International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 01
January 2018

# Increasing the Surface Finish Quality and Mr. by Varying Milling Parameters for Aluminum Alloy 7475

## AUTHOR 1

**SOUDARAPU RAJESH** received the B.Tech degree in mechanical engineering from **Rajiv Gandhi University of Knowledge Technologies** Basar, Adilabad, Telangana, India, in 2014 year, and perusing M.Tech in **ADVANCED MANUFACTURING SYSTEMS** from **Jawaharlal Nehru Technological University Hyderabad College of Engineering**, Telangana, India.

## AUTHOR 2

**Dr. B. ANJANEYA PRASAD, Ph.D, Professor,** Department of Mechanical Engineering, Jawaharlal Nehru Technological University Hyderabad College of Engineering, Telangana, India.

## ABSTRACT

The main objective of this project is to optimize the process parameters in milling to achieve better surface finish and higher material removal rates using different cutting tools.

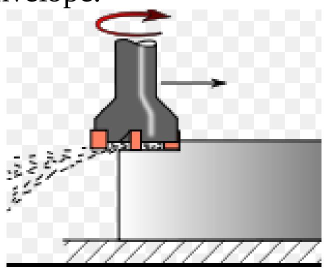
Different experiments are conducted to optimize the process parameters to improve the surface finish quality and material removal rate Solid Carbide cutting tool and Ceramic Insert while machining Aluminum alloy AA 7475. A series of experiments are done by varying the milling parameters spindle speed, feed rate, depth of cut and tool material considering L27 orthogonal array by Regression Analysis and Genetic Algorithm. The optimization is done for least surface roughness and high material removal rates.

The experiment has been done with process parameters feed rate 80mm/min, 120mm/min, 160 mm/min, spindle speeds are 1000rpm, 1200rpm, 1400rpm, and depth of cut 0.5mm, 1mm and 1.5mm and tool material High Speed Steel, Tungsten Carbide and Ceramic Coated Carbide.

## INTRODUCTION

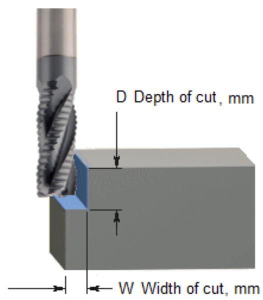
Milling is the machining process of using rotary cutters to remove material from a work piece by advancing (or feeding) in a direction at an angle with the axis of the tool. It covers a wide variety of different operations and machines, on scales from small individual parts to large, heavy-duty gang milling operations. It is one of the most commonly used processes in industry and machine shops today for machining parts to precise sizes and shapes.

Milling can be done with a wide range of machine tools. The original class of machine tools for milling was the milling machine (often called a mill). After the advent of computer numerical control (CNC), milling machines evolved into machining centers (milling machines with automatic tool changers, tool magazines or carousels, CNC control, coolant systems, and enclosures), generally classified as vertical machining centers (VMCs) and horizontal machining centers (HMCs). The integration of milling into turning environments and of turning into milling environments, begun with live tooling for lathes and the occasional use of mills for turning operations, led to a new class of machine tools, multitasking machines (MTMs), which are purpose-built to provide for a default machining strategy of using any combination of milling and turning within the same work envelope.



**Cutting Tool Translator and Rotational Motion**

**MRR in End milling**




**Material Removal Rate in CNC End Milling**

D: Depth of cut, mm.
W: Width of cut, mm.
F: Feed rate, mm/min
MRR = D x W x F cc/min.

## LITERATURE SURVEY

The work done by P. V. Rangarao[1], describes a comparison of tool life between ceramics and cubic boron nitride(CBN) cutting tools when machining hardened steels using the Taguchi method. An orthogonal design, signal-to-noise ratio (S/N) and analysis of variance (ANOVA) were employed to determine the effective cutting parameters on the tool life. The results indicated that the cutting speed was found to be a dominant factor on the tool life, followed by the depth, lastly the feed. The CBN cutting tool showed the best performance than that of ceramic based cutting tool. In addition, optimal testing parameter for cutting times was determined. The confirmation of Experiment was conducted to verify the optimal testing parameter. Improvements of the S/N ratio from initial testing parameters to optimal cutting parameters or prediction capability depended on the S/N ratio and ANOVA results. Moreover, the ANOVA indicated that the cutting speed was higher significant but other parameters were also significant effects on the tool lives at 90% confidence level. The percentage contributions of the cutting speed, tool's hardness, and feed rate were about 42.88, 32.44, and 24.22 on the tool

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 01
January 2018

life,respectively.

The work done by A.K Ghani[2], presents a study of tool life, surface finish and vibration while machining nodular cast iron using ceramic tool. A series of cutting tests have been carried out to verify the change in surface finish of the work piece due to increasing tool wear. The tests have been done under various combinations of speed, feed and depth of cut. The effects of vibration on the flank wear both in the direction of main cutting force and radial cutting force have been investigated. The vibration was measured using two accelerometers attached to the tool holder and the parameters used to make the correlation with surface roughness were the amplitude and acceleration of the signals. The results show that the tool life of the alumina ceramic inserts is not satisfactory when machining nodular cast iron. In the speed range 364–685 m/min, maximum tool life achieved was only about 1.5 min. Surface finish was found to be almost constant with the progression of the flank wear under all cutting conditions. It has been observed that for the same flank wear, vibration during cutting decreases as the speed increases. At low depth of cut, vibration remains almost constant with the increase of flank wear.

The work done by Abdullah Altin[3], the effects of cutting speed on tool wear and tool life when machining Inconel 718 nickel-based super alloy have been experimentally investigated. A series of tool life experiments has been carried out using silicon nitrite based and whisker reinforced ceramic tools which have two different geometries and three different ISO qualities with 10% water additive cutting fluid. The experiment results show that crater and flank wears are usually dominant wear types in ceramic square type (SNGN) inserts while flank and notch wear are dominant in round type (RNGN) inserts. Minimum flank wear is seen with SNGN tools at low cutting speeds while it is seen with RNGN tools at high cutting speeds.

The work done by A. Senthil Kumar [4], the advanced ceramic cutting tools have very good wear resistance, high refractoriness, good mechanical strength and hot hardness. Alumina based ceramic cutting tools have very high abrasion resistance and hot hardness. Chemically they are more stable than high-speed steels and carbides, thus having fewer tendencies to adhere to metals during machining and less tendency to form built-up edge. This results in good surface finish and dimensional accuracy in machining steels. In this paper wear behavior of alumina based ceramic cutting tools is investigated. The machining tests were conducted using SiC whisker reinforced alumina ceramic cutting tool and Ti[C,N] mixed alumina ceramic cutting tool on martensitic stainless steel-grade 410 and EN 24 steel work pieces. Flank wear in Ti[C, N] mixed alumina ceramic cutting tool is lower than that of the SiC whisker reinforced alumina cutting tool. SiC whisker reinforced alumina cutting tool exhibits poor crater wear resistance while machining. Notch wear in SiC whisker reinforced alumina cutting tool is lower than that of the Ti[C, N] mixed alumina ceramic cutting tool. The flank wear, crater wear and notch wear are higher on machining martensitic stainless steel than on machining hardened steel. In summary Ti[C, N] mixed alumina cutting tool performs better than SiC whisker reinforced alumina cutting tool on machining martensitic stainless steel.

The work done by Ali Riza Motorcu[5], the surface roughness in the turning of AISI 8660 hardened alloy steels by ceramic based cutting tools was investigated in terms of main cutting parameters such as cutting speed, feed rate, depth of cut in addition to tool's nose radius, using a statistical approach. Machining tests were carried out with PVD coated ceramic cutting tools under different conditions. An orthogonal design, signal-to-noise ratio and analysis of variance were employed to find out the effective cutting parameters and nose radius on the surface roughness. The obtained results indicate that the feed rate was found to be the dominant factor among controllable factors on the surface roughness, followed by depth of cut and tool's nose radius. However, the cutting speed showed an insignificant effect. Furthermore, the interaction of feed rate/depth of cut was found to be significant on the surface finish due to surface hardening of steel. Optimal testing parameters for surface roughness could be calculated. Moreover, the second order regression model also shows that the predicted values were very close to the experimental one for surface roughness.

The work done by E. Ahmadi [6], the tool life of a cutting tool is an important critical factor in evaluating its performance. The amount of tool abrasion seriously affects the dimensions and surface quality of the working piece so that one of the main factors determining the tool life of a tool is the degree of wear. For this purpose, an abrasion standard is defined for each particular tool above which the tool is no longer applicable. In this paper, studies are concentrated on the machining of PH-hardened Austenitic ferritic (Duplex) stainless steel (330HRC) to analyze the effect of tool wear on the tool life of the ceramic cutting tool with Alumina base (aluminum oxide). The abrasion tool parameters like flank wear, crater wear, and notch wear have been addressed. To develop the mathematical models for the parameters studied in tool wear, the experimental results are applied in a multi-regression analysis (MRA) and the results obtained by these models are studied and analyzed by analysis of variance (ANOVA).

## OBJECTIVES:

The main objective of this project is to optimize the process parameters in milling to achieve better surface finish and higher material removal rates using different cutting tools

Different experiments are conducted to optimize the process parameters to improve the surface finish quality and material removal rate Solid Carbide cutting tool and Ceramic Insert while machining Aluminium alloy AA 7475. A series of experiments are done by varying the milling parameters spindle speed, feed rate and depth of cut considering L27 orthogonal array by Taguchi Method and Genetic Algorithm. The optimization is done for least surface roughness and high material removal rates.

The experiment has been done with process parameters feed rate 80mm/min, 120mm/min, 160 mm/min, spindle speeds are 1000rpm, 1200rpm, 1400rpm, and depth of cut 0.5mm, 1mm and 1.5mm and tool material High Speed Steel, Tungsten Carbide and Ceramic Coated Carbide.

**Selection of process parameters as per Taguchi Technique**

| Factors | Units | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|
| **Material of tool** | - | **High Speed Steel (HSS)** | **Tungsten Carbide (T.C)** | **Ceramic Coated Carbide(CCC)** |
| **Cutting speed, N** | **rpm** | 1000 | 1200 | 1400 |
| **Feed Rate, f** | **mm/min** | 80 | 120 | 160 |
| **Depth of cut, d** | **mm** | 0.5 | 1 | 1.5 |

**Process Parameters as per Taguchi Technique**

| JOB NO. | MATERIAL | SPEED (RPM) | FEED (mm/min) | DEPTH OF CUT (mm) | Surface Roughness $R_a$ (µm) | MRR ($cm^3$/sec) |
|---|---|---|---|---|---|---|
| 1 | HSS | 1000 | 80 | 0.5 | 0.418 | 0.129 |
| 2 | HSS | 1000 | 120 | 1 | 0.544 | 0.407 |
| 3 | HSS | 1000 | 160 | 1.5 | 0.717 | 0.913 |
| 4 | HSS | 1200 | 80 | 1 | 0.533 | 0.658 |
| 5 | HSS | 1200 | 120 | 1.5 | 0.789 | 0.717 |
| 6 | HSS | 1200 | 160 | 0.5 | 0.767 | 0.162 |
| 7 | HSS | 1400 | 80 | 1.5 | 1.217 | 0.824 |
| 8 | HSS | 1400 | 120 | 0.5 | 0.913 | 0.142 |
| 9 | HSS | 1400 | 160 | 1 | 0.877 | 0.421 |
| 10 | TC | 1000 | 80 | 0.5 | 0.548 | 0.133 |
| 11 | TC | 1000 | 120 | 1 | 0.727 | 0.434 |
| 12 | TC | 1000 | 160 | 1.5 | 1.528 | 0.685 |
| 13 | TC | 1200 | 80 | 1 | 0.481 | 0.394 |
| 14 | TC | 1200 | 120 | 1.5 | 0.852 | 1.021 |
| 15 | TC | 1200 | 160 | 0.5 | 0.724 | 0.152 |
| 16 | TC | 1400 | 80 | 1.5 | 1.043 | 1.235 |
| 17 | TC | 1400 | 120 | 0.5 | 0.531 | 0.192 |
| 18 | TC | 1400 | 160 | 1 | 1.212 | 0.458 |
| 19 | CCC | 1000 | 80 | 0.5 | 0.563 | 0.183 |
| 20 | CCC | 1000 | 120 | 1 | 0.728 | 0.593 |
| 21 | CCC | 1000 | 160 | 1.5 | 1.008 | 0.759 |
| 22 | CCC | 1200 | 80 | 1 | 0.542 | 0.407 |
| 23 | CCC | 1200 | 120 | 1.5 | 0.874 | 1.108 |
| 24 | CCC | 1200 | 160 | 0.5 | 0.796 | 0.199 |
| 25 | CCC | 1400 | 80 | 1.5 | 1.259 | 1.421 |
| 26 | CCC | 1400 | 120 | 0.5 | 0.765 | 0.215 |
| 27 | CCC | 1400 | 160 | 1 | 0.913 | 0.538 |

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 01
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**Cutting Tool with Insert**

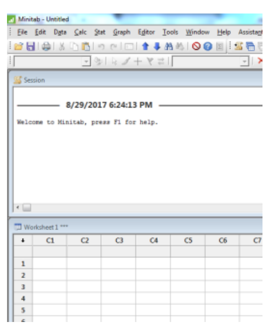
**Machining of work piece by applying parameters** – Spindle Speed 1000rpm, Feed Rate – 80mm/min and Depth of Cut – 0.5mm, Tungsten Carbide Tool

## DESIGN OF EXPERIMENTS BY USING MINITAB SOFTWARE

Here HSS is taken as 1, Tungsten Carbide as 2 and Ceramic Coated Carbide as 3.

### Design of Orthogonal Array

First Taguchi Orthogonal Array is designed in Minitab17 to calculate S/N ratio which steps is given below:




**Minitab Environment**

International Journal of Research
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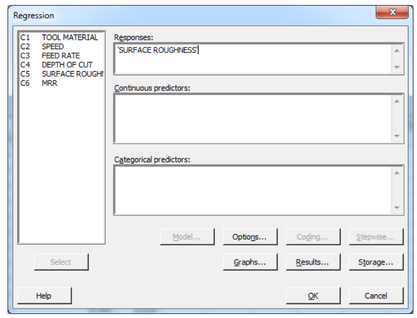
| ↓ | C1 | C2 | C3 | C4 | C5 | C6 |
|---|---|---|---|---|---|---|
| | Tool Material | Speed | Feed | Depth of Cut | Surface Roughness Ra (µm) | MRR (cm3/sec) |
| 16 | 2 | 1400 | 80 | 1.5 | 1.043 | 1.235 |
| 17 | 2 | 1400 | 120 | 0.5 | 0.531 | 0.192 |
| 18 | 2 | 1400 | 160 | 1.0 | 1.212 | 0.458 |
| 19 | 3 | 1000 | 80 | 0.5 | 0.563 | 0.183 |
| 20 | 3 | 1000 | 120 | 1.0 | 0.728 | 0.593 |
| 21 | 3 | 1000 | 160 | 1.5 | 1.008 | 0.759 |
| 22 | 3 | 1200 | 80 | 1.0 | 0.542 | 0.407 |
| 23 | 3 | 1200 | 120 | 1.5 | 0.874 | 1.108 |
| 24 | 3 | 1200 | 160 | 0.5 | 0.796 | 0.199 |
| 25 | 3 | 1400 | 80 | 1.5 | 1.259 | 1.421 |
| 26 | 3 | 1400 | 120 | 0.5 | 0.765 | 0.215 |
| 27 | 3 | 1400 | 160 | 1.0 | 0.913 | 0.538 |

**Observed Surface Roughness and MRR Values**

## REGRESSION ANALYSIS FOR AL 7475




**Responses – Surface Roughness**

## REGRESSION ANALYSIS: SURFACE ROUGHNESS RA VERSUS TOOL MATERIAL, SPEED, FEED, DEPTH OF CUT OF VARIANCE OF SR

| Source | DF | Adj SS | Adj MS | F-Value | P-Value |
|---|---|---|---|---|---|
| Regression | 4 | 1.03600 | 0.25900 | 6.65 | 0.001 |
| Tool Material | 1 | 0.02516 | 0.02516 | 0.65 | 0.430 |
| Speed | 1 | 0.21103 | 0.21103 | 5.42 | 0.029 |
| Feed | 1 | 0.20866 | 0.20866 | 5.36 | 0.030 |
| Depth of cut | 1 | 0.59115 | 0.59115 | 15.19 | 0.001 |
| Error | 22 | 0.85631 | 0.03892 | | |
| Total | 26 | 1.89231 | | | |

Worksheet 1 ***

| ↓ | C1 | C2 | C3 | C4 | C5 | C6 |
|---|---|---|---|---|---|---|
| | Tool Material | Speed | Feed | Depth of Cut | Surface Roughness Ra (µm) | MRR (cm3/sec) |
| 1 | 1 | 1000 | 80 | 0.5 | 0.418 | 0.129 |
| 2 | 1 | 1000 | 120 | 1.0 | 0.544 | 0.407 |
| 3 | 1 | 1000 | 160 | 1.5 | 0.717 | 0.913 |
| 4 | 1 | 1200 | 80 | 1.0 | 0.533 | 0.658 |
| 5 | 1 | 1200 | 120 | 1.5 | 0.789 | 0.717 |
| 6 | 1 | 1200 | 160 | 0.5 | 0.767 | 0.162 |
| 7 | 1 | 1400 | 80 | 1.5 | 1.217 | 0.824 |
| 8 | 1 | 1400 | 120 | 0.5 | 0.913 | 0.142 |
| 9 | 1 | 1400 | 160 | 1.0 | 0.877 | 0.421 |
| 10 | 2 | 1000 | 80 | 0.5 | 0.548 | 0.133 |
| 11 | 2 | 1000 | 120 | 1.0 | 0.727 | 0.434 |
| 12 | 2 | 1000 | 160 | 1.5 | 1.528 | 0.685 |
| 13 | 2 | 1200 | 80 | 1.0 | 0.481 | 0.394 |
| 14 | 2 | 1200 | 120 | 1.5 | 0.852 | 1.021 |
| 15 | 2 | 1200 | 160 | 0.5 | 0.724 | 0.152 |

International Journal of Research
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By observing P – value from above table, it can be found that the most important parameter for Surface Roughness are Depth of cut, Speed.

**Modal Summary of SR**

| S | R-sq | R-sq(adj) | R-sq(pred) |
|---|---|---|---|
| 0.139018 | 76.34% | 72.89% | 61.06% |

The optimization carried out is good as the R-Sq is 76.34%.

**Coefficients of SR**

| **Term** | **Coef** | **SE Coef** | **T-Value** | **p-Value** | **VIF** |
|---|---|---|---|---|---|
| Constant | -0.179 | 0.341 | -1.76 | 0.092 | |
| Tool Material | 0.0374 | 0.0465 | 0.80 | 0.430 | 1.00 |
| Speed | 0.000541 | 0.000233 | 2.33 | 0.029 | 1.00 |
| Feed | 0.00095 | 0.00116 | 2.32 | 0.030 | 1.00 |
| Depth of cut | 0.150 | 0.0930 | 3.90 | 0.001 | 1.00 |

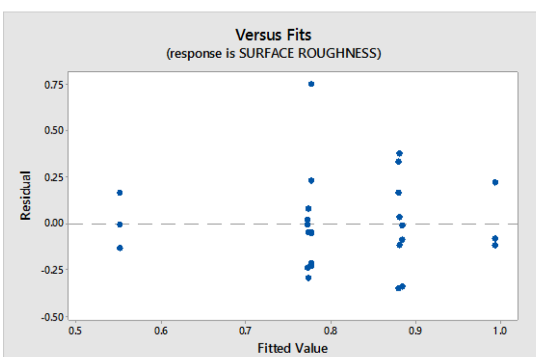
The probability (p) values were used as a tool to check the significance of each of the coefficients. A smaller p-value denote greater significance of the corresponding coefficient.

**Regression Equation for SR**

SURFACE ROUGHNESS = -0.179 + 0.0374 TOOL MATERIAL + 0.000541 SPEED + 0.00095 FEED RATE+ 0.150 DEPTH OF CUT

**Fits and Diagnostics for Unusual Observations**

| Obs | SR(Ra) | Fit | Resid | Std Resid |
|---|---|---|---|---|
| 12 | 1.5280 | 0.9906 | 0.5374 | 3.05 |




**Residual Vs Fits (Response – Surface Roughness)**

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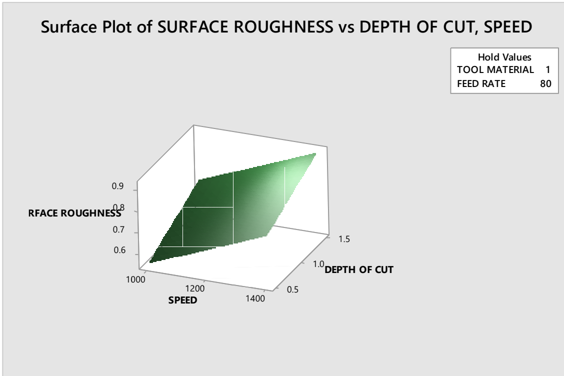
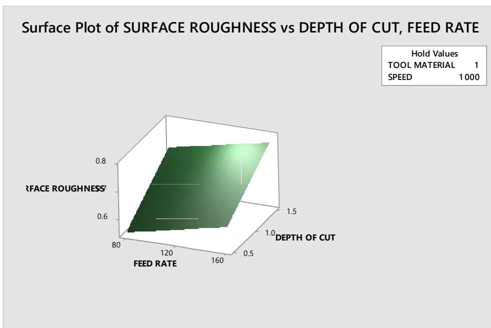


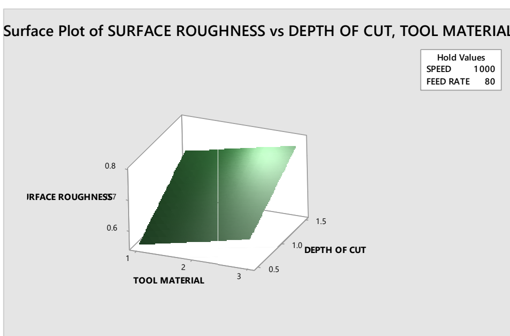

**Surface Plot of Surface Roughness vs Depth of Cut, Speed**

By observing above graph, to minimize surface roughness, the Speed should be set at 1000rpm and Depth of Cut at 0.5mm.




**Surface Plot of Surface Roughness vs Depth of Cut, Feed Rate**

By observing above graph, to minimize surface roughness, the Feed Rate should be set at 80mm/min and Depth of Cut at 0.5mm.




**Surface Plot of Surface Roughness vs Depth of Cut, Tool Material**

**REGRESSION ANALYSIS: MRR VERSUS TOOL MATERIAL, SPEED, FEED RATE, DEPTH OF CUT**

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**Analysis of Variance of MRR**

| Source | DF | Adj SS | Adj MS | F-Value | P-Value |
|---|---|---|---|---|---|
| Regression | 4 | 3.07028 | 0.76757 | 39.72 | 0.001 |
| Tool Material | 1 | 0.06125 | 0.06125 | 3.17 | 0.089 |
| Speed | 1 | 0.08134 | 0.08134 | 4.21 | 0.052 |
| Feed | 1 | 0.06686 | 0.06686 | 3.46 | 0.076 |
| Depth of cut | 1 | 2.86083 | 2.86083 | 148.03 | 0.000 |
| Error | 22 | 0.42517 | 0.01933 | | |
| Total | 26 | 3.49545 | | | |

By observing P – value from above table, it can be found that the most important parameter for MRR is Speed.

**Model Summary of MRR**

| S | R-sq | R-sq(adj) | R-sq(pred) |
|---|---|---|---|
| 0.139018 | 87.84% | 85.62% | 80.94% |

The optimization carried out is good as the R-Sq is 87.84%

**Coefficients of MRR**

| Term | Coef | SE Coef | T-Value | p-Value | VIF |
|---|---|---|---|---|---|
| Constant | 0.203 | 0.240 | -2.49 | 0.021 | |
| Tool Material | 0.0583 | 0.0328 | 1.78 | 0.089 | 1.00 |
| Speed | 0.000336 | 0.000164 | 2.05 | 0.052 | 1.00 |
| Feed | -0.00078 | 0.000819 | 2.32 | 0.030 | 1.00 |
| Depth of cut | -0.093 | 0.0930 | 3.90 | 0.001 | 1.00 |

The probability (p) values were used as a tool to check the significance of each of the coefficients. A smaller p-value denotes greater significance of the corresponding coefficient.

**Regression Equation for MRR**

MRR = 0.203 + 0.0583 TOOL MATERIAL + 0.000336 SPEED - 0.00078 FEED RATE - 0.093 DEPTH OF CUT

**Fits and Diagnostics for Unusual Observations**

| Obs | MRR | Fit | Resid | Std Resid |
|---|---|---|---|---|
| 25 | 1.4210 | 1.1222 | 0.2988 | 2.50 |

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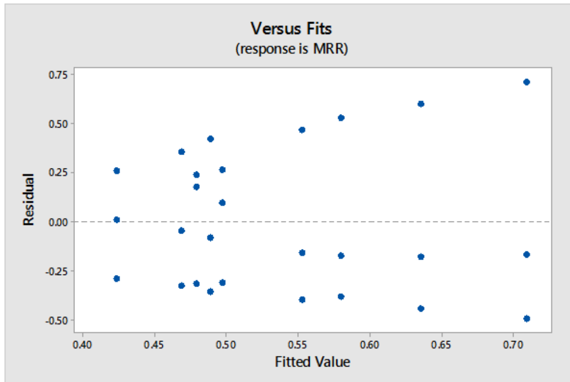
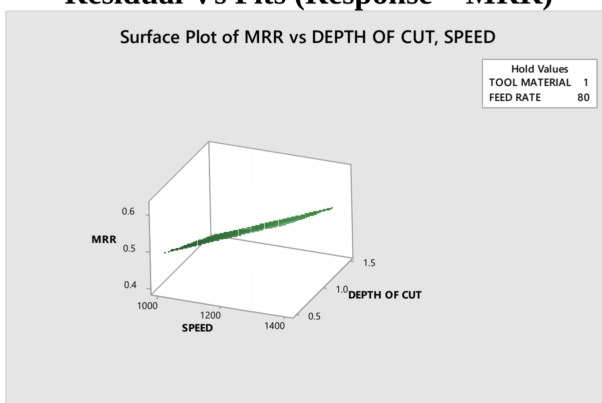
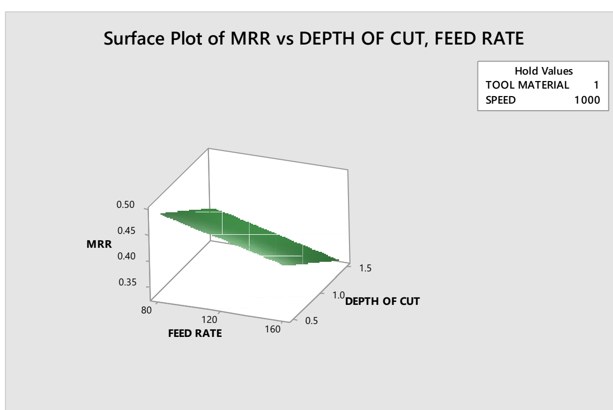



**Residual Vs Fits (Response – MRR)**




**Surface Plot of MRR vs Depth of Cut, Speed**

By observing above graph, to maximize MRR, the Speed should be set at 1400rpm and Depth of Cut at 0.5mm.




**Surface Plot of MRR vs Depth of Cut, Feed Rate**

By observing above graph, to maximize MRR, the Feed Rate should be set at 80mm/min and Depth of Cut at 0.5mm.

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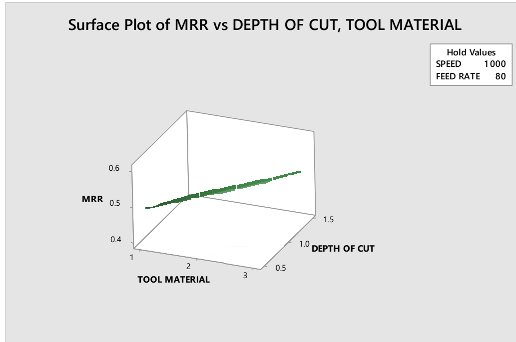
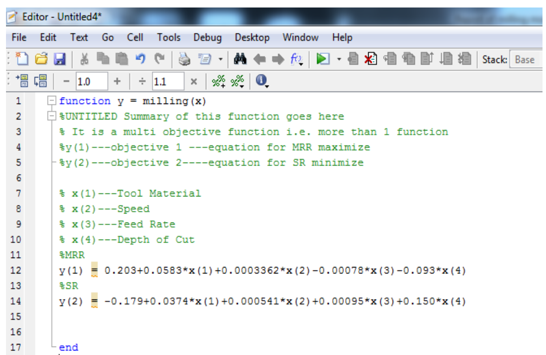



**Surface Plot of MRR vs Depth of Cut, Tool Material**

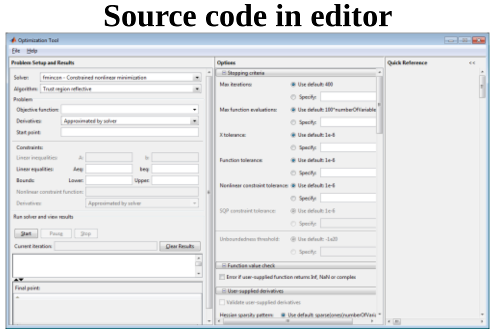
From the above graph, to maximize MRR, the Tool Material should be taken is Ceramic Coated Carbide and Depth of Cut at 0.5mm.

## Multi objective Genetic Algorithm in Matlab

The source code in editor




**Source code in editor**



**Optimization Tool**

## GA control parameters

| | |
|---|---|
| Population size: | 60 |
| Number of generations (Maximum) | 60 |
| Crossover probability (%): | 85 |
| Mutation probability (%): | 5 |
| Reproduction probability (%): | 10 |
| Selection method: | Tournament |

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| Fitness measure: | R2 |
|---|---|

## RESULT

Pareto front - function values and decision variables

| Index | f1 | f2 | x1 | x2 | x3 | x4 |
|---|---|---|---|---|---|---|
| 1 | 0.487 | 0.559 | 1.022 | 1,004.452 | 84.834 | 0.502 |
| 2 | 0.357 | 0.753 | 1.015 | 1,004.709 | 133.5 | 1.49 |
| 3 | 0.487 | 0.559 | 1.022 | 1,004.452 | 84.834 | 0.502 |
| 4 | 0.363 | 0.745 | 1.029 | 1,004.708 | 133.437 | 1.432 |
| 5 | 0.427 | 0.648 | 1.028 | 1,004.576 | 115.703 | 0.902 |
| 6 | 0.36 | 0.749 | 1.017 | 1,004.758 | 133.2 | 1.466 |
| 7 | 0.424 | 0.657 | 1.034 | 1,004.598 | 105.269 | 1.026 |
| 8 | 0.38 | 0.727 | 1.074 | 1,004.666 | 125.528 | 1.35 |
| 9 | 0.467 | 0.585 | 1.037 | 1,004.517 | 109.987 | 0.518 |
| 10 | 0.443 | 0.623 | 1.024 | 1,004.533 | 108.189 | 0.786 |
| 11 | 0.436 | 0.625 | 1.009 | 1,004.598 | 130.985 | 0.657 |
| 12 | 0.381 | 0.716 | 1.019 | 1,004.689 | 131.52 | 1.253 |
| 13 | 0.41 | 0.676 | 1.037 | 1,004.575 | 117.269 | 1.076 |
| 14 | 0.481 | 0.568 | 1.026 | 1,004.55 | 90.626 | 0.525 |
| 15 | 0.45 | 0.606 | 1.002 | 1,004.605 | 117.925 | 0.616 |
| 16 | 0.429 | 0.643 | 1.028 | 1,004.572 | 119.748 | 0.845 |
| 17 | 0.413 | 0.663 | 1.016 | 1,004.643 | 133.181 | 0.894 |
| 18 | 0.432 | 0.635 | 1.031 | 1,004.552 | 130.511 | 0.722 |
| 19 | 0.448 | 0.614 | 1.026 | 1,004.554 | 113.295 | 0.69 |
| 20 | 0.403 | 0.684 | 1.037 | 1,004.629 | 125.042 | 1.08 |
| 21 | 0.388 | 0.715 | 1.087 | 1,004.616 | 126.587 | 1.265 |
| 22 | 0.475 | 0.575 | 1.022 | 1,004.535 | 93.827 | 0.556 |
| 23 | 0.368 | 0.741 | 1.045 | 1,004.564 | 126.671 | 1.447 |

**Function values and decision variables**

Where f1:Material Removal Rate(cc/sec);
f2:Surface Roughness Ra(µm);
x1:Tool Materilal;
x2:Speed;
x3:Feed;
x4:Depth of cut.

As it can be observed from the Figure 5.24, no solution in the front is better than any other. The choice of a solution has to be made purely based on production requirements. For example, if a manufacturing engineer chooses to machine a component with a surface quality of **0.559µm,** he can select the set of input variables from Figured Table 5.24 accordingly; he would achieve the max MRR and fine Surface Quality.

From the above figure, it can be observed that the optimum parameters for achieving minimum surface roughness and maximum material removal rates are as follows:

- Tool Material is 1 (i.e) HSS, Speed – 1000rpm, Feed Rate – 80mm/min, Depth of Cut – 0.5mm.

## RESULTS AND DISCUSSIONS

In the report the study of influence of process parameters on the responses of surface roughness, Material Removal Rate are carried out. The process parameters considered in the present study are speed, feed, depth of cut. The process parameters are optimized for multi objectives of Surface Roughness, MRR by using Genetic Algorithm. The experimental values are obtained from experiments conducted as per plan presented in orthogonal array. Normally, higher value of Material removal rate (MRR) and smaller value of Surface roughness (SR) are desired.

By the application of Genetic algorithm the parameters are optimized based on the empirical model developed through Regression Analysis. Result table gives the optimized results and from this it can be observed that the experiment number 1 has the smallest Surface roughness with value of **0.559µm** and highest MRR with value of 0.487 **cc/sec**.

## CONCLUSION

Different experiments are conducted to optimize the process parameters to improve the surface finish quality and material removal rate of Aluminun alloy 7475. A series of experiments are done by varying the milling parameters tool material, spindle speed, feed rate and depth of cut considering L27 orthogonal array by Taguchi Method. The optimization is done for least surface roughness and high material removal rates.

The experiment has been done with process parameters feed rate 80mm/min, 120mm/min, 160 mm/min, spindle speeds are 1000rpm, 1200rpm, 1400rpm, and depth of cut 0.5mm, 1mm and 1.5mm and tool material High Speed Steel, Tungsten Carbide and Ceramic Coated Carbide.

Empirical model is done by Regression Analysis using Minitab 17 software.By observing the experimental results and by optimizing the parameters using Regression Analysis, the following conclusions can be made:

- To get better surface finish the optimized parameters are Tool Material - HSS, Speed – 1000rpm, Feed Rate – 80mm/min, Depth of Cut – 0.5mm.
- To get high MRR the optimized parameters are Tool Material – Ceramic Coated Carbide, Speed – 1400rpm, Feed Rate – 80mm/min, Depth of Cut – 0.5mm.

The multi-objective Genetic Algorithm optimization technique determines quantitatively the relationship between surface roughness and material removal rate with optimal combination of machining parameters is established. Mathematical models (i.e) equations for optimization are calculated in Regression Analysis for minimizing Surface Roughness and maximizing MRR.

The optimum process parameters from multi objective Genetic Algorithm optimization are Tool Material - HSS, Speed – 1000rpm, Feed Rate – 80mm/min, Depth of Cut – 0.5mm.

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 01
January 2018

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