Jul-Aug 2012

5. Dr. C. J. Raoa , Dr. D. Nageswara Raob, P. Sriharic "Influence of cutting parameters on cutting force and surface finish in turning operation" IConDM2013

6 M. Durairaja, S. Gowri “Parametric Optimization for Improved Tool Life and Surface Finish in Micro Turning using Genetic Algorithm” 2013

7. Ashvin J. Makadia , J.I. Nanavati b, “Optimisation of machining parameters for turning operations based on response surface methodology” 12 January 2012

8. H.M.SOMASHEKARA “optimizing surface roughness in turning operation using taguchi technique and anova” 24 March 2012

9. Dr.K.SRINIVAS ,Dr. P RAM REDDY, A.RAVEENDA, Dr.B.V.R.RAVI KUMAR, “experimental study on the effect of cutting parameters on surface finish obtained in cnc turning operation” August 2011

10. Yigit Kazancoglu, Ugur Esme, Melih Bayramo glu, Onur Guven “multi-objective optimization of the cutting forces in turning operations using the grey-based taguchi method” nov 2010

11 http://en.wikipedia.org/wiki

12 http://www.scribd.com/doc/17390328/Introduction-to-Lathe-Operations

13]http://www.scribd.com/doc/23281243/Lathes-and-Lathe-Machining-Operations

THANK YOU