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PARAMETRIC OPTIMIZATION OF MACHINING PROCESS FOR MRR, SR & MT ON ALUMINIUM ALLOY 6082 USING TAGUCHI METHOD

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Abstract: AA6082 is an emerging alloy is used in various applications of aerospace engineering, automobile engineering etc. As per requirements of automobile industry etc. these materials may be get failed due to their mechanical properties like strength, hardness etc. Mechanical properties of these alloys can be improved with addition of reinforcements i.e. Graphite and B4C. In the present work, An AA6082 MMC was prepared on stir casting setup there after Optimization of machining parameter of CNC drilling with respect to process parameters was done by using L9 orthogonal array on Taguchi methodology.
Keywords: AA6082, Gr, B4C, L9 array, Cutting parameters, Spindle speed, feed and point angle, CNC drilling machine, MRR, SR & Machining timing, Taguchi method.
Nature of Study: Experimental.

I. INTRODUCTION

Composite materials are increasingly used in various fields of science & Engineering due to their unique properties such as high stiffness, light weight, good corrosive resistance, wear resistance high hardness etc. Drilling is easily the most common machining process. One estimate is that 75% of all metal cutting metal remove from drilling operation. Drilling operation is widely used in aero space, aircraft & automotive industries. This is accomplished most typically by using a Twist drill. The experiments were carried out on the basic of Taguchi L9 orthogonal array of experiments. Due to the improper selection of cutting parameters and cutting tool leads to reduce the cutting tool life, work piece surface finish and dimension accuracy of the work piece. The drilling machine highly used in a industry for metal removal operation. It is therefore essential to optimized quality and productivity simultaneously. The quality of the cut surface is strongly dependent on the cutting parameters, tool geometry, tool material, work piece material, machining process etc. In this research work the optimal cutting parameters spindle speed, feed rate and point angle of the drill bit for drilling operation is identified the MRR, SR & machining timing. The quality of design can be improved improving the quality and productivity. Taguchi parameter design offers a systematic method of optimization technique for various parameters with the regarding to performance quality and cost. The drilling machines are to importance aspect surface roughness, material removal rate and machining timing.

In the view of alone machining problems, the main objective of the present work is to investigate the influence of different cutting parameters on surface finish, machining timing and material removal rate criterion. The Taguchi L9 orthogonal array is utilized for experimental planning for drilling of Al, Gr &B4c Composite with H.S.S. drill in CNC Drilling Machine. The results are analyzed to achieve optimal surface roughness (SR), machining timing (MT) and material removal rate (MRR). Impact of drilling parameter industry such as Spindle Speed (1000, 1500 & 2000) in rpm; Feed rate (0.07, 0.14 & 0.21) mm/revolution, Point angle (90,100 & 110) degree. The drilling tool diameter is constant in 12mm. The tool is made by the high speed material (H.S.S.). The experimental result is collected analyzed used by Taguchi method. Taguchi proposed that the engineering optimization of a process should be carried out in three step approach. The Taguchi method use orthogonal array from design of experiments (DOE) theory of study of the large number of variables with a small number of experiments. The experiments results are then transformed in to a signal-to-noise (S/N) ratio. In the present work, statistical analysis software Minitab 16 was used for the design and analysis of experiments to perform the Taguchi.

1.1 HIGH SPEED STEEL

High Speed Steel is the most commonly used material for the drilling operation. High Speed Steel is used for making tool and we used tool diameter 12 mm in the drilling machine. This property allows High Speed Steel to drill faster than High Carbon Steel. Advent of High Speed Steel in around 1905 made a break through at that time in the history of cutting tool materials though got later superseded by many other novel tool materials like cemented carbides and ceramics which could machine much faster than the High Speed Steel (H.S.S.) tools. The basic composition of High Speed Steel (H.S.S.) is 18% W, 4% Cr, 1% V, 0.7% C and rest Fe.

1.2 MATERIAL AND EXPERIMENTION SETUP

For experiment the drilling operation is performed on Al, Gr & B4c composite and High Speed Steel (H.S.S.) drill is used. CNC Surya VF 30 CNC VS is used. The experiment parameter is designed in orthogonal array and Taguchi method is used for the analyzing. CNC drilling machine is in mutually perpendicular direction X, Y and Z. A high speed spindle with a speed range of 30 – 8000 rpm. The spindle speed is controlled through the Frequency converter which allows infinitely variable speed within the range. In this machine there is air cooling for coolant. The High Speed Steel (H.S.S.) drill of 12 mm diameter is used to perform the drilling operation. The cutting parameters are selected for the operation based on the three factors orthogonal array and experimental design.

Figure:- 1.1 Experimental Setup Of Vertical CNC Drilling Machine & Final Image Of Work piece

BSW	(MAKE)
BSMC/CNC 03	(MODEL NUMBER)
SURYA/VF/30/CNC/VS	(MACHINE NAME)

II. DRILLING MACHINING CONDATION

Work Condition	Description
Work Piece	Al/Gr/B4c Composite Rectangular Shape (161*113*26)
Spindle Speed	1000 -2000
Feed	0.07 – 0.21
Point Angle	90 – 110
Tool Diameter	12 mm

2.1 MATERIAL COMPOSITION

Al (6082)	1kg
Graphite	30gm
B4c	10gm

2.2 MACHINING CALCULATIONS

MRR = (3.14d^2/4) f N mm^3/min.

d= Diameter of drill in mm, f= Feed in mm/revolution & N= Spindle Speed in RPM.

III. METHODOLOGY

3.1 DESIGN OF EXPERIMENT (D.O.E.): Design of Experiment is a powerful approach to improve product design or improve process performance where it can be used to reduce cycle time required to develop a new product. It is a test that the input variable of a process is change so that observation and identifying corresponding changes in the output response can be verify. The result of the process is analyzed to find out the optimum value that has a most significant effect to the process. It consist of three phases Planning, Conducting, Analyzing Phase. The surface roughness (SR) is generally dependent on many parameters such as the tool geometry, tool material and work piece material. In the present study Spindle Speed, Feed Rate, and Point Angle have been selected as design factor and in the experiment the observed value of MRR, SR and the Machining Timing.

3.2 ANALYSIS OF S/N RATIO: In the Taguchi Method the term signal represents the desirable value (Mean) for the output characteristic and the term noise represents the undesirable value (Standard Deviation) for the output properties. Therefore the S/N ratio to the desirable value of the Standard Deviation. S/N ratio use to calculate the quality characteristic variable from the desired value. The S/N ratio S is define as S= -10 log (mean of sum square of reciprocal of measure data).

3.3 TAGUCHI DESIGN OF EXPERIMENT & TECHNIQUE: It is one the most powerful tool that provide simple. Effective and systematic approach for optimizing design based on cost, performance and quality. It is a multistep process that can optimize the parameter with the least number of iterations and hence same time effort for getting best response output. Analysis of experimental results is based on the evaluation of the means and analysis of variance of the results obtained. The result obtained were transfer into a S/N ratio. In this the large number of experiments have to be carried out when the number of the process parameter increased, to solve this problem, this method use a special design of orthogonal arrays to study the entire parameter. It provides a simple, efficient and systematic approach to optimized design for performance, quality and cost.

3.4 STEPS INVOLVED ARE

1. Determine of the quality characteristic to be optimized.
2. Identification of the noise factor and test condition.
3. Identification of the control factor and their alternative level.
4. Designing the matrix experiment and defining the data analysis procedure.
5. Conducting the matrix experiment.
6. Analyzing the data and determining the optimum level of control factor.
7. Predicting the performance at these levels.

3.5 EXPERIMENTAL WORK SETUP & PLAN OF EXPERIMENTS

In the present work Surya VF 30 CNC drilling machine is used to drill holes on the composite. In this three control factors were selected with three levels show in table..

Process Parameters	Parameters	Level -1	Level -2	Level -3	Observed Value
Spindle Speed	A	1000	1500	2000	MRR mm^3/min.
Feed	B	0.07	0.14	0.21	Ra
Point Angle	C	90	100	110	Machining Timing

The parameters selected for optimization of MRR, SR and Machining Timing is Spindle Speed, Feed and Point angle. Surface roughness test were carried on (Mitutoyo Surf test SJ-301) surface roughness machine. All the experiments were carried out at atmosphere conditions. In this study a composite of Al (6082), Graphite and Boron Carbide were prepared with the help of furnace. The work piece material specimen size (161*113*26). The drilling experiments conducted according to Taguchi L9 orthogonal array. The drill diameter is 12 mm with High Speed Steel (H.S.S.) drill is used. A Surya VF30 CNC drilling machine was used for conducting experiments. After conducting the experiment

Surface Roughness of drilled holes was measured in terms of end surface of the hole using a (Mitutoyo Surf test SJ-301) profile meter.

3.6 LAYOUT USING L9 ORTHOGONAL ARRAY

Run	Spindle Speed	Feed	Point Angle
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

3.7 THE EXPERIMENT CONDUCTED AS PER THE L9 ORTHOGONAL ARRAY GIVEN SHOW BY IN THE TABLE

Ex. No	SS	F	PA
1	1000	0.07	90
2	1000	0.14	100
3	1000	0.21	110
4	1500	0.07	100
5	1500	0.14	110
6	1500	0.21	90
7	2000	0.07	110
8	2000	0.14	90
9	2000	0.21	100

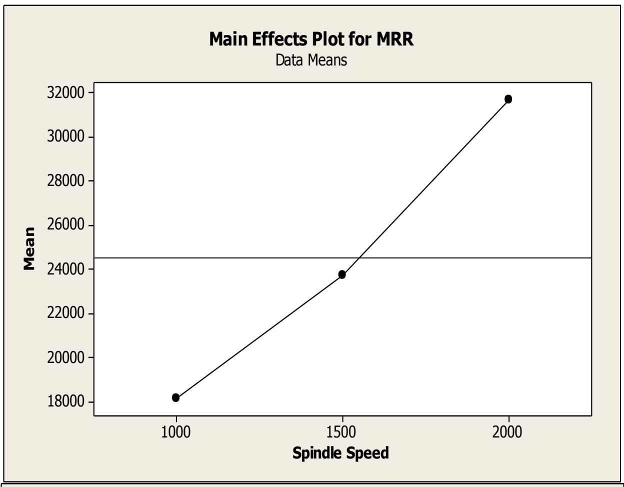
IV. ANALYSIS OF RESULTS AND DISCUSSION

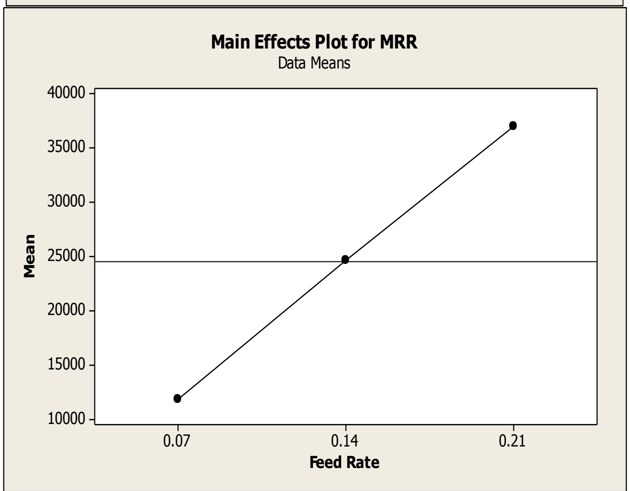
The results of MRR, SR, MT are show in the table. The experimental results were transformed in to S/N and mean ratio. The S/N ratio values for all responses are presented in the table.

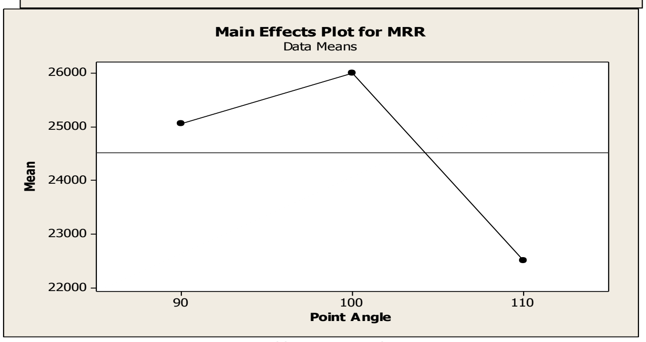
Ex. No	SS	F	PA	MRR	SR	MT
1	1000	0.07	90	7912.8	8.94	114
2	1000	0.14	100	18625.6	5.18	99
3	1000	0.21	110	27938.4	8.61	88
4	1500	0.07	100	11869.2	6.16	134
5	1500	0.14	110	23738.4	4.07	99
6	1500	0.21	90	35607.6	3.06	88
7	2000	0.07	110	15825.6	7.23	134
8	2000	0.14	90	31651.2	9.54	77
9	2000	0.21	100	47476.8	5.53	88

4.1 MAIN EFFECT PLOTS

The main effective graphical representation of change in performance characteristics with the variation in machining parameter level. In fig. show the response graph for three factors and three levels. They show the main effect on SR, MRR & MT.



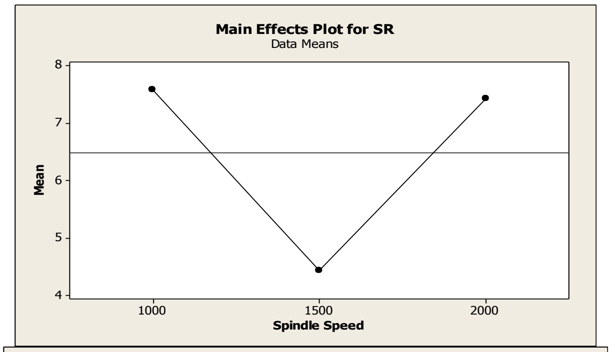


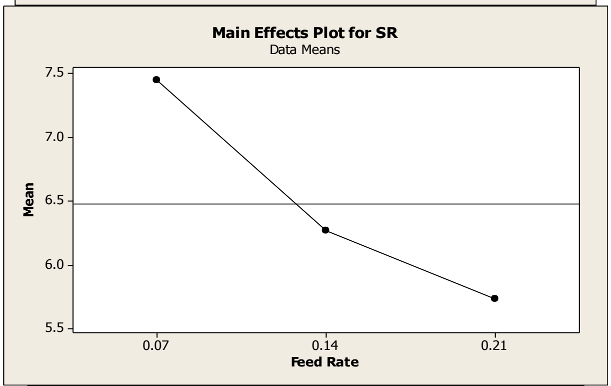


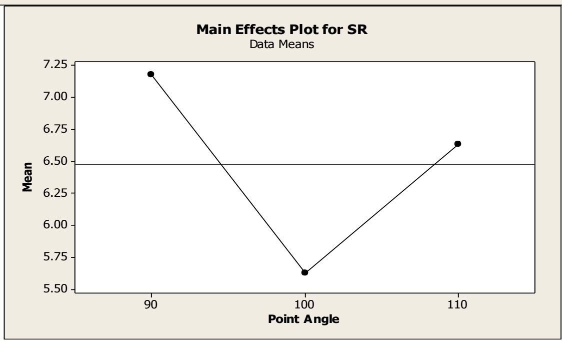
Main Effect Plot for MRR

4.2 MATRIAL REMOVAL RATE

Process parameter to the observed values MRR. The following discussion focuses on the effects of and based on Taguchi methodology. This dig. Show the main effect of MRR each factor for various level conditions. It was increase in spindle speed then increase in the Material Removable Rate. The increase in the feed rate then also increase in the MRR and the increase in the Point Angle the MRR firstly increase then decrease.



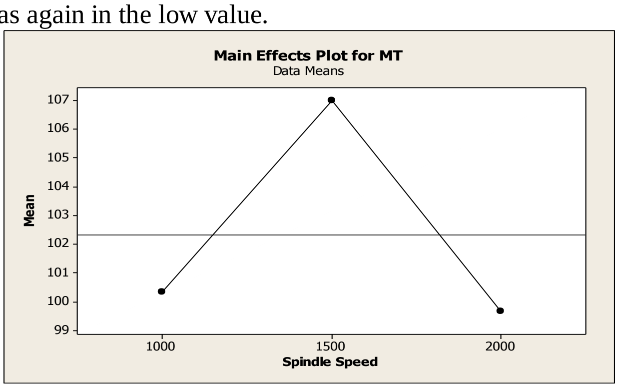


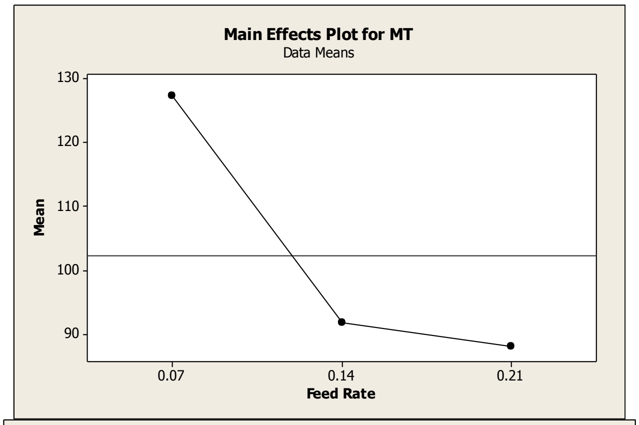


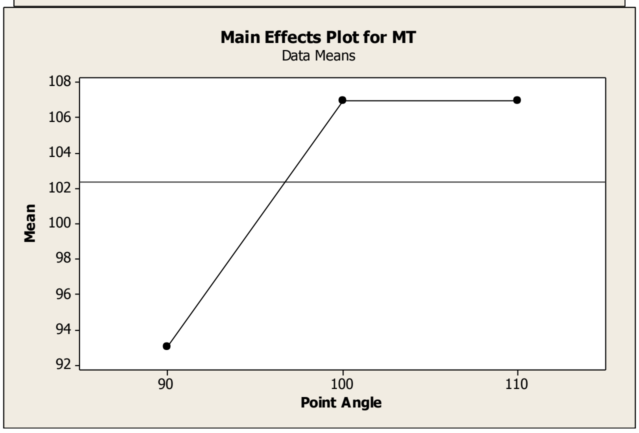
Main Effect Plot for SR

4.3 SURFACE ROUGHNESS

The main effect of SR of each factor for various level conditions. According to predicted optimal parameters setting we have conducted confirmation test and found surface roughness. It was increase in the Spindle Speed then Decrease and after some value it was increase in the Surface Roughness but in the case of the Feed Rate the SR will continue decrease of all values. With the use of Point Angle Firstly increase at high value and then decrease after that it was again in the low value.







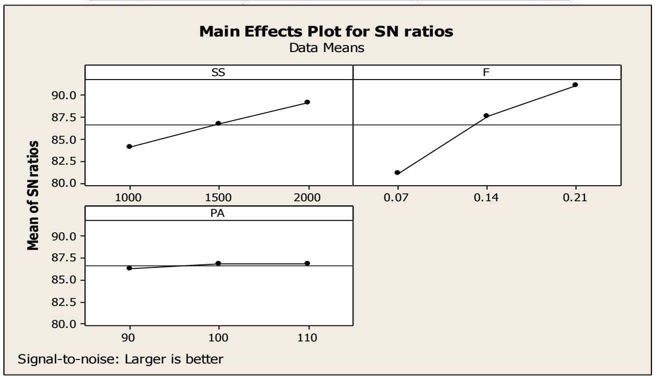
Main Effect Plot for MT

4.4 MACHINING TIMING

The main effect of MT of each factor for various levels condition. It was observed that Machining Timing Increase with the help of the increase in the Spindle Speed. In the case of the Feed Rate it was firstly increase then it was continuously decrease with the increase in the Feed Rate. But in the case of the Point Angle in the starting the MT decrease and as the value increase in the Point Angle the MT was also Increase continuously.

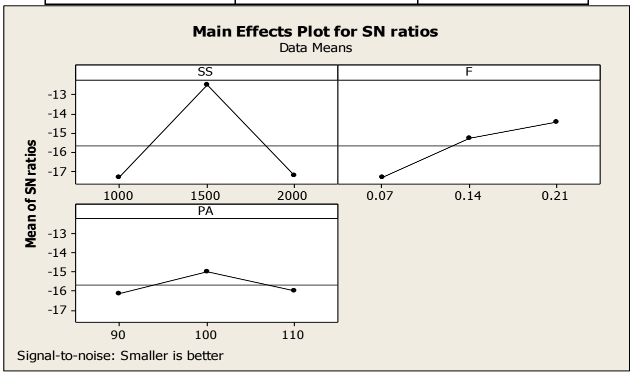
4.5 TABLE FOR SIGNAL TO NOISE RATIOS LARGER IS BETTER (MRR)

Level	SS	F	PA
1	84.10	81.15	86.34
2	86.68	87.64	86.81
3	89.17	91.16	86.81
Delta	5.08	10.01	0.47
Rank	2	1	3



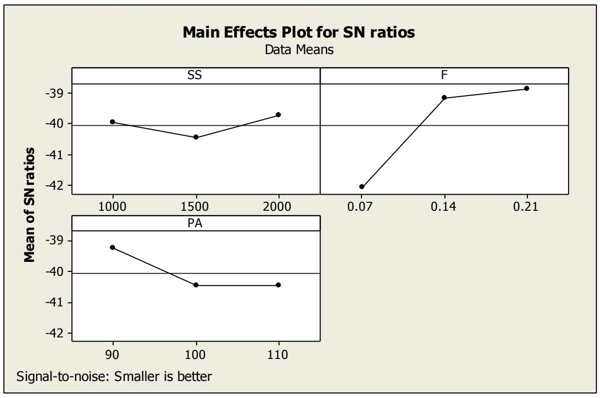
4.6 RESPONSE TABLE FOR SIGNAL TO NOISE RATIOS SMALLER IS BETTER (SR)

Level	SS	F	PA
1	-17.34	-17.33	-16.11
2	-12.52	-15.31	-14.98
3	-17.21	-14.42	-15.97
Delta	4.82	2.91	1.13
Rank	1	2	3



4.7 RESPONSE TABLE FOR SIGNAL TO NOISE RATIOS SMALLER IS BETTER (MACHINING TIMING)

Level	SS	F	PA
1	-39.98	-42.07	-39.25
2	-40.45	-39.19	-40.45
3	-39.72	-38.89	-40.45
Delta	0.73	3.18	1.20
Rank	3	1	2



4.9 FROM THE COMPUTATION RESULTS THE OPTIMUM SET OF MACHINING PARAMETERS WAS FOUND AS SHOWN IN THE TABLE.

OPTIMUM MACHINING PARAMETERS FOR HSS DRILL

Response	Feed rate (f) mm/rev.	Spindle Speed (N) rpm	Point Angle Degree
Surface Roughness	0.21	1500	90
Metal Removal rate	0.21	2000	100
Machining Timing	0.14	2000	90

V. CONCLUSIONS

This paper presents the optimization of cutting process parameters namely Spindle speed, Feed and Point Angle in drilling of Metal Matrix Composite using the application of Taguchi analysis examined the Surface Roughness, Machining Timing and MRR. In this paper discussed the feasibility of machining Metal Matrix Composite by drilling machine with a HSS tool. Taguchi has been used to determine the effects significant factors and optimum machining condition to the performance of drilling hole in Metal Matrix Composite based on the results presented.

- It was observed that with increasing the Feed Rate (mm/rev.) Material Removal Rate will be increased. Results of Taguchi techniques were compared and optimum machining parameters combination set up was suggested for maximum Material Removal Rate. It was identify that a Spindle Speed 2000 rpm, Feed Rate 0.21 mm/rev. and Point Angle 100* is the optimal combination of drilling parameters that produced a high value of Material Removal Rate (MRR).
- It was compared and optimum parameters combination setup was suggested for minimum Surface Roughness (Ra). It was indentify that a Spindle Speed 1500rpm, Feed Rate 0.21 mm/rev. and Point Angle 90* is optimal combination of drilling parameters that produced a low value of Surface Roughness (Ra).
- It was indentify that a Spindle Speed 2000 rpm, Feed Rate 0.14 mm/rev., Point Angle 90* is the optimal combination of drilling parameters that produced a low value of Machining Timing. Optimum machining parameters combination was found through Taguchi technique. Result of Taguchi technique was compared and optimum machining parameters combination setup was suggested for minimum Machining Timing (MT).

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