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*Research Article*

# Effect of SC Parameters on Material Characteristics for Al 5083-Based Hybrid Matrix Composites Using Taguchi RSM Technique

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This research concentrated on material characteristics such as tensile property (TS) and hardness (HV) for AA-5083 manufactured using the stir casting (SC) process. The reinforcing elements silicon carbide (SiC-7.5%) and flyash (FA-5%) in the form of powders will be added to Al alloy to improve the characteristics of composites. Response surface methodology (RSM) was a scientific technique to make optimizing task at stir casting parameters. As per central composite design (CCD), 20 samples (L1-L20) were fabricated at a variation of factors such as stirrer speed (A) 350-550 rpm, stir time (B) 15-35 min, and stir temperature (C) 750-950°C. The result presented that best TS and HV exhibited at experiments L5 (A2-450 rpm, B1-15min, and C1-750°C) and L6 (A1-350 rpm, B1-15min, and C1-750°C). Design expert software (DES) is one of the optimization tools that employed to determine analysis of variance (ANOVA) and the best optimal parameter levels of SC. ANOVA helped to check contribution of SC factors on TS and HV, and it was noticed that mechanical properties were improved with increasing stir speed and stir time but it was reduced with rising of temperature.

## 1. Introduction

The chemical element like Al lacks sufficient strength when used to manufacture components in industrial business areas [1]. To address these challenges, particles or particulate reinforcements such as alumina, silicon-based carbides and oxides, $Tib_2$, and $Tio_2$ are blended with Al to increase the strength of heavy items [2]. Al 5083 is made from many chemical elements including Mg, Mn, and Si. This kind of alloy is generally used in different application such as ship construction, automobile bodies, mine skip work [3], and pressure containers [4]. Stir SC routine is implemented in cheap wise which was able to create difficult designed products among various fabrication techniques powder metallurgy, plasma sintering, etc. [5, 6]. Numerous researches suggested that using a single metal would not be able to produce the needed material properties [33, 34]. It is applied in several production enterprises [7]. $B_2O_3$, $B_6O$, and $BN_3O_6$ are added to the primary matrix as reinforcements to improve material properties [8, 9]. TiC is to improve resistance [10] and wear property while adding on Al alloy [11]. SiC is one of the ceramic metal which had less density compare to titanium carbide [12]. Most of the researchers chose it to add up with different metals to develop properties of material [13]. Nowadays, AMC products are made with light mass [14]; FA powder possesses light weight that avail due to burning waste items of steam boiler plants. Ravi Kumar et al. [15] prepared AA7075 composites by adding Al2O3 (2-6%) and SiC (3-9%) through stir casting route and found reduction of tensile strength at 180°C for Al2O3 (6%)-SiC 9% strengthened with 7075 Al which happened due to not properly mixing of particles in heat treatment process. SAESSI et al. [16] examined the wear performance and tribological behaviour of grained Al5083 alloy/boron carbide at room and prominent temperatures. Low wear rate was observed at 200°C during application of 80 N load. Christy et al. focused on properties, optimization of stir casted specimens of scrap Al alloy reinforced with Al2O3. Four factors were considered in the optimization progress such as squeeze-pressure, time, preheat-temperature, and speed of stirpart. It was detected that the highest UTS (433 MPa) was occurred at L5 sample of 100 MPa, 45S, 250°C, and 525 rpm from ANOVA outcome [17]. Karthik et al. [18] studied the optimization of squeeze cast processing factors of Al2219 alloy through Taguchi routine. Optimized factors for Al-2219 alloy was found at squeeze pressure of 650 MPa, temperature of 225°C, and melt temperature 700°C that make to improve metallographic arrangement and mechanical characteristics. Amra et al. [19] prepared samples via casting method and studied about structural analysis and wear rate of Al-5083 strengthen with CeO2/SiC. All prepared composites possessed greater hardness and wear opposition compared to base metal 5083. Generally, 5083 alloys have been applied in variety of fields such as rail cars, vehicle bodies, tip truck bodies, mine skips, and cages. AA7068 with boron carbide samples were produced by SC method with variant of parameter levels and also studied about corrosion rate. The mixture of reinforcement and stir-time were chief influencing factors which is improving corrosion resistance [20]. Akhlaghi et al. [21] explained the influence of casting hotness on distribution particles and porosity for SiC-A356 composites. Zhang et al. examined the effect of stir speed, time of stirring, and temperature on Al-6.8Mg-SiC [22]. Li-na et al. [23] noticed that the tensile properties increased due to an increment of homogeneousness reinforcement, reducing stirring temperature in AA6061/ABO + SiCp hybrid composites. AA-5083 and FA were effectively produced through FSP method with different speed and feed rate. The higher hardness value was measured at 1400 rpm and 25 mm/min [24]. A popular mathematical and statistical technique for simulating and examining a process in which the variables and the objective by many variables is called response surface methodology (RSM). This first of three in-depth instructions demonstrates how to utilise the Design-Expert® programme for RSM which is helping for optimization process. Taguchi-related RSM technique was utilized to conduct optimal process on AA 6061 alloy; effects of HV and UTS were analyzed by ANOVA test [25]. Pal et al. have investigated to determine the ultimate tensile strength and hardness of AA 5456 alloy particles produced with SiC/flyash powder using a stir casting device, and there was more improvement of hardness and UTS around 87 HV and 109 MPa due to proper mixing of reinforced powders [27]. Metal matrix composites made by stir casting and made of aluminium, silicon carbide, and aluminum and boron nitride were studied by Reddy et al. When compared to pure aluminum, they discovered that the produced hybrid metal matrix composites had better mechanical and metallurgical characteristics [32]. Gugulothu et al. analysed wear behavior of Al5052 with addition of alumina/Zrsio4 with aid of Taguchi optimization techniques, in which load is the dominant characteristic that determines wear behavior of prepared samples by roughly 45%, followed by reinforcing weight percentage 29.5% and sliding speed 25.5 percent [28]. Outputs with the help of design expert software, optimizations of Ts-156 MPa, and 75 HV were measured from impacted optimal parameters (speed of stirrer A: 309 rpm, time B: 13 min, temperature C: 840°C on AMCs samples) [29]. A metal matrix composite made of Al 7075 and SiC was created by Suresh et al. They discovered that the composite material had a lower rate of wear than the basic metal. They noticed that when the silicon carbide content increased, the wear rate decreased [31]. The work presented that an increase of stirrer rotation, squeeze pressure, and time duration affect behavior of composites [26]. After understanding various literature reviews, we aim to fabricate 5083 material which added on FA/Sic for optimizational experimentations.

## 2. Experimental Arrangement and Testing

Generally, Al-5083 has higher yield strength and is used in a variety of sectors, including engine body fabrication. Table 1 has mentioned Al compositions. Silicon carbide particle is with a diameter of 25 microns and a density of 3.6 g/cm$^3$. Initially, 7.5% SiC and 5% FA were heated separately around 400°C and heated 5083 plate around 650-700°C at 7-10 minutes before addition of molten particles to furnace. Stir them well with a stirrer at different speeds ranging from 350 to 550 RPM, at temperatures ranging from 750 to 950°C for 15 to 35 minutes. Inert gas-Ar was used as an oxidizing avoider throughout the entire experiment (Figure 1). Afterward, formulated mould metals transferred into preferred shape dies to create 20 sample according to central composite design (CCD). This procedure is to be continued for remaining casting influences of stir speed (450,550 rpm) and time duration (25.35 min) at temperature of (850,950°C) mentioned at Table 2. Hardness tester (UH-350 model) was utilized to determine specimens hardness with help of (1/16) ball indenter apply the load 150 kgf at 10 seconds dwell time. As per ASTM E3, samples have been prepared to find tensile strength using load of 10 KN by universal testing machine. The basic parameters which is frequently used in the investigation of wear processes are stirrer speed, time, and temperature. The so-called wear factor is also computed using these values.

## 3. RSM Technique

Response surface methodology (RSM) is an arithmetical tool to achieve superior process control so that manufacturing feature can be enhanced considerably. CCD method was

Table 1: Aluminum alloy 5083 compositions.

| Elements | Silicon | Iron | Copper | Manganese | Magnesium | Zinc | Titanium | Chromium | Aluminum |
|---|---|---|---|---|---|---|---|---|---|
| Contribution (%) | 0.50-0.60 | 0.40-0.50 | 0.2-0.30 | 0.75-0.80 | 4-4.5 | 0.3-0.40 | 0.15-0.20 | 0.10-0.20 | Balance |

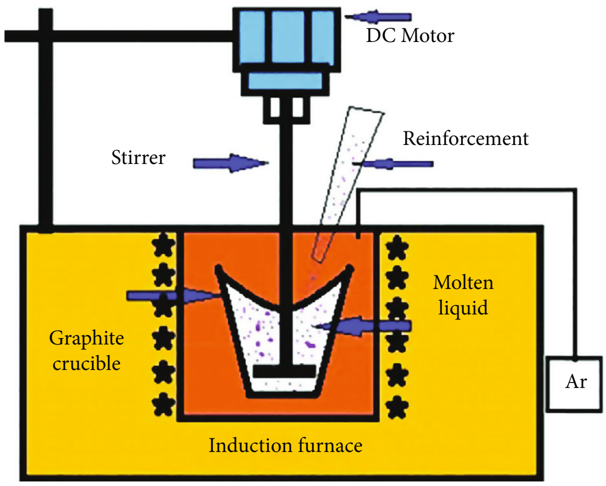


Figure 1: Stir casting process setup.

Table 2: SC input factor details.

| Factors | Level I | Level II | Level III |
|---|---|---|---|
| Stir speed (A) | 350 | 450 | 550 |
| Stirring time (B) | 15 | 25 | 35 |
| Stir temperature (C) | 750 | 850 | 950 |

Table 3: Tensile property and hardness observations.

| Runs | A (rpm) | B (min) | C (°C) | TS (MPa) | HV |
|---|---|---|---|---|---|
| L1 | 350 | 15 | 750 | 150.2 | 85.0 |
| L2 | 350 | 25 | 850 | 126.1 | 75.2 |
| L3 | 350 | 35 | 950 | 145.8 | 81.3 |
| L4 | 350 | 25 | 850 | 138.4 | 72.5 |
| L5 | 350 | 35 | 750 | 175.7 | 74.6 |
| L6 | 350 | 15 | 950 | 152.5 | 75.4 |
| L7 | 350 | 35 | 850 | 163.6 | 70.2 |
| L8 | 450 | 15 | 750 | 178.2 | 83.7 |
| L9 | 450 | 25 | 850 | 164.9 | 83.5 |
| L10 | 450 | 35 | 950 | 159.2 | 76.7 |
| L11 | 450 | 25 | 850 | 145.5 | 81.8 |
| L12 | 450 | 35 | 750 | 129.8 | 77.9 |
| L13 | 450 | 15 | 950 | 138.4 | 80.9 |
| L14 | 550 | 15 | 750 | 159.4 | 79.6 |
| L15 | 550 | 25 | 850 | 169.4 | 75.9 |
| L16 | 550 | 35 | 950 | 170.3 | 82.2 |
| L17 | 550 | 25 | 850 | 153.7 | 73.5 |
| L18 | 550 | 35 | 750 | 148.8 | 68.5 |
| L19 | 550 | 15 | 950 | 158.6 | 74.9 |
| L20 | 550 | 35 | 850 | 161.3 | 78.6 |

applied on casting process parameters of Al5083/SiC/FA. To determine best process parameter, DOE was constructed and produced for twenty samples at three variables. Process factors such as stirrer speed, stir time, and temperature were changed as per L20. Based on the experimental design, output responses (TS and HV) are acquired after exposing the samples to various mechanical property characterizations [30]. SN ratios (signal to noise) is log functions of output that aid for predicting the best process outcomes. The S/N ratio is calculated using the response variables received from the experimental studies. Depending on that whether the variable has to be maximized or reduced, Equation (1) is employed to transform the variables into S/N ratios.

$$\frac{\mathrm{S}}{\mathrm{N}} = 10 \log_{10}\left(\frac{P_s}{P_n}\right). \quad (1)$$

## 4. Result Discussion

Tensile strength is assessed with UTM. This is equipped with a load cell that measures tensile force. A tensile test is also frequently used to gauge tensile strength among other characteristics. Totally, 20 samples have been prepared for conducting the experiment to find out TS and BHN. From Table 3, it can be noticed that tensile strength (TS) for L8 and L5 were maximum, trailed by L16. In this study, interpreting the influence of a single process parameter was extremely difficult, because the process factors were altered consecutively using the CCD technique. For applications purpose, greater tensile strengths should be required, so L8 and L5 process parameters may be considered. TS values (126.1-178.2 MPa) were improved because of reinforcements distributed evenly in matrix and followed increase parameters of speed and time. The standard error have identified from 0.41 to 2.59 and average error -1.04 in whole experiments. $TS_{min}$ was obtained at L2 (350 rpm, 25 min at 850°C) due to the deficiency of reinforcement and more temperature, whereas maximum TS was identified at L8 (450 rpm, 15 minutes with 750°C). Figure 2 showed the effect of interaction of stirrer rotation vs. stir time vs. temperature on tensile strength and hardness for made Al5083 composite. From the graphical illustration, there was an increase in TS when the B and A were increased up to 5-10 min and 300-320 rpm. However, at speed more than 400 rpm, there was a substantial negative or reduction of TS; when interaction between speed and temperature is until 720-750°C and 380-400 rpm, there was an improvement of tensile strength obtained. At constant stirring speed of 400 rpm, the outcome of the interaction influence of B and C parameters in TS of generated composites 5083. Increasing temperature up to 800 and time 25 min enhanced tensile strength; however, there was a loss in TS when B and C were more than 25 minutes and 810°C. Similarly, the maximum hardness is

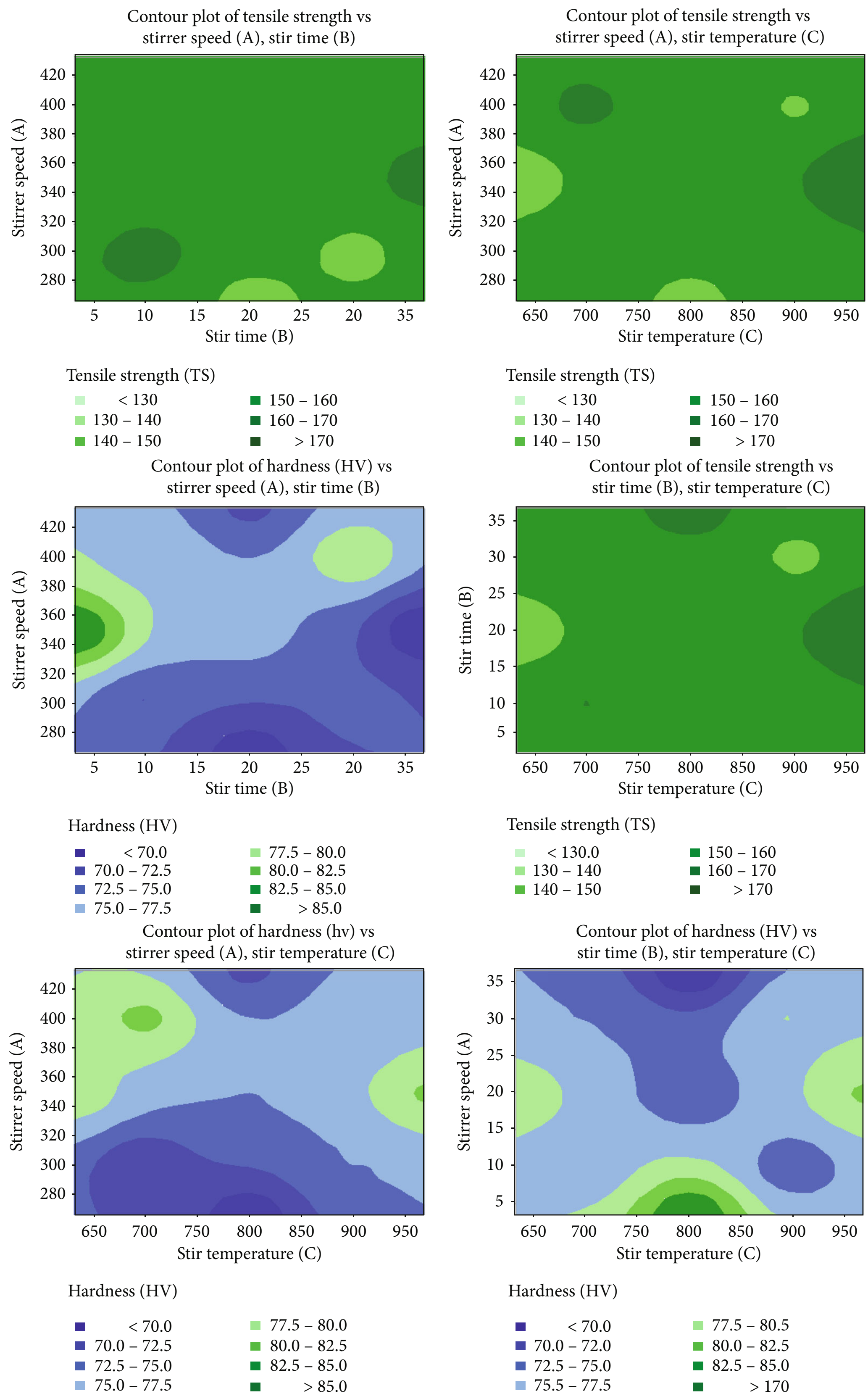


Figure 2: Contour plots of UTS and BHN with stir casting factors.

Table 4: ANOVA model-TS.

| Sources | SS | DF | MS | $F$ ratio | $P$ |
|---|---|---|---|---|---|
| Model | 582.97 | 13 | 52.5 | 2.278 | 1.212 |
| A | 19.08 | 1 | 16.1 | 0.047 | 0.044 |
| B | 0.3842 | 1 | 0.254 | 0.001 | 0.039 |
| C | 21.86 | 1 | 18.9 | 0.055 | 0.920 |
| A * B | 310.0 | 1 | 200.0 | 0.578 | 0.046 |
| A * C | 61.2 | 1 | 60.5 | 0.175 | 0.775 |
| B * C | 21.0 | 1 | 18.0 | 0.052 | 0.824 |
| A * A | 16.6 | 1 | 14.6 | 0.042 | 0.842 |
| B * B | 92.6 | 1 | 72.5 | 0.210 | 0.687 |
| C * C | 100.5 | 1 | 97.2 | 0.281 | 0.718 |
| Residual | 3755.8 | 14 | 346.1 | | |
| Fit | 1871.9 | 3 | 359.4 | 1.09 | 0.487 |
| P. error | 1859.0 | 3 | 332.8 | | |
| Aggregate (Total) | 3 | 19 | | | |

Table 5: ANOVA-hardness.

| Source | SS | DF | MS | $F$ | $p$ |
|---|---|---|---|---|---|
| Model | 352.7 | 13 | 35.2 | 3.31 | 0.184 |
| A | 65.2 | 1 | 65.2 | 4.10 | 0.052 |
| B | 42.3 | 1 | 42.3 | 2.58 | 0.192 |
| C | 0.398 | 1 | 0.398 | 0.027 | 0.923 |
| A * B | 3.00 | 1 | 3.00 | 0.143 | 0.042 |
| A * C | 52.6 | 1 | 52.6 | 3.59 | 0.175 |
| B * C | 14.8 | 1 | 14.8 | 0.696 | 0.526 |
| $A^2$ | 37.5 | 1 | 37.5 | 2.05 | 0.253 |
| $B^2$ | 9.3 | 1 | 9.3 | 0.399 | 0.523 |
| $C^2$ | 50.9 | 1 | 50.9 | 3.24 | 0.142 |
| Residual | 198.2 | 14 | 19.8 | | |
| Lack-fit | 148.7 | 3 | 48.2 | 4.41 | 0.402 |
| Error | 66.4 | 3 | 22.2 | | |
| Aggregate (Total) | 487.3 | 19 | | | |

attained at A of 340–380 rpm and B of 5-15 min when graph is plotted between A and B. HV was improved at B (330-420 rpm) and C (650-750°C) while interaction plot between parameters B and C.

The L1 sample had the highest hardness, followed by the L8 and L9 samples. Increasing the stir speed and time resulted in enhanced matrix density, dislocation containment, and increased hardness values. Furthermore, the inclusion of SiC particles inhibits plastic deformation of the composites during force applied by indenter on sample surface that improving hardness (HV). L7 sample exhibited the lowest HV due to more porosity or gaps in the matrix. Highest and least hardness (85 and 68.5) were observed at L1 (350 rpm, 15 min, 750°C) and L7 (350 rpm, 850°C at 35 min) correspondingly. From Table 4, two interactions (BC and AC) and squared interactions ($A^2$, $B^2$, $C^2$) are not significant due to $p > 0.05$, whereas stir speed (A), stir time (B), and interaction of AB are most significant parameters since $p < 0.05$ and the contribution of A and B variables are more comparing to stir temperature to improve TS property. In the case of hardness, A is the most influence factor that gives more contribution followed by B and C in Table 5, and also, the model is outstanding because Fisher ratio ($F$) was not higher than 5.

## 5. Conclusion

Al 5083 with two reinforcements (silicon carbide/fly ash) at different weight percent composites were produced through stir casting (SC) process. The central composite design at response surface approach were used to assess the impact of individual and combined interactions of three processing parameters of SC on the formation of Al 5083-SiC-FA composite. The modifications of SC input considerations that give effects on mechanical properties of tensile strength and hardness. The ANOVA findings revealed that the stirring parameters impact each attribute, with chosen two-way interactions (stir speed and time) having a significant effect at a 95% confidence level. Maximum amount of TS and HV was obtained on L8 and L1 specimens and lowest values identified at L2 and L3, respectively. According to the response surface technique. Temperature and speed values of less than 750°C and 390 rpm were shown to have a favorable influence at TS and HV responses, whereas values beyond that might have less mechanical properties, due to proper distribution of particles with base metal 5083 alloy tended to make changes in material characteristics and improving the mechanical behavior.

## Data Availability

The data used to support the findings of this study are included in the article. Should further data or information be required, these are available from the corresponding author upon request.

## Disclosure

This was performed as a part of the Employment Bule Hora University, Ethiopia.

## Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.


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## References

[1] C. Rajaganapathy, D. Vasudevan, A. D. Bruno, and T. Rajkumar, "Tribological and mechanical characteristics of AA6082/TiC/WC-based aluminium composites in dry and wet conditions," *Materials Today: Proceedings*, vol. 37, pp. 1133–1136, 2021.

[2] P. Paramasivam and S. Vijayakumar, "Mechanical characterization of aluminium alloy 6063 using destructive and non-destructive testing," *Materials Today: Proceedings*, 2021.

[3] A. P. Pasupulla, H. A. Agisho, S. Seetharaman, and S. Vijayakumar, "Characterization and analysis of TIG welded stainless steel 304 alloy plates using radiography and destructive testing techniques," *Materials Today: Proceedings*, vol. 51, pp. 935–938, 2022.

[4] B. Gugulothu, P. S. Satheesh Kumar, B. Srinivas, A. Ramakrishna, and S. Vijayakumar, "Investigating the Material Removal Rate Parameters in ECM for Al 5086 Alloy- Reinforced Silicon Carbide/Flyash Hybrid Composites by Using Minitab-18," *Advances in Materials Science and Engineering*, vol. 2021, Article ID 2079811, 6 pages, 2021.

[5] M. Ravichandran, M. Meignanamoorthy, G. P. Chellasivam, J. Vairamuthu, A. S. Kumar, and B. Stalin, "Effect of stir casting parameters on properties of cast metal matrix composite," *Materials Today: Proceedings*, vol. 22, pp. 2606–2613, 2020.

[6] R. Ramamoorthi, J. J. M. Hillary, R. Sundaramoorthy, J. D. J. Joseph, K. Kalidas, and K. Manickaraj, "Influence of stir casting route process parameters in fabrication of aluminium matrix composites–a review," *Materials Today: Proceedings*, vol. 45, pp. 6660–6664, 2021.

[7] J. Zhu, W. Jiang, G. Li, F. Guan, Y. Yu, and Z. Fan, "Microstructure and mechanical properties of SiCnp/Al6082 aluminum matrix composites prepared by squeeze casting combined with stir casting," *Journal of Materials Processing Technology*, vol. 283, p. 116699, 2020.

[8] H. P. Pydi, A. Pradeep, S. Vijayakumar, and R. Srinivasan, "Examination of various weld process parameters in MIG welding of carbon steel on weld quality using radiography & magnetic particle testing," *Materials Today: Proceedings*, 2022.

[9] R. M. Badizi, A. Parizad, M. Askari-Paykani, and H. R. Shahverdi, "Optimization of mechanical properties using D-optimal factorial design of experiment: Electromagnetic stir casting process of A357– SiC nanocomposite," *Transactions of Nonferrous Metals Society of China*, vol. 30, no. 5, pp. 1183–1194, 2020.

[10] K. Ravikumar, K. Kiran, and V. S. Sreebalaji, "Characterization of mechanical properties of aluminium/tungsten carbide composites," *Measurement*, vol. 102, pp. 142–149, 2017.

[11] H. P. Pydi, A. P. Pasupulla, S. Vijayakumar, and H. A. Agisho, "Study on microstructure, behavior and $Al_2O3$ content flux A-TIG weldment of SS-316L steel," *Materials Today: Proceedings*, vol. 51, pp. 728–734, 2022.

[12] A. A. Adediran, A. A. Akinwande, O. A. Balogun, and B. J. Olorunfemi, "Optimization studies of stir casting parameters and mechanical properties of TiO2 reinforced Al 7075 composite using response surface methodology," *Scientific Reports*, vol. 11, no. 1, pp. 1–20, 2021.

[13] P. Sathishkumar, V. Deepakaravind, P. Gopal, and P. Azhagiri, "2021. Analysis the mechanical properties and material characterization on magnesium metal matrix nano composites through stir casting process," *Materials Today: Proceedings*, vol. 46, pp. 7436–7441, 2021.

[14] S. Rangrej, V. Mehta, V. Ayar, and M. Sutaria, "Effects of stir casting process parameters on dispersion of reinforcement particles during preparation of metal composites," *Materials Today: Proceedings*, vol. 43, pp. 471–475, 2021.

[15] M. Ravi Kumar, H. N. Reddappa, R. Suresh, and M. Gangadharappa, "Effect of heat treatment on tensile strength of Al7075/Al2O3/SiCp hybrid composite by stir casting technique," *Materials Today: Proceedings*, vol. 5, no. 10, pp. 22460–22465, 2018.

[16] M. Saessi, A. Alizadeh, and A. Abdollahi, "Wear behavior and dry sliding tribological properties of ultra-fine grained Al5083 alloy and boron carbide-reinforced Al5083-based composite at room and elevated temperatures," *Transactions of Nonferrous Metals Society of China*, vol. 31, no. 1, pp. 74–91, 2021.

[17] J. V. Christy, R. Arunachalam, A. H. I. Mourad, P. K. Krishnan, S. Piya, and M. Al-Maharbi, "Processing, properties, and microstructure of recycled aluminum alloy composites produced through an optimized stir and squeeze casting processes," *Journal of Manufacturing Processes*, vol. 59, pp. 287–301, 2020.

[18] A. Karthik, R. Karunanithi, S. A. Srinivasan, and M. Prashanth, "The optimization of squeeze casting process parameter for AA2219 alloy by using the Taguchi method," *Materials Today: Proceedings*, vol. 27, pp. 2556–2561, 2020.

[19] M. Amra, K. Ranjbar, and S. A. Hosseini, "Microstructure and wear performance of Al5083/$CeO_2$/SiC mono and hybrid surface composites fabricated by friction stir processing," *Transactions of the Nonferrous Metals Society of China*, vol. 28, no. 5, pp. 866–878, 2018.

[20] K. Gurusami, S. Shalini, and T. Sathish, "2020. Optimization of stir casting parameters for corrosion rate analysis of AA7068–Boron carbide composites," *Materials Today: Proceedings*, vol. 33, pp. 4650–4655, 2020.

[21] F. Akhlaghi, A. Lajevardi, and H. M. Maghanaki, "2004. Effects of casting temperature on the microstructure and wear resistance of compocast A356/SiCp composites: a comparison between SS and SL routes," *Journal of Materials Processing Technology*, vol. 155, pp. 1874–1880, 2004.

[22] H. Zhang, L. Geng, L. Guan, and L. Huang, "Effects of SiC particle pretreatment and stirring parameters on the microstructure and mechanical properties of SiCp/Al-6.8Mg composites fabricated by semi-solid stirring technique," *Materials Science and Engineering A*, vol. 528, no. 1, pp. 513–518, 2010.

[23] L. N. Guan, L. Geng, H. W. Zhang, and L. J. Huang, "Effects of stirring parameters on microstructure and tensile properties of (ABOw+ SiCp)/6061Al composites fabricated by semi-solid stirring technique," *Transactions of Nonferrous Metals Society of China*, vol. 21, pp. s274–s279, 2011.

[24] G. V. N. B. Prabhakar, N. R. Kumar, and B. R. Sunil, "Surface metal matrix composites of Al5083 - fly ash produced by friction stir processing," *Materials Today: Proceedings*, vol. 5, no. 2, pp. 8391–8397, 2018.

[25] P. Lakshmikanthan and B. Prabu, "Optimization on stir casting process parameters of aluminium alloy (AL6061) nickel coated graphite (NCG) metal matrix composite using Taguchi based RSM," *Materials Science*, vol. 9, no. 6, pp. 260–269, 2016.

[26] J. J. Moses, I. Dinaharan, and S. J. Sekhar, "Prediction of influence of process parameters on tensile strength of AA6061/TiC aluminum matrix composites produced using stir casting," *Transactions of Nonferrous Metals Society of China*, vol. 26, no. 6, pp. 1498–1511, 2016.

[27] D. Pal, S. Vijayakumar, T. V. J. Rao, and R. S. R. Babu, "An examination of the tensile strength, hardness and SEM analysis of Al 5456 alloy by addition of different percentage of SiC/flyash," *Materials Today: Proceedings*, vol. 62, pp. 1995–1999, 2022.

[28] B. Gugulothu, S. L. Sankar, S. Vijayakumar et al., "Analysis of wear behaviour of AA5052 alloy composites by addition alumina with zirconium dioxide using the Taguchi-grey relational method," *Advances in Materials Science and Engineering*, vol. 2022, 7 pages, 2022.

[29] B. Gugulothu, S. Seetharaman, S. Vijayakumar, and D. J. Rani, "Process parameter optimization for tensile strength and Hardness of Al-MMC using RSM technique," *Materials Today: Proceedings*, vol. 62, pp. 2115–2118, 2022.

[30] B. Gugulothu, N. Nagarajan, A. Pradeep, G. Saravanan, S. Vijayakumar, and J. Rao, "Analysis of Mechanical Properties for Al-MMC Fabricated through an Optimized Stir Casting Process," *Journal of Nanomaterials*, vol. 2022, 7 pages, 2022.

[31] S. Suresh, G. H. Gowd, and M. L. S. Deva Kumar, "Tribological behavior of Al 7075/SiC metal matrix nano-composite by stir casting method," *Journal of The Institution of Engineers (India): Series D*, vol. 100, no. 1, pp. 97–103, 2019.

[32] P. S. Reddy, R. Kesavan, and B. Vijaya Ramnath, "Investigation of mechanical properties of aluminium 6061-silicon carbide, boron carbide metal matrix composite," *Silicon*, vol. 10, no. 2, pp. 495–502, 2018.

[33] M. Vigneshkumar, P. Ashoka Varthanan, and Y. Maria Ambrose Raj, "Finite element-based parametric studies of nugget diameter and temperature distribution in the resistance spot welding of AISI 304 and AISI 316L sheets," *Indian Institute of Metals*, vol. 72, no. 2, pp. 429–438, 2019.

[34] M. Vigneshkumar and P. A. Varthanan, "Comparison of RSM and ANN model in the prediction of the tensile shear failure load of spot welded AISI 304/316 L dissimilar sheets," *International Journal of Computational Materials Science and Surface Engineering*, vol. 8, no. 2, pp. 114–130, 2019.