# Experimental study on machining parameters of Al 1100 by using Taguchi Robust Design Methodology.

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**ABSTRACT**

*The machining process is dependent on the material attributes and the machining parameters. The present work details a point by point test study to optimize the impacts of cutting parameters on Surface Roughness, MRR and cutting forces of Aluminium Alloy 1100 by utilizing Taguchi robust design methodology. The paper additionally deals with the optimization of processing parameters, i.e. Cutting Speed, Feed rate, Depth of cut and Coolant flow rate. Taguchi orthogonal array is formulated with three levels of milling process parameters and various trials are performed utilizing $L_9$ ($3^4$) orthogonal array containing nine rows which denotes the nine experiments to be performed and estimations of each parameter was acquired. The nine experiments are performed and the corresponding MRR, cutting forces and surface roughness are found. The Signal to Noise Ratio (S/N) ratio of the predicted value and the corresponding verification test values are valid when compared to the optimum values. It is found that S/N ratio estimation of confirmation test is within the points of confinement of the predicted value and the objective of the work is full filled.*

**Keywords:** *Aluminum Alloy 1100, Taguchi robust design, $L_9(3^4)$ orthogonal array, Signal to Noise Ratio (S/N)*

## 1. Introduction

Optimization of process parameters is the major stage in the Taguchi method for carrying out high quality machining with a very less cost. Overall machining expense and cutting fluid utilization are taken as the fundamental targets in the optimization model, which are influenced by process parameters such as depth of cut, feed rate, cutting speed, and coolant flow rate. In this regard optimization of process parameters can improve the performance characteristics and optimum process parameters found from the Taguchi Method are insensitive to the variation of environmental conditions and other noise factors. The present work outlines a detailed experimental study to optimize the effects of cutting parameters on Surface Roughness, MRR and cutting forces of Aluminium Alloy 1100 by utilizing Taguchi robust design methodology. Four control factors viz. cutting speed, feed rate, depth of cut and coolant flow rate are investigated at three different levels. The work piece material utilized is Aluminium Alloy 1100 and the output parameter investigated is surface roughness using signal to-noise ratio at smaller the better.

In this work, ANOVA is performed for the selected factors, to be significant or insignificant and to build up the prediction models for the surface roughness considering the control factors using regression analysis. Regression analysis is a statistical procedure for assessing the relationships among variables. It incorporates numerous strategies for modelling and analysing several variables, when the concentration is on the relationship between a dependent variable and at least one independent variable.

## 2. Literature Survey

Bolboacă, S.D (2007) Emphasized that the diagram of a trial is suggested remembering the true objective to find as various plans as possible with the best number of segments with balanced levels for the most unassuming number of trial runs. An estimation was set up and specially designed writing computer programs was executed. The limits in time of the guideline social occasions of orthogonal arrays were penniless down for examination continues running of 4, 6, 8, 9, 10, 12, 14, 15, and 16. The results show that the proposed procedure permits the advancement of the biggest gatherings of orthogonal exhibits with the best number of components.

Naidu, G.G. (2014) has redesigned the effects of particular data prerequisites i.e. feed rate, Depth of Cut for Hardness, Type of hardware and Cutting Speed of EN-36 mix steel by using Taguchi Robust Design Methodology. Hardness qualities are measured from the experimentation and their optimal qualities are figured.

In this work examination of Variance urges that the picked cutting parts are noteworthy and the sort of gear dispensed has the most fundamental point of view for the Hardness.

Thakre (2013) has optimized the impacts of a few processing parameters, for example, coolant flow rate, feed rate, Depth of Cut and speed at first glance roughness (Ra) of completed items. The trial arrange relied on upon Taguchi's system consolidating $L_9$ orthogonal array with four factors and three levels for each factor and think the dedication of every component on Surface roughness. The trials were performed on 1040 MS material on CNC vertical milling machine utilizing carbide tips. The investigation of mean and variance is utilized to concentrate the impact of each machining parameter on surface roughness. The outcomes showed that coolant flow rate with the outcome of 60.69% are the most contributing parameter in changing the Surface roughness, followed by shaft speed. The optimum parameters for surface roughness are achieved as Spindle speed of 2500 rpm, feed of 800 mm/min, 0.8 mm Depth of Cut and coolant flow 30 lit/min.

The study aided us in valid selection of control factors and machining process. The experiment setup and suggestion of the present work is assisted through Taguchi robust design methodology for Surface roughness in context of the impressive number of components where the perfect conditions are created.

## 3. Investigational Setup and Design

The experiment is performed using Taguchi Method considering $L_9$ ($3^4$) Orthogonal Array [1]. The details of experimental setup are tabulated in the table no.1. The machining is carried out in CNC Milling Machine (Fig. 2) with carbide mill cutter (Fig. 3) as a tool on 9 different work pieces (Fig. 1) with the same dimensions. Surface roughness is measured utilizing a versatile Surface roughness analyzer Mitutoyo Surftest SJ-301 (Fig. 4). The estimation of Surface texture is finished by diamond tool device (Fig.5). The estimation results are shown on a LCD screen. The four control variables chosen are spindle speed (A), Feed (B), Depth of Cut (C) and coolant flow (D). The machining is performed exclusively relying on the lubricant conditions. The control variables and their option levels are recorded in Table. 2. The results are organized and executed as requirements be [1], the segment task is done by the L9 ($3^4$) orthogonal array and the Surface roughness values are listed in Table. 3.

Table. 1: Material properties, Machine, Tool and Surface roughness measuring equipment details.

| Name | Properties | Figure |
|---|---|---|
| **Material Used-** Aluminium1100 Alloy | **Aluminium:** 99.0-99.95%<br>**Copper:** 0.05-0.20%<br>**Iron:** 0.95% Max<br>**Manganese:** 0.05% Max<br>**Silicon:** 0.95% Max<br>**Zinc:** 0.1% Max<br>**Residuals:** 0.15% Max |  |
| **Machine Used:**<br>Cnc Milling Machine | **Name Of The Company-** BFWAGNI+(BMV45+TC20)<br>**<u>Specifications:</u>**<br>**Length Of The Bed:** 600mm<br>**Height /Stroke Length:** 450mm<br>**Clamps Used:**<br>Hydraulic Vice<br>**Coolant Used:**<br>Velvex Diesel Engine Oil |  |
| **Tool Used** | **Name Of The Tool:**<br>Mill Cutter<br>**Tool Material:**<br>Carbide Material<br>**Diameter Of The Tool:** 55mm<br>**<u>Operation Performed:</u>** Face Milling |  |

| | | |
|---|---|---|
| **Instrument Used:**<br><br>Digital Surface Roughness Measuring Instrument | **Name Of The Instrument:** Mitutoyo Surftest Sj-301<br><br>**Material Of The Tip:** Diamond<br><br>**Traverse Length Of Tip:** 8mm |  |

Table. 2: Control Factors and Levels

| **Factors /Levels** | **Spindle Speed (A) (rpm)** | **Feed (B) (mm/min)** | **Depth Of Cut (C) (mm)** | **Coolant Flow (D) (lt/min)** |
|---|---|---|---|---|
| 1 | 2000 | 1200 | 0.5 | 80 |
| 2 | 3000 | 840 | 1.0 | 100 |
| 3 | 4000 | 600 | 1.5 | 120 |

Table. 3: Experimental results of Surface roughness& Calculated S/N Ratios

| **Iteration No** | **Control Factors** | | | | **Surface roughness** | **S/N Ratio** |
|---|---|---|---|---|---|---|
| | **Spindle Speed** | **Feed** | **Depth of Cut** | **Coolant Flow** | | |
| 1 | 2000 | 1200 | 0.5 | 80 | 0.62750 | 4.0477253 |
| 2 | 2000 | 840 | 1 | 100 | 0.60500 | 4.3648925 |
| 3 | 2000 | 600 | 1.5 | 120 | 0.40750 | 7.7974477 |
| 4 | 3000 | 1200 | 1 | 120 | 0.68750 | 3.2545459 |
| 5 | 3000 | 840 | 1.5 | 80 | 0.40500 | 7.8508995 |
| 6 | 3000 | 600 | 0.5 | 100 | 0.39750 | 8.0132573 |
| 7 | 4000 | 1200 | 1.5 | 100 | 0.39250 | 8.1232067 |
| 8 | 4000 | 840 | 0.5 | 120 | 0.44750 | 6.9841392 |
| 9 | 4000 | 600 | 1 | 80 | 0.40500 | 7.8508995 |

## 4. Results & Discussion

Table. 4: Summary of S/N Ratios

| **Factor** | **Level 1** | **Level 2** | **Level 3** |
|---|---|---|---|
| **Spindle Speed(A)** | 5.403355 | 6.37290 | **7.652748** |
| **Feed(B)** | 5.141826 | 6.399977 | **7.887201** |
| **Depth of Cut(C)** | 6.348373 | 5.156779 | **7.923851** |
| **Coolant Flow (D)** | 6.583174 | **6.833785** | 6.012014 |

Table. 5: Optimum Set of Control Factors

| Factors/Levels | Spindle Speed(A) (rpm) | Feed(B) (mm/rev) | Depth of Cut(C) (mm) | Coolant Flow(D) |
|---|---|---|---|---|
| Optimum Value | **4000** | **600** | **1.5** | **100** |

### 4.1. Selection of Optimum Set of Conditions for Surface roughness:

The best condition for Spindle Speed factor is level 3 (4000rpm), for Feed is level 3 (600mm/rev), for Depth of Cut is level 3 (1.5mm) and Coolant Flow is level 2 (100). Thus, the optimum machining parameters chosen were: **A3-B3-C3-D2**.

### 4.2. Forecast of Process Average for Optimum Condition for Surface roughness:

From Table. 7 the accompanying counts are done, for every one of the cases the anticipated esteem is figured in a similar methodology.

$\eta_{predicted}$= Y+ (A3-Y) + (B3-Y) + (C3-Y) + (D2-Y)

= A3+B3+C3+D2-3Y

= [(**7.652748**) + (**7.887201**) + (**7.923851**) + (**6.833785**)] – [3X (6.4766334)]

$\eta_{predicted}$= 11.03479673

Therefore, the predicted average for optimum condition of Surface roughness is 11.03479673.

### 4.3. Performing Verification Test for Surface roughness:

A confirmation test is performed with the obtained optimum cutting parameters (spindle speed 4000rpm, Feed 600mm/rev, depth of Cut 1.5mm and coolant flow 100). The Surface roughness values are taken for two trials and the S/N ratio is computed for this condition. The consistence test and the foreseen qualities are sorted out in the Table. 6 and 7.

Table. 6: Conformation Experimental Results

| SURFACE ROUGHNESS(Ra) VALUES | | | S/N RATIO |
|---|---|---|---|
| 1 | 2 | Average | |
| 0.33 | 0.25 | 0.29 | 10.75204004 |

Table. 7: Comparison of S/N Ratios

| | |
|---|---|
| **$\eta$ predicted** | 11.03479673 |
| **$\eta$ conformation** | 10.75204004 |

### 4.4. Effect of Cutting Parameters on Surface roughness:

4.4.1. From Fig. 6, it is observed that, the Surface roughness is more at high spindle speed and absolutely diminishing from direct to low Spindle speed conditions.

4.4.2. From Fig. 7, it is observed that, the Surface roughness is high at low Feed conditions and absolutely diminishing from direct to high Feed conditions.

4.4.3. From Fig. 8, it is observed that, the Surface roughness is high at high Depth of Cut and surely diminishing from exceedingly profundity of slice to direct Depth of cut conditions, and from direct to low Depth of cut, the Surface roughness increments.

4.4.4. From Fig. 9, it is observed that, the Surface roughness is high when coolant stream is low and roughness increments and roughness increments from low to direct flow, and from direct to high coolant flow, the Surface roughness diminishes.

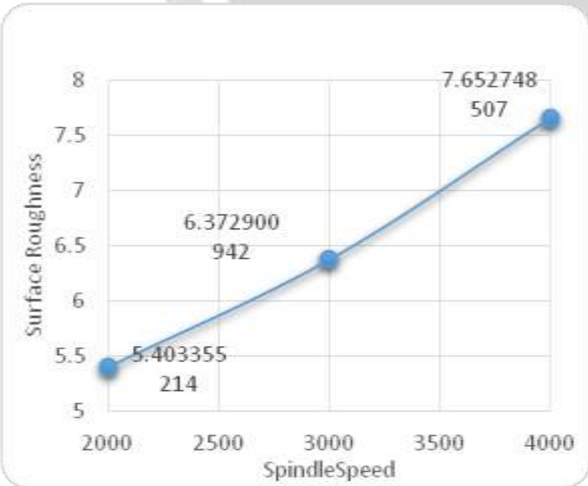


Fig. 6- Spindle Speed Vs Surface roughness

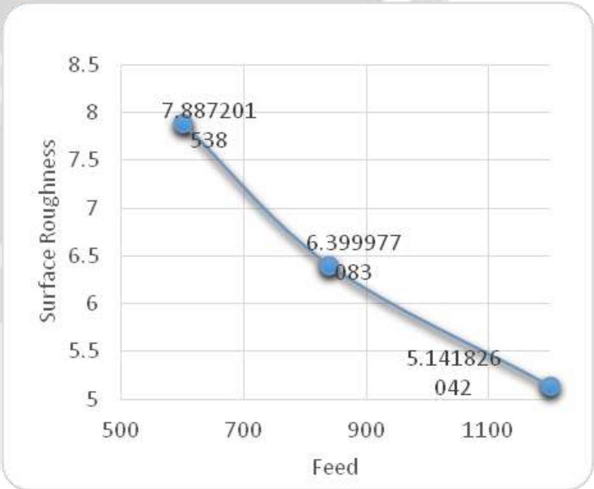


Fig. 7- Feed Vs Surface roughness

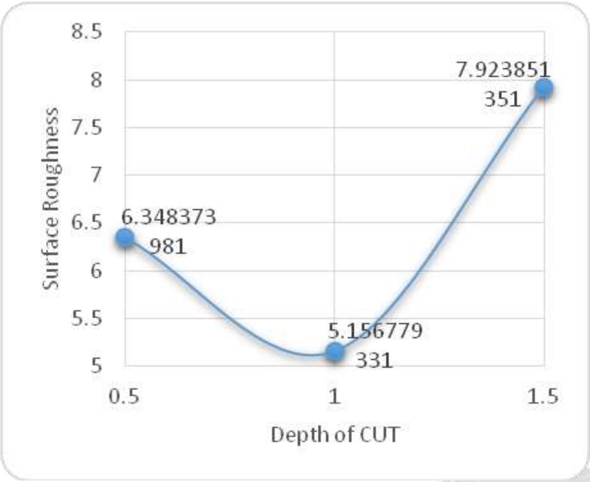


Fig. 8- Depth of Cut Vs Surface roughness

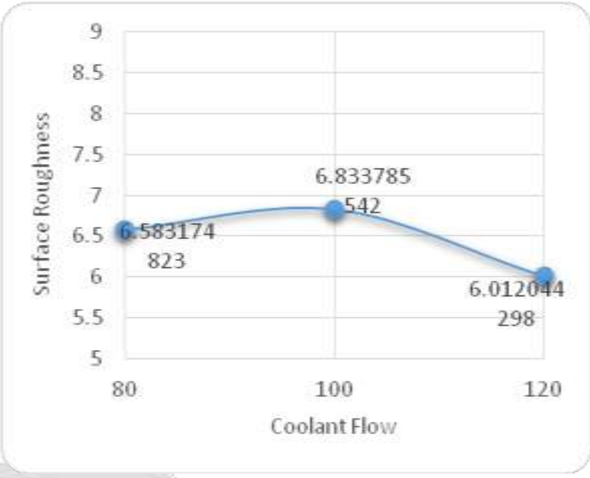


Fig. 9- Coolant Flow Vs Surface roughness

## 5. Conclusion

The aim of the present work is to find out the set of optimum parameters in order to reduce Surface roughness, using Taguchi's techniques in view of the selected parameters for Aluminium Alloy 1100. Based on the results of the present research the following conclusions can be drawn:

- In the present experimentation the optimum speed obtained using Taguchi Robust Design Methodology is 4000rpm. So also the outcomes acquired for Feed and Depth of Cut are 600mm/rev and 1.5mm individually. Henceforth it can be presumed that the parameters acquired are substantial and within the range of Aluminium Alloy 1100 machining Standards.
- The associating Coolant Flow is 100.
- The S/N extent of foreseen regard and confirmation test results are considerable when differentiated and the perfect qualities. It is found that S/N proportion estimation of confirmation test is within the cut-off points of the anticipated esteem and the objective of the work is full filled.

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