March – April 2020
ISSN: 0193-4120 Page No. 10338 - 10345

An Evaluation Offriction Welding Parameters Onal6061 & Al7075 Using Taguchi Optimization Technique

C. Nithiyapathi[1], R. Masilamani[2], P. Prakash[3]
[1]Asst Prof, Dept of Mech, Karpagam Academy of Higher Education, India
[2]Asst Prof, Dept of Mech, Karpagam College of Engineering, India
[3]Asst Prof, Dept of Mech, Karpagam Institute of Technology, India
nithiyapathi.c@kahedu.edu.in.

Article Info
Volume 83
Page Number: 10338 - 10345
Publication Issue:
March - April 2020

Article History
Article Received*: 24 July 2019*
Revised*: 12 September 2019*
Accepted*: 15 February 2020*
Publication*: 12 April 2020*

Abstract: Friction Stir Welding (FSW) is the most effective welding process that welds dissimilar metal to evaluate the properties of mechanical and metallurgy. In this research investigation, AA 6061 and AA 7075 grade is used as a base material. The input parameters such as Spindle speed (rpm), Welding speed (mm/min) and Welding time (sec) are used when the output parameters is Tensile strength in terms of N/mm2. The ranking process can be identified by using Taguchi L9 orthogonal array technique & the most convincing parameters and its contribution can be identified by using Analysis of variance (ANOVA). By using experimental results, the optimized parameters are analyzed and confirmed.

Keywords: *Friction Stir Welding, Analysis of variance etc.*

I. INTRODUCTION

Friction Stir welding (FSW) is identified as the most influencing welding technique and it play a vital role in industrial applications. According to Cavaliere and its team, the major influence of distribution of heat on the base metals, structures, metal flow and strength depends on the tool geometry and edge preparation [1]. Nansaarng and Chaivanich investigates FSW is the tool which has no flaws in mechanical and metallurgical properties [2]. Taguchi and ANOVA are the most powerful technique in identifying optimum input parameters and results. Most of the research conclude that the most convincing parameter of FSW is Tool rotational Speed, and it depends on choosing the parameters [3]. Jayaraman investigates few things in Aluminium Alloys by choosing Tool rotational speed; welding speed and vertical force, he states that tool rotational speed is the most influencing parameter whereas, welding speed and vertical force support to achieve maximum tensile strength of 143 MPa. Here, he discussed the same work using Artificial Neural Network (ANN). The same statement is evaluated by Lakshminarayanan in 2008 and the author reveals that the most convincing parameter is tool rotational speed [4]. Daniel Das and his team investigates the modified technique from FSW in the year 2015, and they reveal that Tool rotational speed is the most convincing parameter. But in this research work, we decide to have an experimental research work by choosing two different input parameters along with spindle speed [6-10]. In this research work, we got different opinion from the previous author illustration. In general, the Aluminium 7075 cannot be welded using fusion welding technique. Hence, we decide to weld the base metal Al 7075 using friction stir welding. In this research work, the effects of parameters such as spindle speed, welding speed and welding time are investigated using FSW welded base metal AA 7075 and the effectiveness are measured by analyzing tensile strength, results are determined [5].

Published by: The Mattingly Publishing Co., Inc

March – April 2020
ISSN: 0193-4120 Page No. 10338 - 10345

II. EXPERIMENTAL METHODS

The material chosen in this research work are from the same family. AA 6061 and AA 7075 in the form of plates of dimensions 70 mm X 140 mm X 5 mm. By using OES method, the composition is identified and it was tabulated in Table 1 and Table 2 respectively.

Table 1.Al 6061 material composition

Alloy	Mg	Si	Fe	Cu	Cr	Zn	Ti	Mn	Al
Wt %	0.9	0.7	0.6	0.3	0.25	0.2	0.1	0.05	Balance

Table 2.Al 7075 material composition

Alloy	Fe	Si	Cu	Mn	Mg	Cr	Zn	Ti	Al
Wt %	0.5	0.4	1.6	0.1	2.5	0.15	5.5	0.4	Balance

In this research investigation, Taguchi L9 is proposed.The parameters used in this research work are spindle speed (rpm), welding speed (mm/min) and welding time (sec).

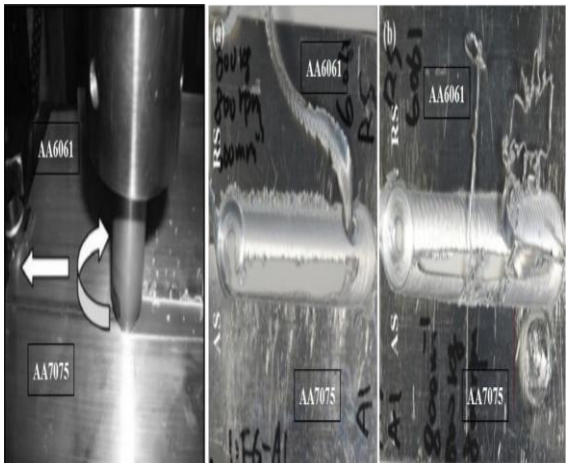

Fig 1. Sample welded by FSW

The quality of the process parameters is identified using Taguchi ranking process that was framed by Genichi Taguchi. The dimension of the tool pin 18mm diameter in shoulder and 5mm diameter in pin. The tensile test has been carried out using MTS – 317 universal tensile testing machine with the strain rate of 1/1000 1/s. Table 3 shows the input factors and levels of L_9 orthogonal array. Fig 1 shows the sample that welded by FSW.

Table.3 DOE levels for each factors

FACTOR	LEVELS		
	1	2	3
Spindle Speed (rpm)	900	1200	1500
Welding Speed (mm/min)	3	6	9
Welding time (sec)	90	100	110

In this research investigation, the factors are spindle speed, welding speed and welding time. There are three levels used in this research work for each and every factors. 900 rpm, 1200 rpm and 1500 rpm are the three levels for the factor spindle speed. 3 mm/min, 6 mm/min and 9 mm/min are the three levels for the factor welding speed are 90 sec, 100 sec and 110 sec respectively.

III. RESULTS AND DISCUSSIONS

1. Signal to Noise Ratio

The signal to noise ratio helps in reducing fluctuations in the output parameter tensile strength. In this research work, the tensile strength is the most significant output parameter, that evaluates the quality of joints. The optimum parameters have been optimized by using "Larger is better" criteria. The following equation helps in identifying SN ratio.

$$\text{SN Ratio} = -(10\log(\Sigma(1/N^2)/x))$$

Published by: The Mattingly Publishing Co., Inc

March – April 2020
ISSN: 0193-4120 Page No. 10338 - 10345

Table.4 L_9Orthogonal Array

Runs	Input Constrains			OUTPUT PARAMETER
	SPINDLE SPEED (rpm)	WELDING SPEED (mm/min)	WELDING TIME (mm)	TENSILE STRENGTH (N/mm^2)
1	900	3	90	152.24
2	900	6	100	149.17
3	900	9	110	146.10
4	1200	3	100	159.10
5	1200	6	110	156.03
6	1200	9	90	134.97
7	**1500**	**3**	**110**	**165.95**
8	1500	6	90	144.89
9	1500	9	100	141.82

According to Table 4, the nine experimental values along with the i/p& o/p parameters have been tabulated. From Table 4, the optimum tensile strength has been identified by input parameters are1500 rpm spindle speed, 3 mm/min welding speed and 110 sec welding time is 165.95 N/mm^2. Table 5 and Table 6 provides response table of S/N Ratio and means and Fig 2 The graph plot that reveals the effects for Signal to Noise ratio and Data means provided in Fig 3. The welding speed is the most convincing parameter that produces optimum tensile strength.

Table 5. Response table for SN Ratio

Level	Spindle Speed (rpm)	Welding Speed (mm/min)	Welding time (sec)
1	43.47	44.03	43.16
2	43.50	43.52	43.51
3	43.55	42.98	43.85
Delta	0.08	1.05	0.69
Rank	**3**	**1**	**2**

Published by: The Mattingly Publishing Co., Inc

March – April 2020
ISSN: 0193-4120 Page No. 10338 - 10345

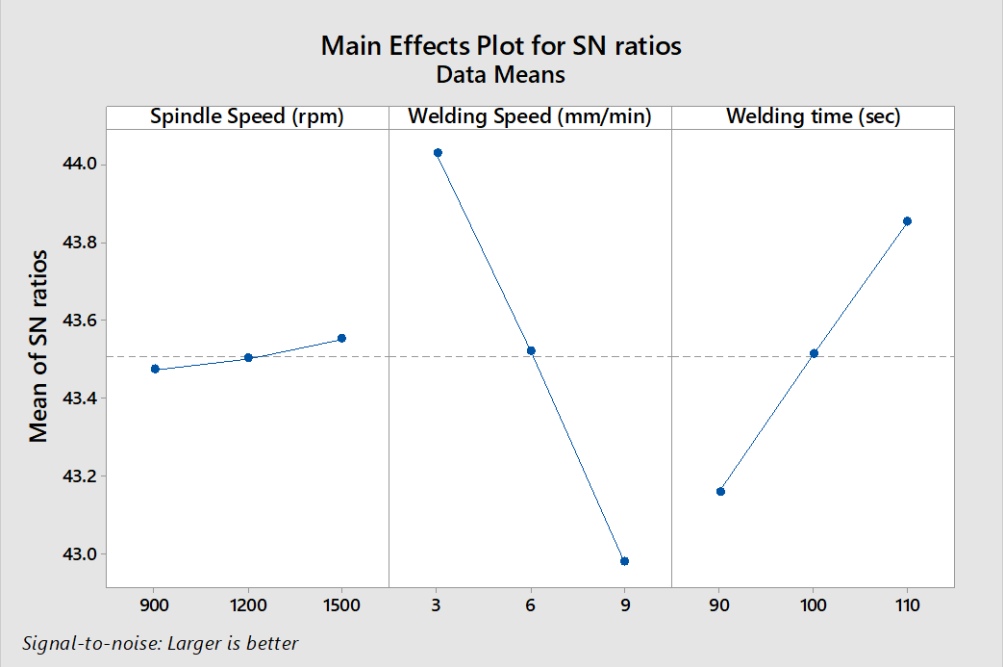

Fig 2.Graph plot for Effects in S/N ratios.

Table 6. Response table for data means

Level	Current (A)	Speed (mm/min)	Arc Gap (mm)
1	149.2	159.1	144.0
2	150.0	150.0	150.0
3	150.9	141.0	156.0
Delta	1.7	18.1	12.0
Rank	**3**	**1**	**2**

Published by: The Mattingly Publishing Co., Inc

March – April 2020
ISSN: 0193-4120 Page No. 10338 - 10345

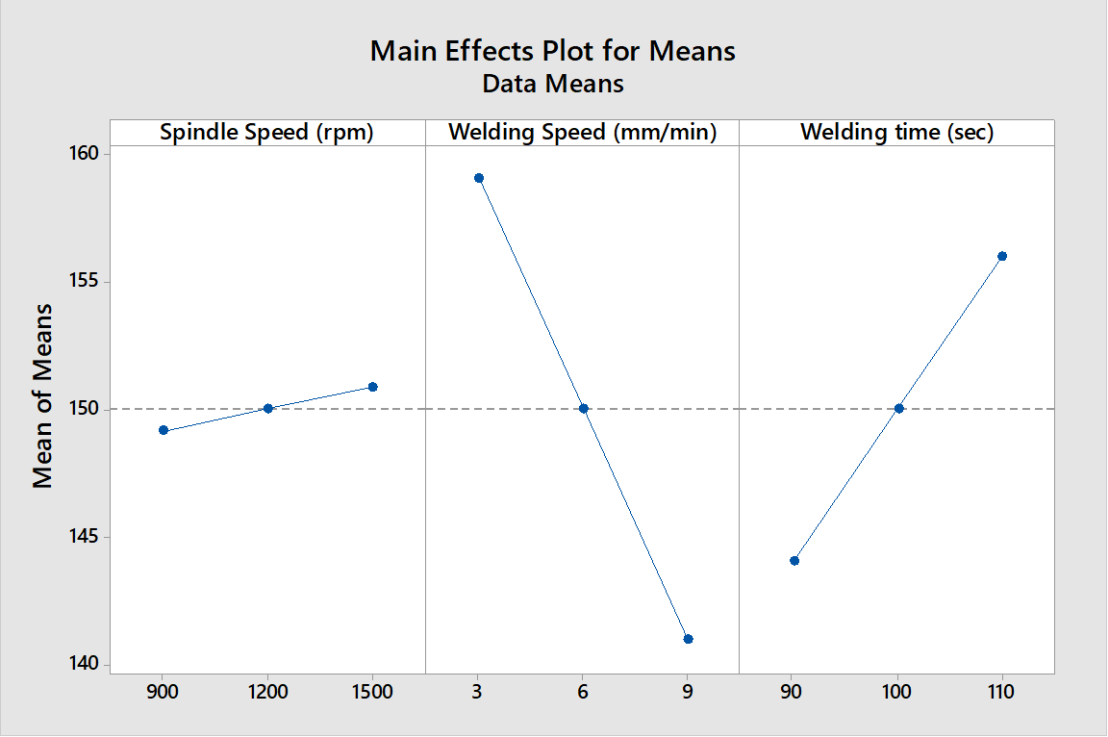

Fig 3.Graph plot for Effects of means.

From Table 5, the welding speed of FSW is the most convincing parameter followed by the welding time in terms of seconds. These two parameters contribute more in joining quality joints. From Fig 2, the graph plot for SN shows that 44.03 mm/min welding speed contributes more compared with the other two parameters. The delta value has been recorded as 18.1. This SN ratio records high optimized value and it solved using Larger is better criteria

.

Table 7. Model summary of R-Sq, Adj and Prediction

S	R-sq	R-sq(adj)	R-sq(pred)
0	100%	100%	100%

Table 7 shows that the model summary of R-Square value and its adjacent value. The values are recorded as 100%, which means the errors are minimum.Table 8 shows that the contribution of process parameters where as the spindle speed contributes 9.61%, Welding speed contributes 63.13% and welding time contribution is 30.25%. From table 7, the welding speed is the highest contributing parameters followed by welding time (30.25%). Fig 4 shows the pictorial representation of process parameters. Fig 5 shows the interaction plot of the process parameters.

Table 8. Percentage of contribution by ANOVA

Source	DoF	Adj SS	Adj MS	F-Value	P-Value	Percentage of Contribution
Spindle Speed (rpm)	2	4.417	2.208	-	-	9.61
Welding Speed (mm/min)	2	493.154	246.577	-	-	63.13

Published by: The Mattingly Publishing Co., Inc

March – April 2020
ISSN: 0193-4120 Page No. 10338 - 10345

Welding time (sec)	2	215.784	107.892	-	-	30.25
Error	2	0.000	0.000	-	-	0
Total	8	713.355	-	-	-	100%

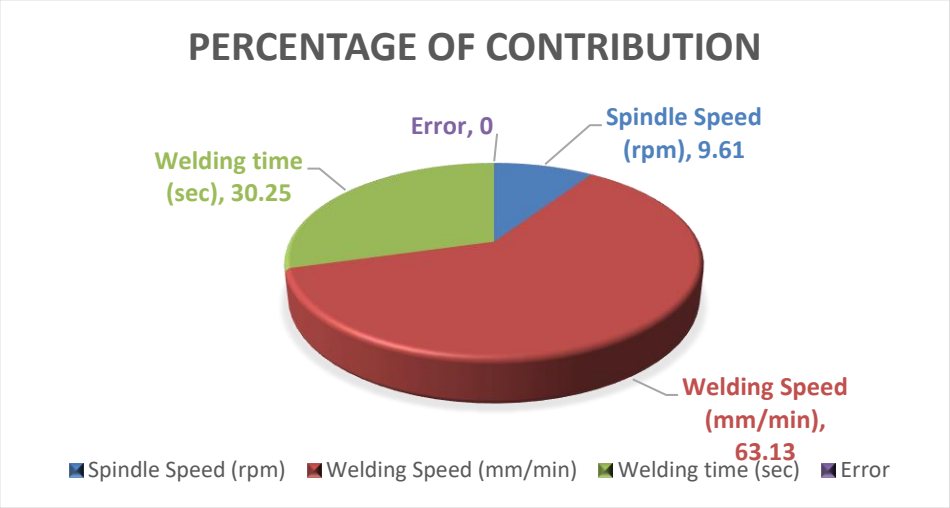

Fig 4. Percentage of contribution of process parameters

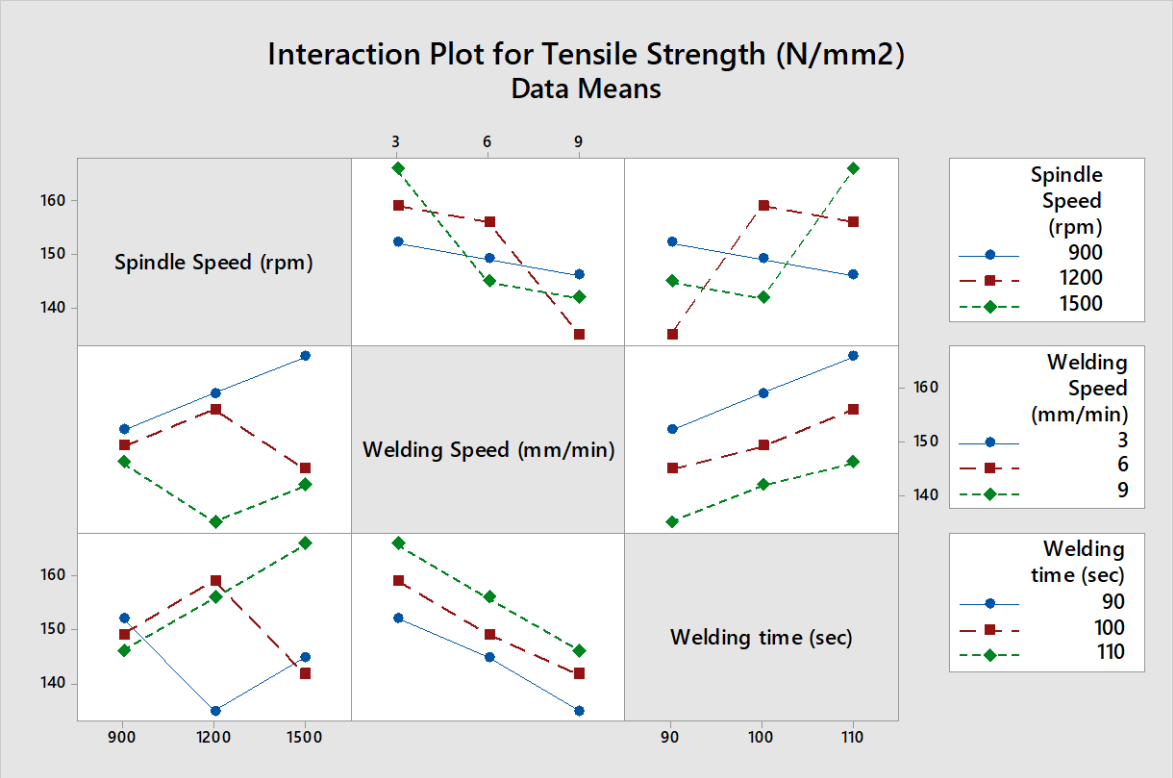

Fig 5.Interaction plot of process parameters

Table 9 is the comparison table between the process parameters of experimental and Taguchi method. From the table, it clearly shows that there will be slight deviation between the optimum tensile strength of Experimental and Software predicted method.

Published by: The Mattingly Publishing Co., Inc

ISSN: 0193-4120 Page No. 10338 - 10345

Equation 1 shows that regression equation that produces optimum tensile strength values.

Table 9. Theoretical and experimental values – a comparison

Method	Input parameters			Output Parameter
	Spindle Speed (rpm)	Welding Speed (mm/min)	Welding Time (sec)	Tensile strength (N/mm^2)
Taguchi	1500	3	110	165.95
Experimental	1500	3	110	161.30

Tensile Strength = 104.8 + 0.002860 * Spindle Speed - 3.022 * Welding Speed + 0.5997 * Welding time - (1)

IV. CONCLUSION

In this research investigation, Al 6061 and Al7075 are welded using Friction Stir Welding process. The input parameters are Spindle speed (rpm), Welding speed (mm/min) and Welding time (sec). From the above investigation, conclusions are listed

Radiography test concludes that there was no speck at the weld interface

By Taguchi analysis, the optimum strength has been achieved by using 1500 rpm spindle speed, 3 mm/min welding speed and 110 sec.

By Analysis of variance, the optimum joint has been achieved by contribution of welding speed (63.13%), followed by the welding time (30.25%) and spindle speed (9.61%).

By comparing the experimental and software predicted value, there was a slight deviation of tensile strength values.

REFERENCES

[1]. Cavaliere, P., G. Campanile, F. Panella, and A. Squillace. "Effect of welding parameters on mechanical and microstructural properties of AA6056 joints produced by friction stir welding." Journal of Materials Processing Technology 180, no. 1-3 (2006): 263-270.

[2]. Yadhav, V. D., and S. G. Bhatwadekar. "Friction stir welding of dissimilar aluminium alloys AA1100 to AA6101-T6." Int J Res Aeronaut Mech Eng 3, no. 1 (2015): 1-6.

[3]. Bayazid, S. M., H. Farhangi, and A. Ghahramani. "Investigation of friction stir welding parameters of 6063-7075 aluminum alloys by Taguchi method." Procedia Materials Science 11 (2015): 6-11.

[4]. Balasubramanian, V., and A. K. Lakshminarayanan. "The mechanical properties of the GMAW, GTAW and FSW joints of the RDE-40 aluminium alloy." International Journal of Microstructure and Materials Properties 3, no. 6 (2008): 837-853.

[5]. Paramaguru, Dhanis, SrinivasaRaoPedapati, MokhtarAwang, and HamedMohebbi. "Mathematical Model to Predict Tensile Strength of Underwater Friction Stir Welded (UFSW) on 5052 Aluminium Alloys." In ASME 2018 International Mechanical Engineering Congress and Exposition. American Society of Mechanical Engineers Digital Collection, 2018.

[6]. Jayaraman, N., Paul S. Prevéy, and Murray Mahoney. "Fatigue Life Improvement of an Aluminum Alloy FSW with Low Plasticity Burnishing." In Proceedings 132nd TMS Annual Meeting, San Diego, CA. 2003.

[7]. Das, A. Daniel, and S. SenthilKumaran. "FWTPET Investigation on SA213 Tube to SA387 Tube Plate." In Applied Mechanics and

Published by: The Mattingly Publishing Co., Inc

Materials, vol. 852, pp. 355-361. Trans Tech Publications Ltd, 2016.
[8]. Kumaran, S. Senthil, and A. Daniel Das. "An investigation of Boiler Grade Tube and Tube Plate without block by using friction welding process." Materials Today: Proceedings 5, no. 2 (2018): 8567-8576.
[9]. Kumaran, S. Senthil, and A. Daniel Das. "An Examination of Seamless Ferritic tube and Austenitic alloy tube plate joining by Friction Welding process." Materials Today: Proceedings 5, no. 2 (2018): 8539-8546.
[10]. Das, A. Daniel, and S. SenthilKumaran. "FWTPET Investigation on SA213 Tube to SA387 Tube Plate." In Applied Mechanics and Materials, vol. 852, pp. 355-361. Trans Tech Publications Ltd, 2016.
[11]. MINITAB 17, Minitab Inc.,
[12]. Sellappa, S., Prathyumnan, S., Keyan, K. S., Joseph, S., Vasudevan, B. S. G., &Sasikala, K. (2010). Evaluation of DNA damage induction and repair inhibition in welders exposed to hexavalent chromium. Asian Pac J Cancer Prev, 11(1), 95-100.
[13]. Sudha, S., Kripa, S. K., Shibily, P., Joseph, S., &Balachandar, V. (2011). Biomonitoring of genotoxic effects among shielded manual metal arc welders. Asian Pac J Cancer Prev, 12(4), 1041-4.
[14]. Karthik, R., Chen, S. M., Elangovan, A., Muthukrishnan, P., Shanmugam, R., & Lou, B. S. (2016). Phyto mediated biogenic synthesis of gold nanoparticles using Cerasusserrulata and its utility in detecting hydrazine, microbial activity and DFT studies. Journal of colloid and interface science, 468, 163-175.
[15]. Balakrishnan, M., Dinaharan, I., Palanivel, R., &Sivaprakasam, R. (2015). Synthesize of AZ31/TiC magnesium matrix composites using friction stir processing. Journal of Magnesium and Alloys, 3(1), 76-78.
[16]. Selvan, M. C. P., Raju, N. M. S., &Sachidananda, H. K. (2012). Effects of process parameters on surface roughness in abrasive waterjet cutting of aluminium. Frontiers of Mechanical Engineering, 7(4), 439-444.
[17]. Shanmughasundaram, P., Subramanian, R., &Prabhu, G. (2011). Some studies on aluminium–fly ash composites fabricated by two step stir casting method. European journal of scientific research, 63(2), 204-218.

Published by: The Mattingly Publishing Co., Inc