*January – February 2020*
*ISSN: 0193-4120 Page No. 13817 – 13823*

# Optimization of turning operation on Mg alloy (Az91) and Al alloy (64430) using Taguchi method

Dr. B. Sudarshan[1], Dr.D.Ravikanth [2]

[1] Associate Professor, [2] Professor

[1,2]Mechanical engineering Department, K.S.R.M.College of Engineering (Autonomous), Kadapa, AndhraPradesh, India.

[1]sudarshan765@gmail.com,[2]Doddaravi2007@rediffmail.com.

***Article Info***
***Volume 82***
***Page Number: 13817 – 13823***
***Publication Issue:***
***January-February 2020***

***Article History***
***Article Received****: 18 May 2019*
***Revised****: 14 July 2019*
***Accepted****: 22 December 2019*
***Publication****: 24 February 2020*

**Abstract**

CNC Machine devices are broadly utilized by Manufacturing specialists and skilled operators, to set up assembling forms rapidly and viably for new products. The experiments for the utilization of Taguchi method for parametric investigation of CNC turning activity for surface hardness and material expulsion rate as a reaction variable. The Taguchi Technique is a productive exploratory strategy, in which response variable can be considered, utilizing less trial runs than a Factorial design technique. The control constraints for machining operation are, Spindle Speed (N), Feed Rate (VF) and Depth of cut (DOC). A couple of trial runs are to lead utilizing a symmetrical cluster, and the perfect mix of controllable factor levels will be resolved for the surface hardness (Ra) and material removal rate, cutting constraints and utilizing numerous direct relapses, and scientific models identifying with surface roughness (Ra) and Material Removal Rate (MRR) examine the influence of cutting constraints during turning operation.

**Keywords;** *CNC lathe, Production strategy, TAGUCHI method, Effectiveness.*

## I. INTRODUCTION

Surface roughness as frequently as conceivable shortened to hardness, is a bit of surface. The deviations assessed by toward the ordinary vector of an affirmed surface from its optimal structure. In the event that these deviations are colossal, the surface roughness is s; in the event that they are pretty much nothing, the surface looks like astoundingly smooth. In surface metrology, roughness is usually observed as the short-wavelength, high-rehash, and segment of a cognizant surface. Roughness can be assessed by manual evaluation against a "surface hardness comparator" (an instance of known surface hardness), at any rate more commonly a surface profile estimation is made with a Profilometer. These can be of the contact blend (normally an important stone stylus).

In particular, building controls need to make logical and computational upgrade strategies to improve the viability of the methodology. Upgrade is the future, since the endeavor cost, viability, essentialness save reserves, etc. are fundamental. To apply multi-target improvement to issues having conflicting objectives. Pareto-based multi-target improvement strategies grant to make a front of non-instructed plans.

### 1.2. Taguchi's standard for assembling

Taguchi techniques are quantifiable strategies, or now and again called amazing structure strategies, made by Genchi Taguchi to improve the idea of made product, and even more starting late furthermore applied to planning, biotechnology, exhibiting and publicizing. Capable experts have regarded the destinations and upgrades accomplished by Taguchi systems, particularly by Taguchi's improvement of plans for looking at



*Published by: The Mattingley Publishing Co., Inc.*

*January – February 2020*
*ISSN: 0193-4120 Page No. 13817 – 13823*

assortment, anyway have examined the inefficiency of a bit of Taguchi's suggestions. Taguchi work consolidates three significant duties to estimations [1].

- System design
- Parameter design
- Tolerance design

**1.2.1. System design:**

At the conceptual level, system design involving creativity and innovation.

**1.2.2. Parameter design:**

At the point when the idea is developed, the ostensible estimations of the various estimations and structure constraints ought to be set, the detail setup. Taguchi's extraordinary information was that the positive determination of characteristics required is under-controlled by the exhibition necessities of the structure. Much of the time, this empowers the constraints to be picked so as to confine the impacts on execution rising up out of assortment underway, condition and consolidated demolition.. Vigorous (Strong) parameter plans assess controllable and wild clamor features. It would like to manhandle affiliations and streamline settings that limit for the impacts of the disorder features.

**1.2.3. Tolerance Design**

With an effectively finished parameter design, and a comprehension of an impact of the different constraints have on execution, resources can be centered on diminishing and controlling variety in any measurements.

**1.3. Design of experiments (DOE)**

Taguchi developing his trial hypotheses openly. Taguchi's Design of Experiments (DOE) is quirky and regularly defective, anyway covers a great deal of tremendous worth. He developed different advancements.

**1.4. Orthogonal Arrays (Outer arrays)**

Taguchi's design methods created for grant great understanding cognizance of assortment than a customary structures, from the Analysis of Variance (ANOVA). In plan of examinations of Fisher's and ANOVA, tests expect decline the effect of unsettling influence factors, grant relationships of the mean treatment-impacts.

Taguchi strategy growing each assessment with an orthogonal array is recreate the irregular condition, where item would work. This is an instance of basic testing. Numerous quality specialists have been using "orthogonal array". Later headway in orthogonal array brought about "aggravated noise" This incorporates merging several parts to make two levels in the orthogonal array: basically, noise includes that gives yield is littler, and second, noise includes that drive is yield higher. "Intensified noise" reenacts the breaking points of variety of noise, anyway uses less preliminary runs than would past Taguchi structures [2].

## II. METHODOLOGY

Taguchi strategy is indicated instrument for assessing and executing updates in things, structures, materials, apparatus, and working environments. These overhauls are made arrangements for improving the perfect characteristics and at the same time reducing the amount of flaws by mulling over the key highlights controlling the procedure and streamlining the techniques or design to yield the best results [2]. The system is fitting over a wide extent of structuring fields that join procedures for gathering unrefined materials, sub systems. To be sure, the system can be applied to any procedure be it building creation, PC helped arrangement, banking and organization divisions, etc. Taguchi system is useful for 'tuning activity' and furthermore a given procedure for 'best' results.



*Published by: The Mattingley Publishing Co., Inc.*

January – February 2020
ISSN: 0193-4120 Page No. 13817 – 13823

Taguchi recommended normal 8-advance methodology for applying his strategy for upgrading barely any procedure.

### 2.1. Procedure for Optimization

Step-1: Recognize the essential limit, disappointment mode and symptoms.

Step-2: Distinguish the commotion highlights, testing conditions, and quality highlights

Step-3: Distinguish the objective ability to be upgraded

Step-4: Recognize the control factors and their levels

Step-5: Select the even bunch arrange test

Step-6: Lead the network try

Step-7: Break down the data. Anticipate (anticipated) the ideal levels and execution

Step-8: Do the check and plan the future movement

### 2.2. Sorting out least conceivable number of analyses

The Design of Experiments (DOE) using the orthogonal array is, all around, compelling when diverged from numerous other measurable structures. The least conceivable number of tests are required to coordinate the Taguchi strategy can assessed subject to the Degrees of Freedom (DOF) approach [3].

… .. (1)

Where,

N Taguchi - Number of tests.

NV - Number of requirements

L - Number of levels

In this work Number of requirements

= 3 and L = 3, Hence Number of tests. = 1+ 4 (3-1) = 9

For example, if there ought to be an investigation of emerge an event of 8 autonomous factors, having 1 free factor with 2 levels and staying 7 autonomous highlights with 3 levels (L18 orthogonal array), the least conceivable number of preliminaries vital subject to the above condition is 16. Brought about by the comparing property of the orthogonal arrays, without a doubt the quantity of tests will be 2 and 3. Hence the outcome is 18 for the above case.

#### 2.2.1. Material Remove Rate (MMR)

Material remove rate define as “an amount (volume) of the material is removed by the machining time”.

Mathematically, Material Remove Rate is expressed as [5]

Cutting Speed (V) = 3.14 × D × N ……. (2)

Material Remove Rate (MRR) =V × F × DOC……. (3)

### 2.3. S/N ratio

In Taguchi's technique the structure constraints (features that can be obliged by architects) and clamor constraints (features that can't be obliged by originators, for instance, natural features) are seen as convincing on the item quality. S/N ratio is used in this investigation which takes both the mean and the inconstancy of the trial result into understanding. The S/N ratio relates the quality features of the item/technique to be advanced. Typically, there are three characterizations of the introduction features in the examination of the S/N ratio; that is, the littler is-better, the bigger is - better, and the ostensible is - better [5]. The S/N ratio for every reaction is registered another way, in light of the class of the exhibition features and thus paying littler is-better classification the bigger S/N ratio compares a better presentation trademark. Anyway the entirety of the S/N ratios have been registered for every run of an analysis. Taguchi building up a graphical method to break down the information. In the graphical philosophy, the S/N ratios and normal reactions are



Published by: The Mattingley Publishing Co., Inc.

TEST Engineering & Management

*January – February 2020*
*ISSN: 0193-4120 Page No. 13817 – 13823*

plotted for every factor against every of its levels [5].

Mathematically,

S/N (Signal to noise) ratio for "Larger - is - better" category, the goal is maximize response and data character is positive [5].

S/N ratio = −10 *log (Σ (1/Y2)/n)…… (4)

S/N (Signal to noise) ratio for "Nominal- is -better" category, the goal is Target the response and you want to base the signal-to-noise ratio on standard deviations only, and data character is Positive, zero, or negative[5]

S/N = −10 *log (σ2)……. (5)

S/N (Signal to noise)) ratio for "Smaller - is - better" category, the goal is minimize the response and data character Non-negative with a target value of zero [5]

S/N = −10 *log (Σ (Y2)/n))…….. (6)

## III. ANALYSIS ON IMPACT OF INPUT FEATURES ON SURFACE ROUGHNESS FOR AL ALLOY (64430)

In this study 'Smaller- the- better' characteristic is used for calculation of S/N ratio and mean for getting the optimized cutting forces. The S/N ratio equation utilized here, and values can be improved.

Table 1. The response for S/N ratio is been created by calculating the average values and mean error delta.

The input constraints are speed, feed and Depth of Cut:

| Exp. No | Speed(N) | Feed ($V_F$) | DOC | MRR | Ra |
|---|---|---|---|---|---|
| 1 | 1000 | 0.1 | 0.1 | 1068.14 | 2.59 |
| 2 | 1000 | 0.2 | 0.3 | 6408.85 | 2.17 |
| 3 | 1400 | 0.4 | 0.5 | 2999.08 | 2.02 |
| 4 | 1400 | 0.2 | 0.3 | 8972.39 | 1.92 |
| 5 | 1800 | 0.1 | 0.5 | 9613.27 | 1.83 |
| 6 | 1800 | 0.4 | 0.1 | 7690.62 | 2.06 |
| 7 | 2200 | 0.4 | 0.5 | 46998.23 | 2.08 |
| 8 | 2200 | 0.2 | 0.3 | 14099.47 | 1.29 |
| 9 | 2600 | 0.1 | 0.1 | 2777.17 | 1.83 |

The rank is resolved dependent on impacting level and mean blunder of comparing parameter superficially harshness. While observing feed rate is the most compelling parameter on surface roughness than speed and profundity of cut. The impacts plot for S/N proportion and mean are appeared in two tables.

**Table 2: Response for S/N ratio.**

| Level | Speed(N) | Feed($V_F$) | DOC |
|---|---|---|---|
| 1 | -65.34 | -66.69 | -66.04 |
| 2 | -71.29 | -76.38 | -76.38 |
| 3 | -75.68 | -77.22 | -77.87 |
| 4 | -85.20 | | |
| 5 | -65.86 | | |
| Delta | 19.86 | 10.53 | 11.82 |
| Rank | 1 | 3 | 2 |

**Table3: Response for Mean**

| Level | Speed(N) | Feed($V_F$) | DOC |
|---|---|---|---|
| 1 | 1871 | 2244 | 1924 |
| 2 | 2994 | 4915 | 4915 |
| 3 | 4327 | 9616 | 9936 |
| 4 | 15275 | | |
| 5 | 1389 | | |
| Delta | 13886 | 7372 | 8013 |
| Rank | 1 | 3 | 2 |

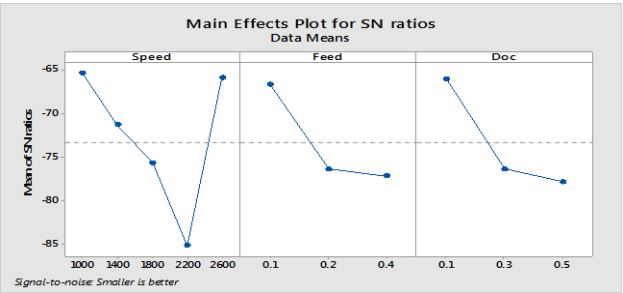


**Fig1: Main effect plot for S/N ratios**

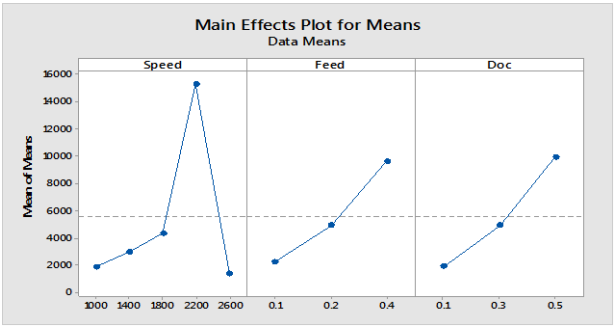


**Fig 2: Main effect plot for means**



*Published by: The Mattingley Publishing Co., Inc.*

January – February 2020
ISSN: 0193-4120 Page No. 13817 – 13823

The principle impact plot for surface irregularity S/N ratio diagram shows, the optimum values affecting the components. The value of relating constraints are the most elevated worth gotten by the bend in regarded plots. On the perception of primary impacts plots of feed rate, speed, and depth of cut the ideal qualities are:

Speed (N) = 2200 rpm.

Feed rate ($V_F$) = 0.4 mm per minute.

Depth of cut (DOC) = 0.5mm.

### 3.1 Analysis on influence of input features on surface roughness for Mg alloy (Az91):

In this study 'Smaller is better' characteristic is used for calculation of S/N ratio and mean for getting the optimized forces.by using The S/N ratio equation the roughness values can be simplified.

**Table 4.The response for signal to noise ratio is been created by Calculating the average values and mean error delta.**

| Exp. No | Speed(N) | Feed($V_F$) | DOC | MRR | Ra |
|---|---|---|---|---|---|
| 1 | 1500 | 0.15 | 0.1 | 3110.18 | 1.10 |
| 2 | 1500 | 0.25 | 0.3 | 15550.88 | 1.30 |
| 3 | 1500 | 0.45 | 0.5 | 46652.65 | 1.87 |
| 4 | 2000 | 0.25 | 0.5 | 34557.52 | 1.38 |
| 5 | 2000 | 0.45 | 0.3 | 62203.55 | 2.15 |
| 6 | 2000 | 0.15 | 0.1 | 4146.9 | 1.48 |
| 7 | 2500 | 0.45 | 0.3 | 46652.65 | 2.27 |
| 8 | 2500 | 0.15 | 0.5 | 25918.14 | 1.21 |
| 9 | 2500 | 0.25 | 0.1 | 8639.38 | 1.46 |

The rank is resolved dependent on impacting level and mean-error of the corresponding parameter surface roughness. On observing feed rate is the most compelling parameter on surface roughness than speed and depth of cut. The impact plots for S/N ratio and mean are shown in the two tables.

**Table 5: Response of S/N ratio**

| Level | Speed(N) | Feed($V_F$) | DOC |
|---|---|---|---|
| 1 | -79.35 | -73.82 | -70.64 |
| 2 | -83.52 | -81.43 | -88.02 |
| 3 | -83.78 | -91.20 | -87.80 |
| Delta | 4.44 | 17.35 | 17.38 |
| Rank | 3 | 1 | 2 |

**Table 6: Response for Mean**

| Level | Speed(N) | Feed($V_F$) | DOC |
|---|---|---|---|
| 1 | 10886 | 553o | 2650 |
| 2 | 16819 | 9792 | 20735 |
| 3 | 13536 | 25919 | 17855 |
| Delta | 5932 | 20389 | 18085 |
| Rank | 3 | 1 | 2 |

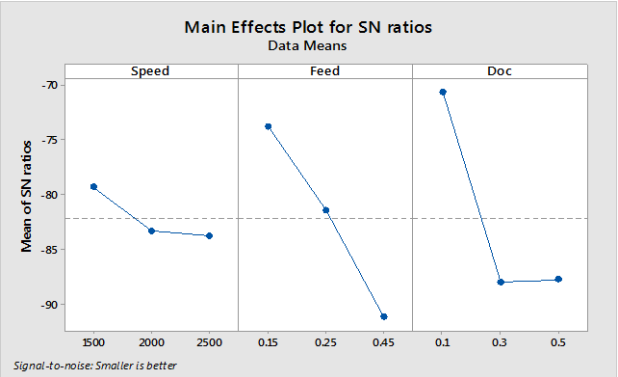


**Fig 3: Main effect for S/N ratios**

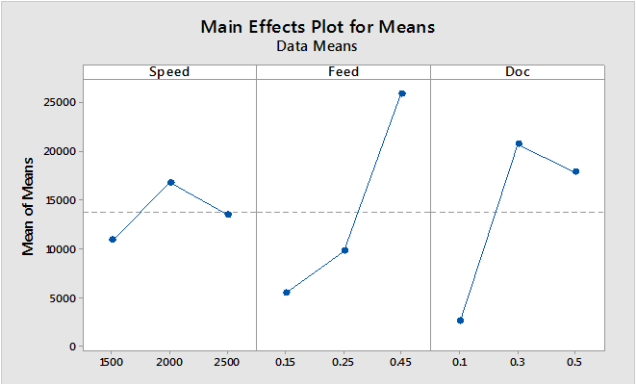


**Fig 4: Main effects for Means**

The main effect plot for surface roughness S/N ratio graph shows that the optimum values of influencing features. The value of corresponding constraints are the highest value obtained by the curve in respected plots. On the observation of main effects plots of speed, feed rate and depth of cut the optimum values are:

- N =2500rpm



Published by: The Mattingley Publishing Co., Inc.

*January – February 2020*
*ISSN: 0193-4120 Page No. 13817 – 13823*

- $V_F$ =0.45mm
- DOC =0.5mm

### 3.2. Analysis on influence of input features on surface roughness for both Al alloy (64430) and Mg alloy (Az91):

In this investigation 'Smaller- is- better' characteristic is utilized for calculation of S/N ratio and mean for getting the improved cutting powers. The S/N ratio equation utilized here can be improved.

**Table 7 .The response for S/N ratio is obtained by calculating the S/N ratio average values and mean error delta.**

| EXP. NO | Speed (N) | Feed ($V_F$) | DOC | MMR | Mtrl | Ra |
|---|---|---|---|---|---|---|
| 1 | 1000 | 0.1 | 0.1 | 1068.14 | 1 | 2.59 |
| 2 | 1000 | 0.2 | 0.3 | 6408.85 | 1 | 2.17 |
| 3 | 1400 | 0.4 | 0.5 | 2999.08 | 1 | 2.02 |
| 4 | 1400 | 0.2 | 0.3 | 8972.39 | 1 | 1.92 |
| 5 | 1800 | 0.1 | 0.5 | 9613.27 | 1 | 1.83 |
| 6 | 1800 | 0.4 | 0.1 | 7690.62 | 1 | 2.06 |
| 7 | 2200 | 0.4 | 0.5 | 46998.23 | 1 | 2.08 |
| 8 | 2200 | 0.2 | 0.3 | 14099.47 | 1 | 1.29 |
| 9 | 2600 | 0.1 | 0.1 | 2777.17 | 1 | 1.83 |
| 10 | 1500 | 0.15 | 0.1 | 3110.18 | 2 | 1.10 |
| 11 | 1500 | 0.25 | 0.3 | 15550.88 | 2 | 1.30 |
| 12 | 1500 | 0.45 | 0.5 | 46652.65 | 2 | 1.87 |
| 13 | 2000 | 0.25 | 0.5 | 34557.52 | 2 | 1.38 |
| 14 | 2000 | 0.45 | 0.3 | 62203.53 | 2 | 2.15 |
| 15 | 2000 | 0.15 | 0.1 | 4146.9 | 2 | 1.48 |
| 16 | 2500 | 0.45 | 0.3 | 46652.65 | 2 | 2.27 |
| 17 | 2500 | 0.15 | 0.5 | 25918.14 | 2 | 1.21 |
| 18 | 2500 | 0.25 | 0.1 | 8639.38 | 2 | 1.46 |

The rank is determined based on impact level and mean error of the corresponding parameter on the surface roughness. On observing feed rate is the most impact factor on surface roughness, than speed and depth of cut. The effects plot for S/N ratio and mean are shown in following tables.

**Table 8: Response for S/N ratio**

| Level | Speed(N) | Feed($V_F$) | DOC | Mtrl |
|---|---|---|---|---|
| 1 | -65.34 | -66.69 | -68.34 | -73.43 |
| 2 | -71.29 | -73.82 | -82.20 | -82.15 |
| 3 | -79.35 | -76.38 | -82.83 | |
| 4 | -75.68 | -81.43 | | |
| 5 | -83.32 | -77.22 | | |
| 6 | -85.20 | -91.20 | | |
| 7 | -83.78 | | | |
| 8 | -65.86 | | | |
| Delta | 1986 | | | |
| Rank | 2 | 1 | 3 | 4 |

**Table 9: Response for Mean**

| Level | Speed(N) | Feed($V_F$) | DOC | Mtrl |
|---|---|---|---|---|
| 1 | 1870 | 2244 | 2287 | 5591 |
| 2 | 2994 | 5530 | 12825 | 13747 |
| 3 | 10886 | 4914 | 13896 | |
| 4 | 4327 | 9792 | | |
| 5 | 16819 | 9616 | | |
| 6 | 15275 | 25919 | | |
| 7 | 13536 | | | |
| 8 | 1390 | | | |
| Delta | 15429 | 23675 | 11609 | 8156 |
| Rank | 2 | 1 | 3 | 4 |

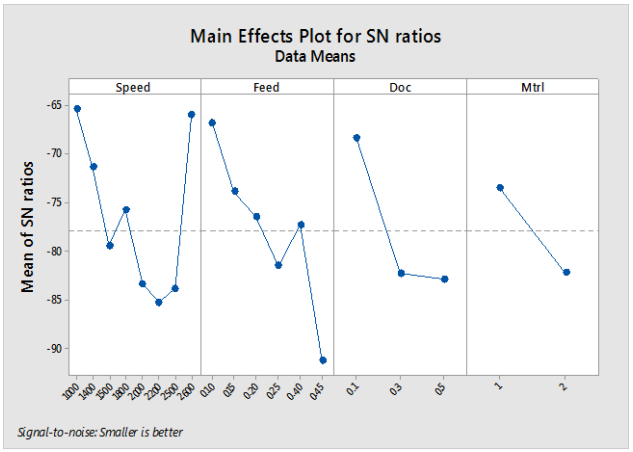


**Fig 5: Main effects for S/N ratios**

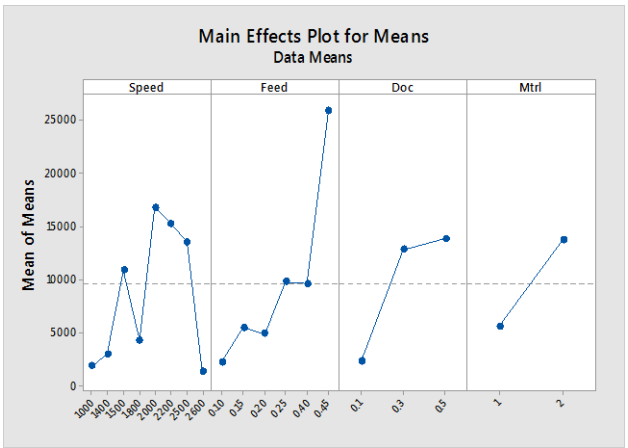


**Fig 6: Main effects for Means**



*Published by: The Mattingley Publishing Co., Inc.*

January – February 2020
ISSN: 0193-4120 Page No. 13817 – 13823

The principle impact plot for surface roughness S/N ratio graph shows that the values of corresponding constraints are the benefits of affecting elements. The values of relating constraints are the value obtained by the bend in regarded curve in respected plots. On the perception of principle impacts plots of speed, feed rate and profundity of cut the ideal qualities are:

- Speed (N) = 2200 rpm
- Feed rate (VF) = 0.45mm
- Depth of cut (DOC) = 0.5 mm
- Material = Mg alloy (Az91)

## IV. MERITS AND DEMERITS OF TAGUCHI METHOD

Benefits and Demerits in performing enhancement of signal target issue are as per the following.

1. Taguchi method proposed a significance of a mean performance trademark value near the objective value, as opposed to a value inside determined breaking points, in this manner improving the nature of item.

2. Taguchi's method for experimental structure is anything but difficult to apply for some building circumstances, and making it a useful asset for taking care of any sort of issue.

3. It very well may be used as far as possible the degree of an assessment adventure or to recognize issues in a collecting strategy.

4. Likewise, the Taguchi method mulls over the examination of a wide scope of highlights without a prohibitively high proportion of experimentation.

5. The negative mark is that the results obtained, simply are just comparing values and don't precisely demonstrate what factor has the most noteworthy impact on value of the performance trademark.

## V. CONCLUSIONS

The whole experimental examination has been done at CNC machine in smaller than normal device room, and got great outcomes. With the CNC machine, the investigations directed utilizing Taguchi method for two distinctive compounds (like Al combination (64430) and Mg composite (Az91).The expected consequences of examination decides the S/N proportion and at each level reaction of mean. The positions dictated by thinking about the info imperatives of Speed (N), feed (VF), and Depth of Cut (DOC). At each stage the surface Roughness (Ra) impacted by profundity of cut. Applying Taguchi method, littler is-better character utilized and signal to noise(S/N) proportion have been broke down and with that reaction to mean plotted the diagrams with the thought of information requirements at each level.

## REFERENCES:

[1.] Konishi S, Taguchi G, Taguchi Methods, orthogonal arrays and linear graphs, tools for quality American supplier institute, American Supplier Institute; 1987.

[2.] W.T. Foster, Basic Taguchi design of experiments, National Association of Industrial Technology Conference, Pittsburgh, PA, 2000.

[3.] DomnitaFratilia, CristianCaizar, Application of Taguchi method to selection of optimal lubrication and cutting conditions in face milling of AlMg3, Journal of Cleaner Production 19 (2011) 640-645.

[4.] Ernest Doebelin, Engineering Experimentation, Tata MCGRAW HILL Publication.

## WEB SITES

http://www.ecs.umass.edu/mie/labs/mda/fea/sankar/chap2.html.