Investigation of Optimum Machining Parameters for Aluminum 7075 / Zirconium Composite by Using Taguchi and Rsm Methods

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ABSTRACT

Manufacturing of Aluminum alloy based casting composite materials via stir casting is one of the prominent and economical route for development and processing of metal matrix composites materials. Properties of these materials depend upon many processing parameters and selection of matrix and reinforcements. Literature reveals that most of the researchers are using 2, 6 and 7xxx Aluminum matrix reinforced with SiC (silicon carbide) particles for high strength properties whereas, insufficient information is available on reinforcement of "Al_2O_3" particles in 7xxx Aluminum matrix. The 7xxx series Aluminum matrix usually contains Cu-Zn-Mg.

Therefore, the present research was conducted to investigate the effect of elemental metal such as Zirconium oxide in Aluminum 7075 matrix. Mechanical properties Aluminum composite materials reinforced using simple foundry melting alloying and it done by stir casting route.

The age hardening treatments were also applied to study the aging response of the Aluminum matrix on strength, ductility and hardness. In this project we are going to take pure Aluminum 7075 alloy with the mixture of Zirconium oxide for the testing purpose. And the testing is done to find the tensile and hardness of the material results for the better matrix reinforced material.

Here machining is done on the Wire Cut EDM process and Taguchi methods is used to obtain the better parameters. Data obtained from the testing results will be analysed using Minitab 17 software.

INTRODUCTION

Casting is a manufacturing process in which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process. Casting materials are usually metals or various time setting materials that cure after mixing two or more components together; examples are epoxy, concrete, plaster and clay.

Casting is most often used for making complex shapes that would be otherwise difficult or uneconomical to make by other methods. Heavy equipment like machine tool beds, ship's propeller etc. can be cast easily in the required size rather than fabricating them by joining several small pieces

INTRODUCTION TO EDM

A machining technique generally used for hard metals, Electric discharge Machining (commonly called "EDM Machining") makes it possible to figure with metals that ancient machining techniques machining are ineffective. A crucial purpose to recollect with EDM Machining is that it'll solely work with materials that are electrically semiconducting.

With sensible EDM Machining instrumentation it's possible to chop tiny odd-shaped angles, elaborated contours or cavities in hardened steel similarly as exotic metals like Titanium, Hastelloy, Kovar, Inconel, and inorganic compound.

The EDM method is often employed in the Tool and Die business for mold-making, but in recent years EDM has become an integral half for creating model and production elements. This is often seen within the region and natural philosophy industries wherever production quantities stay low.

LITERATURE REVIEW

Within the paper by S V Subrahmanyam et al. [1] the optimization and improvement of Wire discharge Machining method parameters for the machining of H13 HOT DIE STEEL, with multiple responses Material Removal Rate (MRR), surface roughness (Ra) supported the Grey–Taguchi methodology. Taguchi's L27(21x38) Orthogonal Array was used conduct experiments, For that correspond to indiscriminately arbitrary chosen completely different mixtures of process method parameter setting, with eight method parameters: TON, TOFF, IP, SV WF, WT, SF, WP every to be varied in three completely different levels. Data knowledge associated with the every response viz. material removal rate (MRR), surface roughness (Ra) are measured for every experimental run With grey relative Analysis optimum levels of method parameters were known. The comparatively vital parameters were determined by Analysis of Variance. The variations of output responses with method parameters were mathematically shaped and designed by exploitation non-linear multivariate analysis. For any other material Mathematical relations between machining and characteristics of performance established

Within the paper by Atul Kumar et al. [2] variation of cutting performance with pulse on time, pulse off time, open voltage, feed rate override, wire feed, servo voltage, wire tension and flushing pressure were through an experiment investigated in wire spark machining (WEDM) method. Brass wire with zero.25mm diameter and Skd sixty one steel with 10mm thickness were used as tool and work materials within the experiments. The cutting performance outputs thought-about during this study were material removal rate (MRR) and surface roughness. Experimentation has been completed by exploitation Taguchi

L18 (21 completely different conditions of parameters. optimum mixtures of parameters were obtained by this system. The study shows that with the minimum variety of experiments the entire downside are often resolved when put next to full factorial style. The results obtained area unit analysed for the choice of associate optimum combination of WEDM parameters for correct machining of Skd sixty one alloy to attain higher surface end. Additionally the importance of the cutting parameters on the cutting performance outputs is decided by exploitation analysis of variance (ANOVA) L37 orthogonal array.

EXPERIMENTAL PROCEDURE

The objective of the present work is to investigate the effects of the various Wire cut EDM process parameters on the surface quality, maximum material removal rates obtain the optimal sets of process parameters so that the quality and MRR of machined parts can be optimized.

Experiments are conducted on COMPOSITE MATERIAL i.e. on Aluminium with the mixture of 5% Zirconium Oxide and 10% Zirconium Oxide by varying parameters. The process parameters varied and their respective values are Pulse Time on - 100µsec, 110 µsec, 120 µsec & Pulse Time off – 52 µsec, 56 µsec, 60 µsec, Servo Voltage – 20V, 30V, 40V and Wire Feed – 2mm/min, 3mm/min, 4mm/min. Other parameters are kept constant such as Wire diameter - 0.25mm, Peak Current – 1.1Amp, Coolant is Distilled water, Wire Tension – 7Kgf. The optimization is done by using Taguchi technique considering L09 orthogonal array. Optimization is done in Minitab 17 software.

The selection of parameters for experimentation is done as per Taguchi design. An orthogonal array for three controllable parameters is used to construct the matrix of three levels of controllable factors. The L9 orthogonal array contains 9 experimental runs at various combinations of three input variables.

S.NO.	PROCESS PARAMETERS	LEVEL 1	LEVEL 2	LEVEL 3
1	**PULSE TIME ON (T_{ON}) (µsec)**	100	110	120
2	**PULSE TIME OFF (T_{OFF}) (µsec)**	52	56	60
3	**SERVO VOLTAGE (V)**	20	30	40
4	**WIRE FEED (mm/min)**	2	3	4

Table - Process Parameters for Machining

Casting Parameters for Specimens:

Processing Temperature: 2000 ^{o}C
Reinforcement Percentage: 5% and 10%
Stirring Time: 4 min
No. of Blades: 4
Depth of the stirrer: 3/4th

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 06 Issue 10
September 2019

Figure Casting of Specimen

G – Gauge length	= 25 mm
W – Width	= 6 mm
T – Thickness	= 6 mm
L – Overall length	= 100 mm
A – Length of reduced section	= 32 mm
R – Radius of the fillet	= 6 mm
B – Length of grip section	= 30 mm
C – Width of grip section	= 10 mm

Figure - Tensile Testing Specimens

Hardness Test

Hardness test was performed at Hyderabad Engineering Labs. The hardness was measured by Rockwell Hardness test machine.

Figure – Hardness Testing Specimens

Taguchi L9 Orthogonal Array

The L9 orthogonal array for input parameters Pulse on time, pulse off time, servo voltage and wire feed is shown in table below:

JOB NO.	PULSE TIME ON (T_{ON}) (µsec)	PULSE TIME OFF (T_{OFF}) (µsec)	SERVO VOLTAGE (V)	WIRE FEED (mm/min)
1	100	52	20	2
2	100	56	30	3
3	100	60	40	4
4	110	52	30	4
5	110	56	40	2
6	110	60	20	3
7	120	52	40	3
8	120	56	20	4
9	120	60	30	2

Table – Process Parameters taken for machining

Surface Roughness Test:

Surface roughness is one of the most important responses in any machining process. Surface roughness affects several functional attributes of parts, such as friction, wear and tear, light reflection, heat transmission, ability of distributing and holding a lubricant, coating etc. Therefore, the desired surface finish is usually specified and appropriate processes are required to maintain the quality. There are many different roughness parameters in use, but Ra is by far the most common.

The Surface Roughness values are measured for the machined pieces and the same are tabulated below:

Table - Surface Roughness Results

S.No.	Sample Identification	Surface Roughness (R_a) in microns (µm)
AVERAGE		
01	Sample No. 1	3.35
02	Sample No. 2	3.12
03	Sample No. 3	3.48
04	Sample No. 4	2.92

International Journal of Research Available at https://journals.pen2print.org/index.php/ijr/

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 06 Issue 10
September 2019

05	Sample No. 5	3.83
06	Sample No. 6	2.71
07	Sample No. 7	2.58
08	Sample No. 8	2.45
09	Sample No. 9	3.31

Stat – DOE – Taguchi – Create Taguchi Design
Select 3-Level Design and Enter No. of factors - 4

↓	C1	C2	C3	C4
	PULSE TIMEON	PULSE TIME OFF	SERVO VOLTAGE	WIRE FEED
1	100	52	20	2
2	100	56	30	3
3	100	60	40	4
4	110	52	30	4
5	110	56	40	2
6	110	60	20	3
7	120	52	40	3
8	120	56	20	4
9	120	60	30	2

Figure - Arrangement of parameters as per L9 orthogonal array

Enter Surface Roughness Values in the table

↓	C1	C2	C3	C4	C5
	PULSE TIMEON	PULSE TIME OFF	SERVO VOLTAGE	WIRE FEED	SURFACE ROUGHNESS
1	100	52	20	2	3.35
2	100	56	30	3	3.12
3	100	60	40	4	3.48
4	110	52	30	4	2.92
5	110	56	40	2	3.83
6	110	60	20	3	2.71
7	120	52	40	3	2.58
8	120	56	20	4	2.45
9	120	60	30	2	3.31

Figure - Observed Surface Roughness values from experimentation

Results Table

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 06 Issue 10
September 2019

↓	C1	C2	C3	C4	C5	C6	C7
	PULSE TIMEON	PULSE TIME OFF	SERVO VOLTAGE	WIRE FEED	SURFACE ROUGHNESS	SNRA1	MEAN1
1	100	52	20	2	3.35	-10.5009	3.35
2	100	56	30	3	3.12	-9.8831	3.12
3	100	60	40	4	3.48	-10.8316	3.48
4	110	52	30	4	2.92	-9.3077	2.92
5	110	56	40	2	3.83	-11.6640	3.83
6	110	60	20	3	2.71	-8.6594	2.71
7	120	52	40	3	2.58	-8.2324	2.58
8	120	56	20	4	2.45	-7.7833	2.45
9	120	60	30	2	3.31	-10.3966	3.31

Figure - Calculated Signal to Noise Ratios for Smaller is better

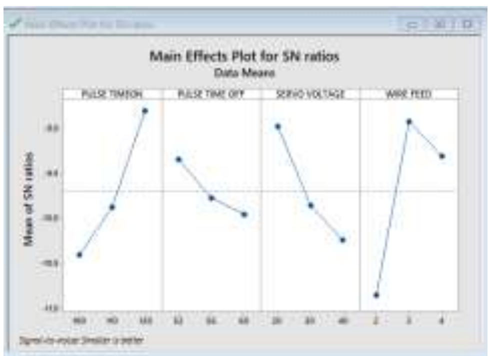


Figure - Effect of machining parameters on Surface Roughness for S/N ratio for Smaller is better

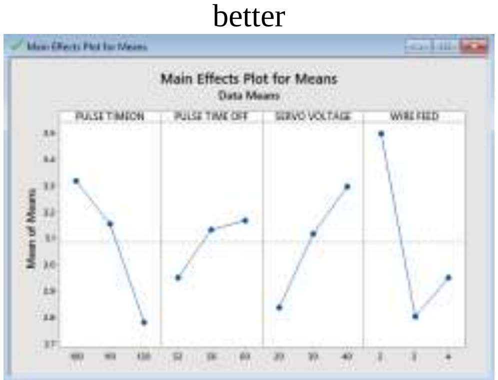
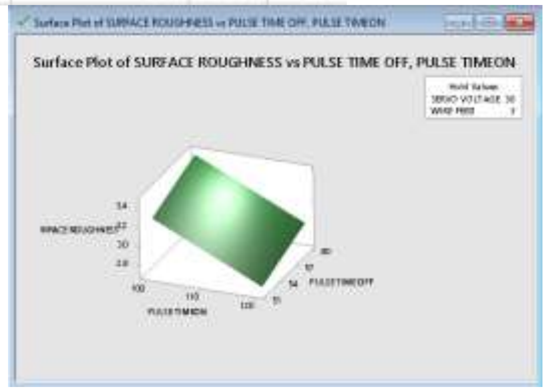


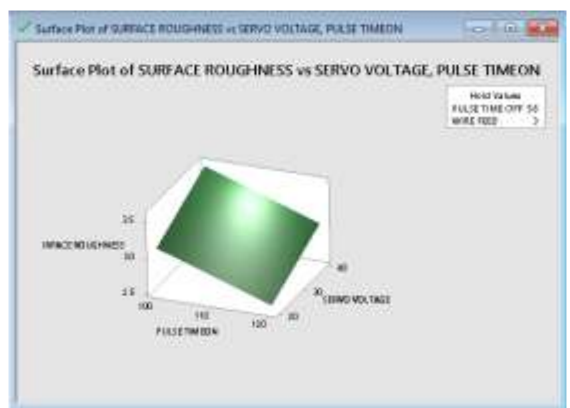
Figure - Effect of machining parameters on Surface Roughness for Means

RSM GRAPHS



Graph - Surface Plot of Surface Roughness Vs Pulse Time on and Pulse Time off (µsec)

By observing above graph, to minimize surface roughness, the pulse time off should be set at 52 µsec and pulse time on should be set at 120 µsec.

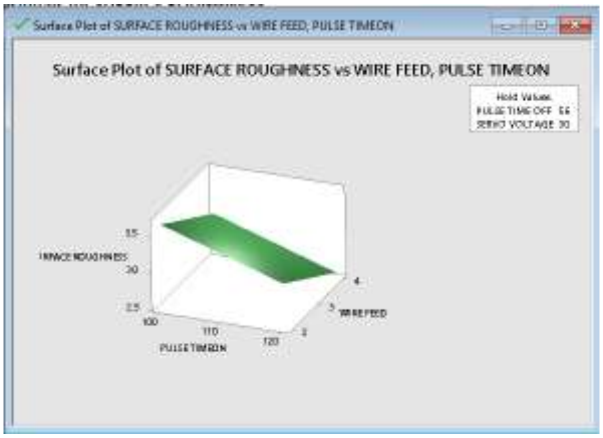


Graph - Surface Plot of Surface Roughness Vs Servo Voltage, Pulse Time on (µsec)

By observing above graph, to minimize surface roughness, the servo voltage should be set at 20V and Pulse Time on at 120µsec.

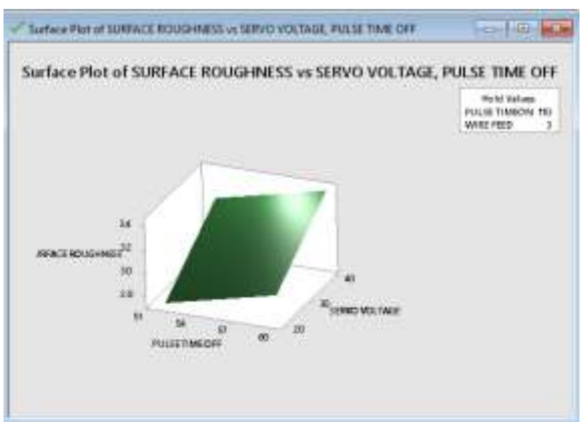
International Journal of Research Available at https://journals.pen2print.org/index.php/ijr/

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 06 Issue 10
September 2019



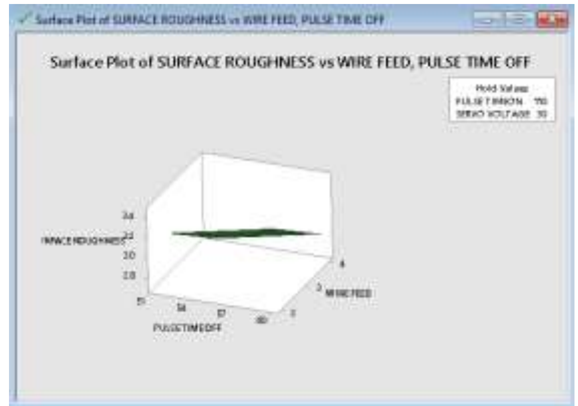
Graph - Surface Plot of Surface Roughness Vs Wire Feed (mm/s), Pulse Time on (µsec)

By observing above graph, to minimize surface roughness, the Wire Feed should be set at 4mm/min and Pulse Time on at 120µsec.



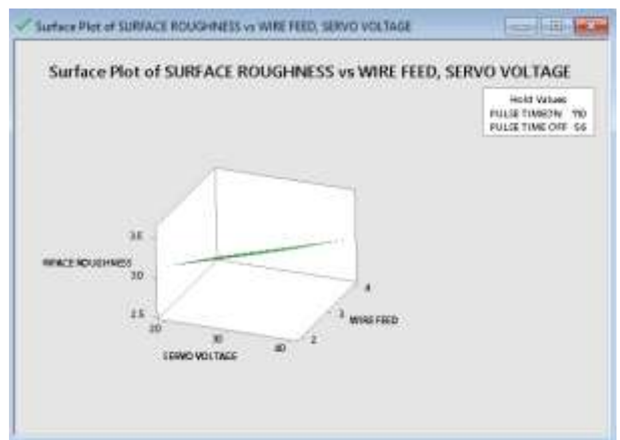
Graph - Surface Plot of Surface Roughness Vs Servo Voltage, Pulse Time off (µsec)

By observing above graph, to minimize surface roughness, the servo voltage should be set at 20V and Pulse Time off at 52µsec.



Graph - Surface Plot of Surface Roughness Vs Wire Feed (mm/s), Pulse Time off (µsec)

By observing above graph, to minimize surface roughness, the Wire Feed should be set at 4mm/min and Pulse Time off at 52µsec.



Graph - Surface Plot of Surface Roughness Vs Wire Feed (mm/s), Servo Voltage

By observing above graph, to minimize surface roughness, the Wire Feed should be set at 4mm/min and servo voltage at 20V.

CONCLUSIONS

Experiments are conducted on the composite work pieces by varying parameters. The process parameters varied and their respective values are Pulse Time on - 100µsec, 110 µsec, 120 µsec & Pulse Time off – 52 µsec, 56 µsec, 60 µsec, Servo Voltage – 20V, 30V, 40V and Wire Feed – 2mm/min, 3mm/min, 4mm/min. Other parameters are kept constant such as Wire dia - 0.25mm, Peak Current – 1.1Amp, Coolant is Distilled water, Wire Tension – 7Kgf. The optimization is done by using Taguchi technique considering L09 orthogonal array. Optimization is done in Minitab software. Optimization is done in Minitab software. Tensile and hardness tests are performed on the pieces.

From the Optimization techniques, the following results can be obtained:

From Taguchi Method:

The Minimum Surface Roughness was obtained from the optimum parameters taken as Pulse Time on is 120µsec, Pulse Time off is 52µsec, Servo voltage is 40V and Wire Feed is 2mm/min.

The Maximum MRR was obtained from the optimum parameters the optimum parameters taken as Pulse Time on is 120µsec, Pulse Time off is 50µsec, Servo voltage is 40V and Wire Feed is 4mm/min.

From Response Surface Method:

The main parameter affecting Surface Roughness is Wire Feed. For minimum Surface Roughness the optimum required Wire Feed is 4mm/min . The optimum parameter variables for minimum Surface Roughness are Pulse Time on is 120µsec, Pulse Time off is 52µsec, Servo Voltage 20V and Wire Feed is 4mm/min.

The main parameter affecting MRR is Pulse Time on. For maximum MRR the optimum required Pulse Time on is 120µsec. The optimum parameter variables for maximum MRR are Pulse Time on is 120µsec, Pulse Time off is 60µsec, servo voltage 40V and Wire Feed is 4mm/min.

From the Hardness Test Reports:

It was found that the hardness is very high for the sample piece No. 5 i.e. From reports of Hardness Test done in Hyderabad Engineering Labs. The piece which is been machined with parameters of Pulse Time on is 120µsec, Pulse Time off is 56µsec, Servo voltage is 40V and Wire Feed is 2mm/min.

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