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OPTIMIZATION OF SURFACE ROUGHNESS AND MRR IN CNC MILLING MECHINING OF ALUMINIUM 6061

BANOTH.SREENIVAS *[1] G. GOPINATH *[2]
1* Student, Department of Mechanical Engineering, M. tech (CAD/CAM) JBIET, Telangana 500075
2* Assistant Professor, Department of Mechanical Engineering, JBIET, Telangana 500075
Email id: anothsreenivas.s@gmail.com

ABSTRACT
The objective of the project is to obtain an optimal setting of CNC machining process parameters, cutting speed, feed rate resulting in optimal values of the feed and cutting forces while machining Al 6061, the cutting tool tungsten's carbide inserts. the sub-sequent optimal settings of the parameters and the effects of the selected process parameters on the special characteristics have been accomplished using Taguchi's parameter design method The process parameters considered are – Cutting speed 3000rpm, 2500rpm, and 2000rpm. Feed rate 300mm/min, 400mm/min and 500mm/min and depth of cut is 0.5mm, 0.6mm and 0.7mm. The effect of these parameters on the surface roughness and material removal rate is considered for analysis. The thrust force and feed force are also taken experimentally using a dynamometer for the above Cutting speeds, feed rate, and depth of cut. The optimal values for speed, feed rate, and depth of cut are taken by using the orthogonal L09 Taguchi technique in Minitab software. The process used milling process of the Machine selected is a Vertical CNC milling center.
Key words: Al 6061, Cutting speeds, Taguchi technique, Minitab software

1.0 INTRODUCTION

The milling machine is one of the most critical operations of machining. In this process, the part of the milling is fed in contrast to a cylindrical rotating device. The revolving unit has several points of the cut (more point cutting device). Rotation feed usually axis provided to the workpiece Milling operation is based on the proof of the location between the system axis and the feeding route from other machining operations, but in other operations as a drilling, milling and so on. In this context. The instrument is fed into the direction that is relative to the rotation axis. The cutting tool used in the milling process is known as a flipping cutter that includes extra teeth than one power.

Surface Roughness:

Response surface method proposes a holistic view of quality, which relates quality to cost, not just to the manufacturer at the time of production, but to the customer and society as a whole. It defines quality as, "The quality of a product is the (minimum) loss imparted by the product to the society from the time product is shipped." This economic loss is associated with losses due to rework, waste of resources during manufacture, warranty costs, customer complaints and dissatisfaction, time and money spent by customers on failing products, and eventual loss of market share.

Aluminium-6061:

Aluminum- 6061 is a precipitation hardened alloy, containing magnesium and silicon as its major alloying elements. Originally called Alloy 61S. It has good mechanical properties, exhibits good weldability and is very commonly extruded. It is one of the most common alloys of aluminum for general purpose use.

The alloy composition of 6061 is:

- Silicon minimum 0.4%, maximum 0.8% by weight
- Iron no minimum, maximum 0.7%
- Copper minimum 0.15%, maximum 0.4%
- Manganese no minimum, maximum 0.15%
- Magnesium minimum 0.8%, maximum 1.2%
- Chromium minimum 0.04%, maximum 0.35%
- Zinc no minimum, maximum 0.25%
- Titanium no minimum, maximum 0.15%

CNC Milling Machine: The regulation of the surface texture together was established with additional precision demands of today's engineering products. This study examines the different methods of optimization used to maximize surface ruggedness during final framing operations. Traditional workflows take a lot of effort and time. The methods cannot be as accurate as possible. It becomes simple and precise with the invention of CNC machines to perform different processes. Modern technology and a new generation of production equipment, particularly computer numerical control (CNC), have changed the manufacturing sector tremendously. In general, the manual or human experience is utilized to pick convenient computer parameters.

Fig 1.1: CNC milling machine

The study of surface roughness in the CNC method of finished milling is a major development challenge. In order to achieve the desired surface quality, many factors involved in the machining must be optimized machining parameters (spindle velocity, feed rate, and depth of cut) are taken into account in this research. Computer Numerical Control (CNC) is the control of a machine tool's functions and motions via a program that includes coded alphanumeric data.

OBJECTIVE OF WORK:

The main aim of the project is to improve the consistency and removal of material from workpieces made of aluminum alloy 6061 by using carbide spikes. The sort is the tip of the bullnose. Variation of milling parameters spindle speed, feed rate and cutting depth can perform a number of experiments. The spindle speeds are 3500/min, 3000/min, and 2000/min. Feed rates of 200mm/min, 300mm/min and 400mm/mon are given. The cutting depth is 0,2 mm, 0,3- and 0,4-mm. DOE (experimental designs) developed in MINITAB Software by TAGUCHI Technique. On the CNC milling gadget experiments with the following parameters are carried out:

2.0 LITERATURE REVIEW:

Mandeep Chahal et al. [1] Surface performance has become more relevant with more accurate demands of modern manufacturing goods. This study outlines the Taguchi technique for optimizing cutting parameters in finish milling operations. The research was carried out in the machining of tough H-13 steel die. The task was carried out under final conditions by using solid carbide four flute end-mill instruments.

M Maiyer et al. [2] Use Taguchi-based gray relational analysis to optimize the machining parameters for end-frying of the Inconel 718 superalloy. Optimized with consideration of surface ruggedness and material removal rate, feed rate and cut depth (MRR). Used 10mm diameter and 4 flute uncoated carbide method. The Response surface method's orthogonal array L9 is used.

Alauddin et al. [3] "Surface finish optimization process in Al7075 End Friction by using a dry tungsten carbide insert" was investigated Study. Cutters are cutting instruments that are normally used in friction machines or machining centres (and occasionally in other machine tools).

Piyush Pandey et al. [4] "Parametric optimization of CNC tool end framing in varying situation" has been experimented in 2013. Solid Carbide and Mild Steel workpiece were used as the tool used for the test. The test has been competently conducted and completes its whole optimization objective.

M. Aruna et al. [5] In 2012 Inconel said 718; a nickel-based superscript is a widespread alloy that secretariat weighing approximately 50% equipment, mainly in the gas turbine market, for an aero engine. When Inconel 718 is turned with ceramic inserts, the paper focuses on enhancing surface ruggedness. The device relies on the answering process (RSM).

3.0 METHODOLOGY

Surface finishing is one of the most important quality aspects of production, affecting both the efficiency of the mechanical components and the price of the production. In practice, several factors influence surface ruggedness, e.g., MRR conditions for cutting, instrument variables and workpiece variables. The cutting conditions include cutting speed, feed, and depth, while the tool variables are tool material, nose range, rake angle, cutting edge geometry, vibration, overhang of tooling, angle of tool point, and so on. Variable workpiece includes hardness of material and other mechanical properties. The Taguchi robust technique for designing the optimal conditions of the experimental data is used in this work. For Mean Analysis (ANOM) and Variance Analyses, statistical software Minitab

15.0 is used (ANOVA). Efficiency in producing this information is important for marketing windows, low production and development costs and goods of high quality. Robust design is a method of engineering to increase production when designing and developing to ensure that high quality goods can be manufactured at low cost.

Fig. 3.1: Experimental analysis

Taguchi method is a technique, in conjunction with statistical analyses, which essentially improves the quality of the product or process, in order to minimize product variability in order to manufacture products that are of higher quality. Robust design is based on the optimization principle, which specifies the objective function as a signal to note ratio, helping to identify the design parameter values where the response to different noise effects is less sensitive

Experimentation through robust design method:

The robust design methodology involves the following steps. The entire experimentation was done through eight steps. These steps are as follows.

Step1: Identify the principal feature, side effects and modes of failure. This phase involves awareness of the product or process and the environment of the company.

Step2: Classification of the test conditions for the assessment of noise and loss of efficiency. To capture the effect of the more significant noise variables, the test conditions are chosen. The test conditions must ensure that noise factor sensitivity for any combination of control factor levels is consistent.

Signal-to-Noise ratio:

Dr. Taguchi has formulated the Noise Ratio Signal Theory in a strong design in order to test device efficiency. This transforms the data into a new value that shows the current variance. The signal-to-noise rate indicates the degree of revisable output of a product or process in the presence of noise factors. The ratio of signal to noise combines predictable output fluctuation and unpredictable signal levels.

Analysis of Variance (ANOVA): Variance analysis is a statistically based, objective decision-making technique to find variations in the average output of a tested group of items. The decision takes account of variation rather than of absolute judgement. In the 1930s, Sir Ronald Fisher invented this approach to understand the effects of agricultural experiments. The key benefit of ANOVA performance is to assess the relative value of variables and the other differences. ANOVA is one of the most important instruments used to calculate this with robust nature and can make the percentage contribution of the factor to the method or characteristic of quality. ANOVA makes some assumptions. Specifically, the factor taken for the analysis of the process is a major or negligible factor in the F-test process and contributes to the process by the percentage of the respective factor.

EXPERIMENTAL DESIGN AND SETUP

In the field of the science behind experiential sensation, each experimenter must prepare and carry out research in order to receive adequate and applicable information.

Basic concepts of Taguchi design of experiments Every array is for a certain number of independent design variables and levels although several regular orthogonal arrays are available. For example, if you want to experiment to understand the effect of 4 separate variables with three values (level values) in each variable, an orthogonal array of L09 might be the right option. The orthogonal array L09 is

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intended to understand the effect of four independent factors with 3-factor level values each. This array assumes that two variables are not interactive.

Table: The layout of the L_{09} orthogonal array.

L_{09} (3^4) Orthogonal array					
	Independent variables				Performance Parameter Value
Experiment	Level 1	Level 2	Level 3	Level 4	
1	1	1	1	1	p1
2	1	2	2	2	p2
3	1	3	3	3	p3
4	2	1	2	3	p4
5	2	2	3	1	p5
6	2	3	1	2	p6
7	3	1	3	2	p7
8	3	2	1	3	p8
9	3	3	2	1	p9

Input Parameters

Cutting Tool Material –Cemented Carbide Tool
Work Piece Material – Aluminum Alloy 6061
Feed – 200mm/min, 300 mm/min, 400 mm/min
Cutting Speed – 3500rpm, 3000rpm, 2000rpm,
Depth of Cut – 0.2mm, 0.3 mm, 0.4 mm

Table: Process parameter values and level

PROCESS PARAMETERS	LEVEL1	LEVEL2	LEVEL3
CUTTING SPEED (rpm)	3500	3000	2000
FEED RATE (mm/min)	200	300	400
DEPTH OF CUT (mm)	0.2	0.3	0.4

Design 0f experiment in L09 Taguchi Orthogonal Array

Design requirements are shown on the desk and their values. It was also determined to look at the interaction results of two issues with process parameters on selected features simultaneously to milling. The interactions were between cutting speed and feed (AXB), feed charge and cutting strength (BXC), cutting speed and cutting distances.

Table: Design of experiment in L09 orthogonal array

Exp. No.	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)
1	2000	200	0.2
2	2000	300	0.3
3	2000	400	0.4
4	3000	200	0.3
5	3000	300	0.4
6	3000	400	0.2
7	3500	200	0.4
8	3500	300	0.2
9	3500	400	0.3

Design of Orthogonal Array

First Taguchi Orthogonal Array is designed in Minitab19 to calculate SIGNAL TO NOISE RATIOS ratio which steps is given below:

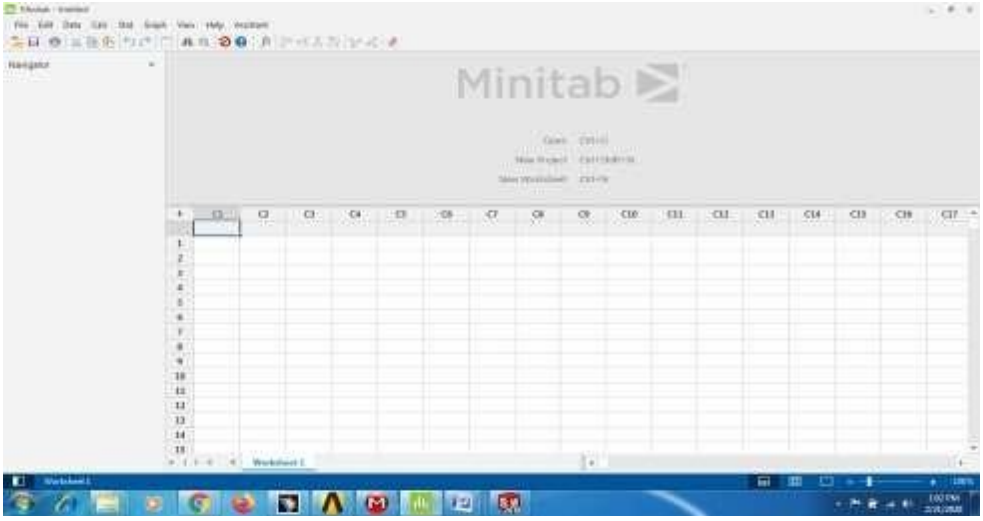

Fig 4.1: Open the Mini Tap Software

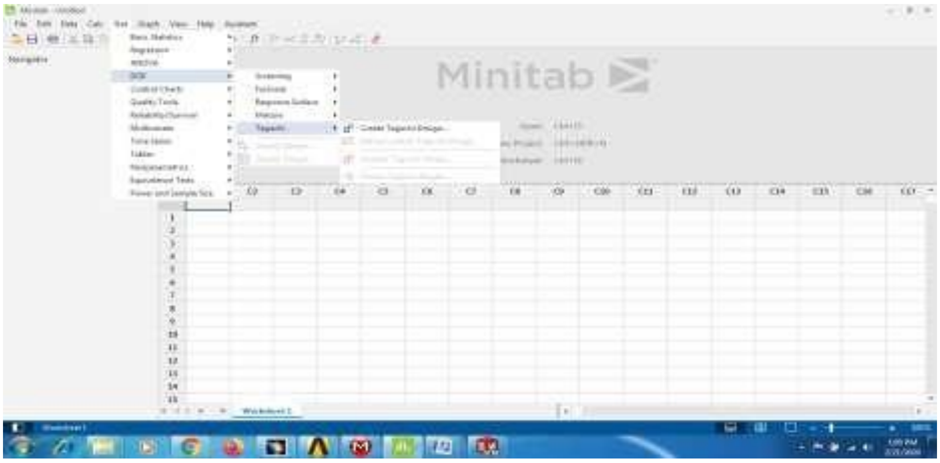

Figure: Taguchi design selection process

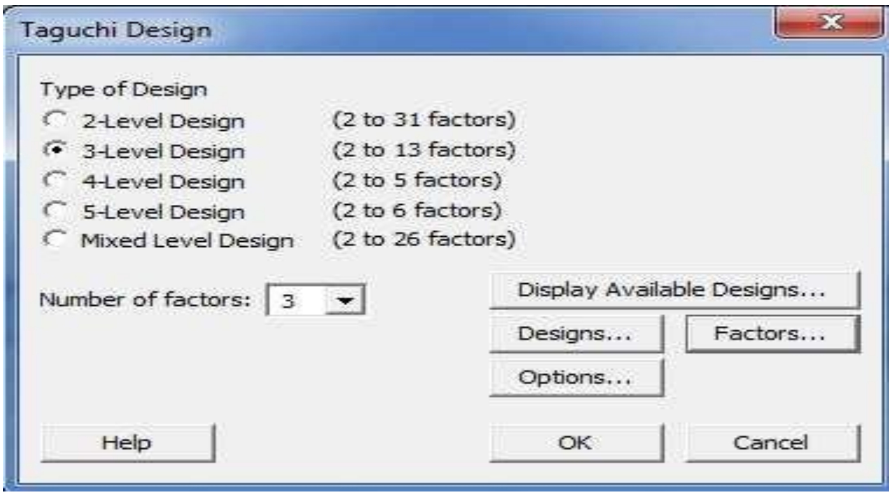

Figure: Taguchi level design

Factors

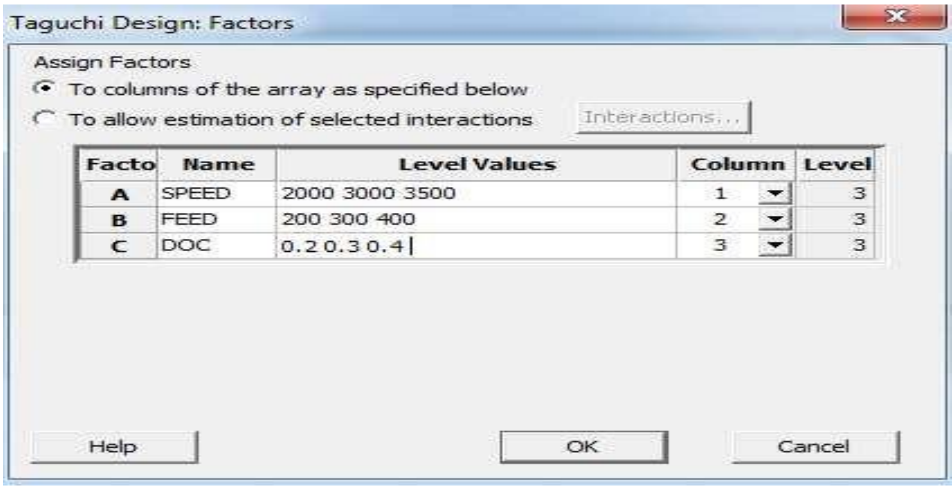

Figure: Taguchi design factors

Figure: CNC milling machine

Figure: Milling insert cutter

The cutter is designed with a positive axial rake angle that allows the insert to cleanly and quietly shear the workpiece materials.

4.0 RESULTS AND DISCUSSION

The Tal surf is a high precision instrument for measuring ruggedness and onset. The low noise axes and high-resolution measuring indicators ensure integrity of calculations.

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SURFACE ROUGHNESS VALUES

Table: Material removal rate values of Al 6061

EXP NO.	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)	MRR (cm^3/min)
1	2000	200	0.2	1.339
2	2000	300	0.3	1.5996
3	2000	400	0.4	1.7999
4	3000	200	0.3	1.67956
5	3000	300	0.4	1.91952
6	3000	400	0.2	1.43
7	3500	200	0.4	1.11
8	3500	300	0.2	1.27
9	3500	400	0.3	2.15946

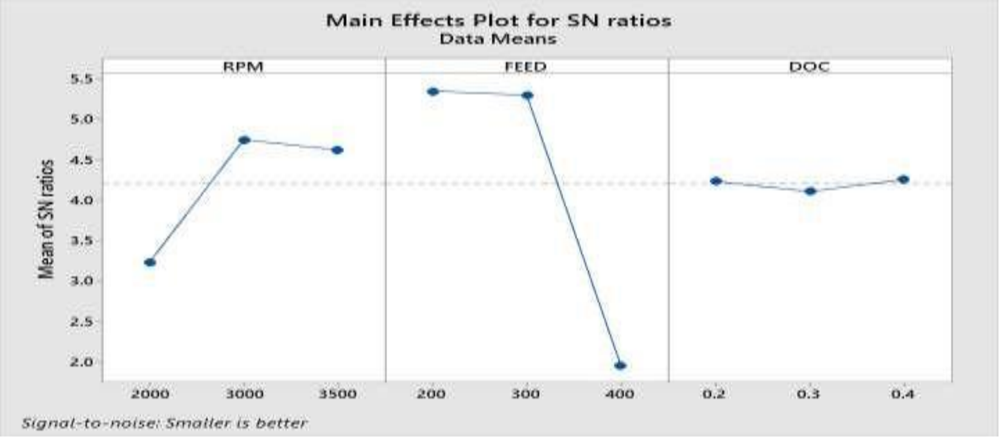
Optimization of Surface Roughness Using Minitab Software

Taguchi Analysis:

Linear Model Analysis: SN ratios versus RPM, FEED, DOC

Table: Response Table for Signal to Noise Ratios

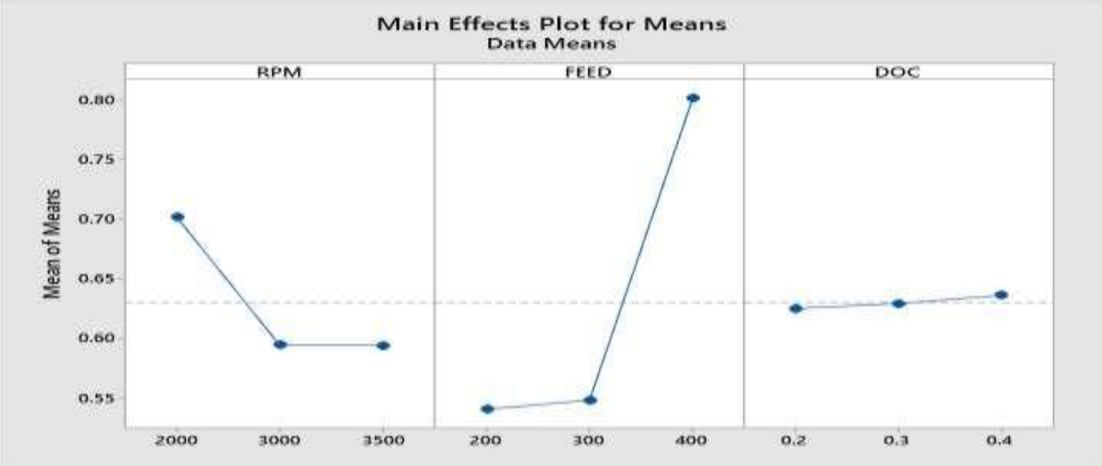
Level	RPM	FEED	DOC
1	3.232	5.348	4.235
2	4.748	5.298	4.108
3	4.621	1.955	4.258
Delta	1.516	3.393	0.150
Rank	2	1	3



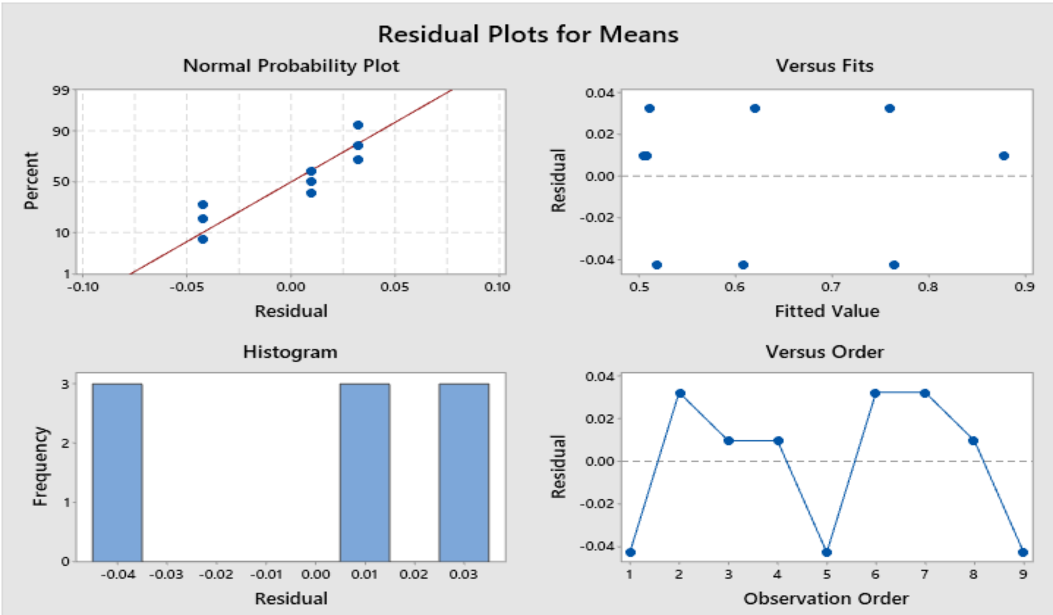
Graph: Main effects plots for Signal to noise ratios of surface roughness

Table: Response Table for Means

Level	RPM	FEED	DOC
1	0.7020	0.5407	0.6250
2	0.5943	0.5483	0.6293
3	0.5940	0.8013	0.6360
Delta	0.1080	0.2607	0.0110
Rank	2	1	3



Graph: Main effects plot for means of surface roughness



Graph: Residual plots for Means of surface roughness

The TAGUCHI method presses for the location to learn a signal-to-noise (SINGAL TO NOISE RATIOS) response difference, resulting in an in containable parameter reducing the value typical variation. The cutting force is considered as the value type with the concept of "the larger-the-better". The SINGAL TO NOISE RATIOS ratio for the larger-the-better is:

$$\text{Singal to noise ratios} = -10 *\log(\Sigma(Y^2)/n))$$

Where n is the number of measurements in the test/row, n=1 and y are the calculated value in the run/row in this case. The values of the signal to noise ratio are determined with the aid of the Minitab software 19. Table shows the force values measured from the experiments and their corresponding signal to noise values.

Analysis and Discussion

A greater signal-to-noise ratio is equivalent to higher efficiency regardless of performance characteristics category. Thus, the optimum standard is the highest value for the machining parameters.

CONCLUSION

In this thesis, the Taguchi Optimization Technique is used to optimize cutting limitations during aluminum 6061 high-speed milling using cemented carbide cutting tools by observing the experimental results and by TAGUCHI, the following conclusions can be made:

- Better surface finish, the optimal parameters are spindle speed – 3500rpm, feed rate – 200 mm/min, depth of cut – 0.3mm.
- optimal parameter of surface finish the Single to Noise ratios is 3.2586 and mean is 1.52282

- Better Material removal rate, the optimal parameters are spindle speed – 3500rpm, feed rate – 400mm/min, depth of cut – 0.3mm.
- The optimal parameter of material removal rates the Single to Noise ratios is 5.57622 and mean 1.94309

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