Hindawi
Advances in Materials Science and Engineering
Volume 2023, Article ID 9781204, 1 page
https://doi.org/10.1155/2023/9781204

*Retraction*

# Retracted: Effect of Reinforcement on Tensile Characteristics in AA 5052 with ZrC and Fly Ash-Based Composites

**Advances in Materials Science and Engineering**

Received 26 December 2023; Accepted 26 December 2023; Published 29 December 2023



This article has been retracted by Hindawi, as publisher, following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of systematic manipulation of the publication and peer-review process. We cannot, therefore, vouch for the reliability or integrity of this article.

Please note that this notice is intended solely to alert readers that the peer-review process of this article has been compromised.

Wiley and Hindawi regret that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

## References

[1] K. Mallikarjuna, M. K. Harikeerthan, B. S. Shubhalakshmi et al., "Effect of Reinforcement on Tensile Characteristics in AA 5052 with ZrC and Fly Ash-Based Composites," *Advances in Materials Science and Engineering*, vol. 2022, Article ID 7070304, 7 pages, 2022.

Hindawi
Advances in Materials Science and Engineering
Volume 2022, Article ID 7070304, 7 pages
https://doi.org/10.1155/2022/7070304



*Research Article*

# Effect of Reinforcement on Tensile Characteristics in AA 5052 with ZrC and Fly Ash-Based Composites

**K. Mallikarjuna,[1] M. K. Harikeerthan,[2] B. S. Shubhalakshmi,[2] K. S. Vinay Kumar,[2] Ravindra Pratap Singh,[3] Maddali Srikanth,[4] Y. Krishna Srinivasa Subba Rao,[5] Suresh Kumar,[6] and Aggegnenu Shara Shata[7]**

[1]*Department of Mechanical Engineering, Government Polytechnic, Kudligi-583135, Karnataka, India*
[2]*Department of Civil Engineering, Dayananda Sagar Academy of Technology and Management, Bangalore 560082, Karnataka, India*
[3]*Department of Mechanical Engineering, GLA University, Mathura, Uttar Pradesh 281406, India*
[4]*Department of Humanities and Basic Sciences, Aditya Engineering College (A), Surampalem, Andhra Pradesh 533437, India*
[5]*Department of Mechanical Engineering, Aditya College of Engineering, Valasapalle, Andhra Pradesh, India*
[6]*Department of General Engineering (MECH), Panimalar Engineering College Chennai City Campus, Chennai, Tamil Nadu, India*
[7]*Faculty of Mechanical Engineering, Arba Minch Institute of Technology, Arba Minch University, Ethiopia*

Correspondence should be addressed to Aggegnenu Shara Shata; agegnehu.shara@amu.edu.et

Received 5 July 2022; Revised 8 September 2022; Accepted 10 September 2022; Published 30 September 2022

Academic Editor: K. Raja



Aluminum Alloy 5052/ZrC/fly ash composites' tensile properties are changed by the addition of reinforcements and thermal exposure, according to this study. The precipitation hardening of samples manufactured with various weight percent of fly ash and zirconium carbide was employed to improve the properties under thermal circumstances. The tensile properties of reinforced and heat-treated specimens were studied in a series of scientifically-designed experiments. Tensile strength and yield strength rise up to 200°C, after which they begin to decrease slightly (i.e., 250°C) based on the results of the research. Adding reinforcements and exposing the composites to heat increases their elastic modulus which decreases the percentage of El of the composites substantially. Several factors contribute to composites' increased strength and elastic modulus, the diffusion process, temperatures, and reinforcement composition. It is also possible to manufacture hybridized composite mechanisms for numerous automotive and aviation industries utilizing optimization studies, which interpolate the findings of several sets of parameters to make the process easier.

## 1. Introduction

The examination of required materials for certain applications to enhance the ability to communicate has helped to aid the most current advances in the development of composites [1]. Airplanes are increasingly using aluminum composites because of their better tensile and yield strength and corrosion resistance, which makes them ideal for use in aircraft structures. High-speed flight conditions need the use of composite materials that can withstand high temperatures [2]. As a result, they've widened the scope of their composites research to encompass uses in aircraft operating at higher Mach numbers and temperatures ranging from 200–250°C [3]. Furthermore, for aerospace industries such as wing structures, airframes and heat exposure of Al composites to maximum temperatures are critical [4]. High-strength alloys are castable and resistant to corrosion features of aluminum alloys are particularly impressive [5]. High-temperature applications have seen an increase in the characteristics of Al castings synthesized by chemical stir casting [6]. This work utilizes aluminum oxide particles as reinforcement for studying wear and increasing the effective surface area for subsequent applied mechanical retention strengths [7]. Denture bases are made of aluminum, and crowns are made of aluminum ceramics [8]. Dental prosthetics such as dentures, crowns, and bridges are made with zirconia-fused alumina metals. Basic and noble metal alloys predominate over other materials [9]. They are polished and finished after casting. Abrasives made from zirconia-fused alumina metals can be used to grind, sandblast, and treat metals and other materials [10, 11].

Hypo-eutectic Al alloy blends and reinforcements make up the bulk of the composites. The tensile parameters of composites are heavily affected by the carbide particle shape [12–14]. To boost the composites' tensile strength, heat treatment under the T6 temper conditions is applied to them [15]. According to a study by [16], heat treatment improves the tensile properties of Aluminum Alloy 7075 composites by increasing the Orowan strength and connection. In their experiment, they used an AA 7075 alloy as a matrix and E-glass and fly ash as strengthening, all of which were stir cast, treated with solutions, and then water quenched [17]. When the fly-ash size was increased with thermal treatment, researchers observed that grain growth and involution occurred during the matrix phase, which led to enhanced tensile strength [18]. A study by [19] found that inoculation of the composite reinforcements improved the properties of aluminum-fly ash–ZrC hybrid composites after a heat treatment procedure. The tensile properties of an aluminum-7Si-0.35 magnesium alloy matrix supplemented with varied weight percent of $Al_2O_3$ in the range of 2 to 8 were improved owing to particle dispersal and particle-matrix connection [20]. An experiment [21] found that the characteristics of composites enhanced with a rise in fly ash material, which was next followed by microcoring and separation in the composite, all of which were linked to the composites' improved fly ash content. Composites made from L-aluminum alloys and reinforced with ZrC and fly ash [22, 23]. According to research, it is also possible to study the properties of heat treatment, in particular the inoculation caused by fly ash, on parameters of composites. The combination of reinforcements and treatment for a wide variety of thermal cycles has been revealed to enhance TS required for potential automotive and aerospace applications, as proven in this study.

## 2. Materials and Methods

Aluminum Alloy 5052 alloys were reinforced with ZrC with an average particle size of 35 to 70 $\mu$m, C-type, and fly ash. It was decided to start with a matrix and then add reinforcements after conducting a ground survey to determine the availability and requirements. The supplier specifications were used to determine the matrix and reinforcement properties, as shown in Tables 1–3.

As a result of their capacity to produce high-performance compounds, AA 5052-ZrC-fly ash composites are made by stir casting. Weighed aluminum AA 5052 pieces were put into a furnace and heated to 700°C in accordance with the work of [24]. At 600 RPM, the metal was agitated for 10 minutes using a ceramic-coated AISI 316L stirrer, which had been preheated for two and half hours with ZrC and fly-ash flake addition. In order to remove the trapped air, perchloroethane tablets were inserted into melted metal. The melted metal was then maintained at 750°C for 10 minutes before being poured into the preheated die after another round of continuous stirring. A range of temperatures, including 50°C, 100°C, 150°C, 200°C, and 250°C, were used to test the stir cast composites containing various amounts of ZrC and fly ash. These composite samples are tabulated in Table 4, organized with the name of the specimen, matrix composition, reinforcement materials, and the temperature at which the specimen was exposed.

T6-grade thermal treatment included two stages, i.e., the resulting treatment was completed at 530°C for 2 hours after water quenching and ageing for 6 h at 150°C, heating to temperatures of 50°C, 100°C, 150°C, 200°C and 250°C in [25] make Oven operated at 0.5 MPa working pressure and 10 hours soak period in still air with time and temperature controls as per AMS-2771 conditions. They are more easily dissolved because of their siliconisation and exposure to heat.

Table 1: Chemical arrangement of the AA 5052.

| Materials | Wt.% |
|---|---|
| Copper | 0.10 |
| Zinc | 0.10 |
| Chromium | 0.35 |
| Magnesium | 2.80 |
| Silicon | 0.25 |
| Iron | 0.40 |
| Manganese | 0.10 |
| Aluminum | Balance |

Table 2: Properties of AA 5052.

| Properties | Value |
|---|---|
| Melting point | 605°C |
| Electrical resistivity | $0.0495 \times 10^{-6}$ Ωm |
| Density | 2.68 g/cm$^3$ |
| Modulus of elasticity | 70 GPa |
| Thermal expansion | $23.7 \times 10^{-6}$/K |
| Thermal conductivity | 138 W/mK |

Table 3: ZrC arrangement.

| Formula | ZrC |
|---|---|
| IUPAC ID | Zirconium carbide |
| Molar mass | 40.11 g/mol |
| Melting point | 2730°C |
| Density | 3.24 g/cm$^3$ |

*2.1. Characterization for Tensile Properties.* ASTM E8-95 requirements as in Figure 1 were followed in the preparation of the composites, which had tensile properties with a gauge width of 12.5 mm and gauge span of 62.5 mm. Fine devices

Table 4: Experimental conditions for different trials.

| Trials | wt.% of fly ash | HT temperature oC | wt.% of ZrC |
|---|---|---|---|
| L1 | 0 | 50 | 0 |
| L2 | 0 | 50 | 3 |
| L3 | 0 | 50 | 6 |
| L4 | 0 | 50 | 9 |
| L5 | 0 | 50 | 12 |
| L6 | 3 | 100 | 0 |
| L7 | 3 | 100 | 3 |
| L8 | 3 | 100 | 6 |
| L9 | 3 | 100 | 9 |
| L10 | 3 | 100 | 12 |
| L11 | 6 | 150 | 0 |
| L12 | 6 | 150 | 3 |
| L13 | 6 | 150 | 6 |
| L14 | 6 | 150 | 9 |
| L15 | 6 | 150 | 12 |
| L16 | 9 | 200 | 0 |
| L17 | 9 | 200 | 3 |
| L18 | 9 | 200 | 6 |
| L19 | 9 | 200 | 9 |
| L20 | 9 | 200 | 12 |
| L21 | 12 | 250 | 0 |
| L22 | 12 | 250 | 3 |
| L23 | 12 | 250 | 6 |
| L24 | 12 | 250 | 9 |
| L25 | 12 | 250 | 12 |

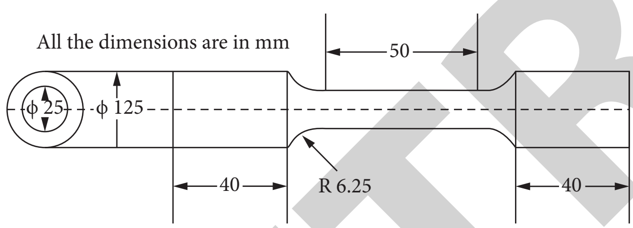


Figure 1: Schematic of a tensile test sample.

(Miraj, Maharashtra, India) manufactured TFUN-600 UTM was used to characterize the specimens and the tensile testing results were listed using the strain rate of 1.5 percent per minute (0.00025/s).

*2.2. Taguchi Method.* An important statistical instrument in the study of process optimization is Taguchi's approach. An orthogonal array (OA)-based experimental design was used, followed by a reduction of the experimental strategy and a feasibility study looking at the interactions between various experimental factors. According to the "larger is better" and "smaller is better" conditions for the UTS and YS, Minitab software was used to conduct optimization studies. The characteristic formulas for both conditions are given in (1) and (2), respectively, for each factor level combination.

For "Larger is Better Condition,"

$$\frac{S}{N} = -10 * \log\left(\Sigma \frac{\left(1/Y^2\right)}{n}\right). \quad (1)$$

For "Smaller is Better Condition,"

$$\frac{S}{N} = -10 * \log\left(\frac{\Sigma\left(Y^2\right)}{n}\right). \quad (2)$$

## 3. Results and Discussion

Composite materials were studied to determine their tensile properties, as well as temperature and the weight of reinforcements, affect these properties.

*3.1. Ultimate Tensile Strength (UTS).* According to [26], discoveries associated with fly-ash reinforcement effects on TS of AA 5052 and depicted graph Figure 2 shows that UTS of composites rises with the rise in weightage percent of fly ash owing to inoculation acceleration enhanced by heat exposure in the post-treatment disorder up to a heat of 200°C. Particle dispersions in the matrix are reduced slightly when heat exposure is increased to 250°C in a study by [27]. This reduction in UTS and particle dispersions can be traced back to the increased temperature-induced agglomeration of reinforcements, which can be observed in the study.

Tensile characterization of aluminum AA 5052/ZrC/fly ash compounds was reported by [28]. Results from this investigation were compared to those from the base alloy. When ZrC was added to the mix, mechanical properties such as tensile strength improved up to 3 to 6 wt.%; however, once ZrC was added beyond this range, tensile strength began to decline. They concluded that high-performance hybrid aluminum composites were needed. Here, controlled dispersion of ZrC reinforcing materials with fly ash is combined with T6 thermal treatment to precipitate solute components in the Al solid solution, making it easier to form strong bonds between matrix and reinforcements. This is what the current study is attempting to do. Due to stronger bonding and interstitial strengthening, thermal treatment is necessary in order to improve the composites' tensile characteristics. A similar study in [29] found that the mechanical characteristics of aluminum-fly ash compounds can be enhanced by thermal treatment. Using different weight percentages of fly ash and heat treatments on composite specimens, they were able to improve the mechanical characteristics by altering the crystalline structure, which was then followed by different weight percentages and particle sizes of fly ash.

*3.2. Yield Strength.* Figures 3 show a comparison of the YS of the composite samples at various thermal treatment temperatures and the mix of reinforcements. According to the graph, inoculation rises the YS of the composites, resulting in grain packing and atom connecting, which in turn increases yield strength. This is made possible by thermal exposure at 200°C, which is attributed to the material's increased stiffness. However, yield strength decreases slightly at temperatures higher than 200°C. An interstitial microcoring was formed in the matrix when fly ash was added to the mix, according to investigations by [30]. Using

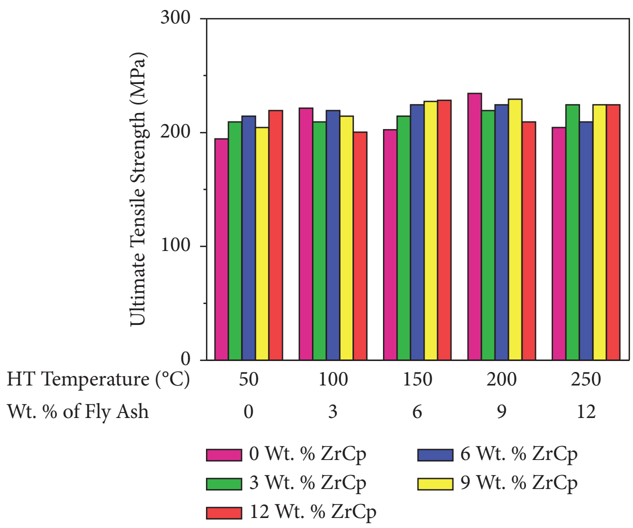


Figure 2: Ultimate tensile strength for variant wt.%.

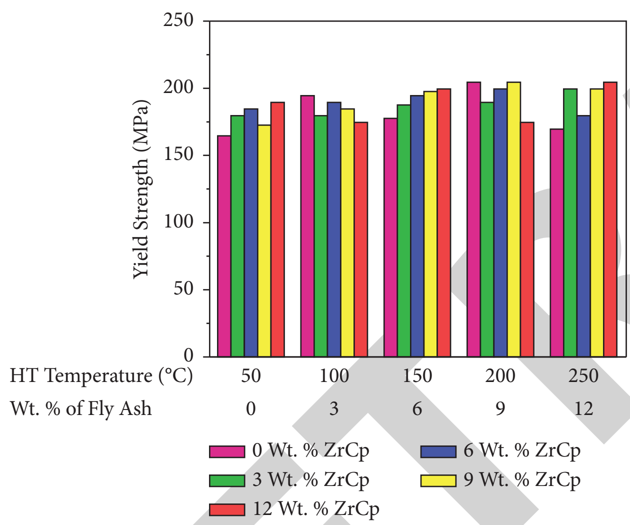


Figure 3: Yield strength for different experimental conditions.

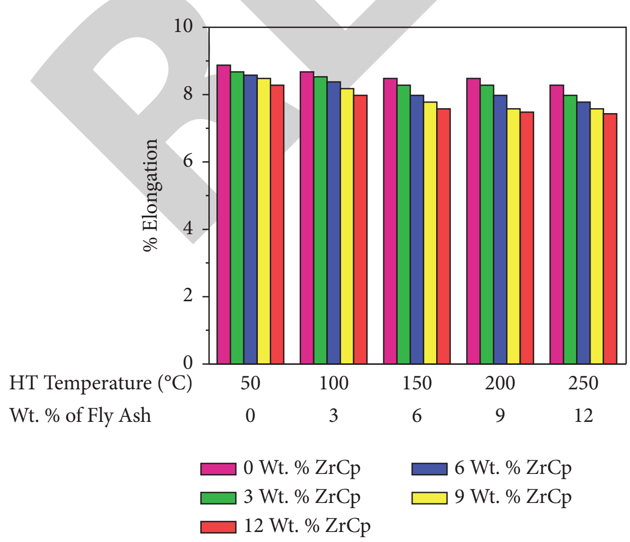


Figure 4: % elongation for different experimental conditions.

continual stirring as well as post-treatment thermal revelation, the authors of the current study were able to homogenize fly ash particles in the composites and speed up the inoculation process.

*3.3. Percentage Elongation.* A composite's ductility can be assessed by measuring the percent of elongation, which provides a picture of how far the material can stretch in the plastic zone before snapping. Figure 4 shows the percentage of elongation that the composites experience before they fail. Because the base alloy specimens (AA 5052) lack stiffness and are unable to absorb applied loads before failure, the %El of these samples is greater than that of the composites. Though, the %El reduces with the addition of reinforcements, particularly ZrC reinforcements, which are strong ceramic elements that rise the strength and hardness of a material, causing embrittlement in the composites. Al-C compound bonds are also strengthened by fly ash elements and thermal treatment, which accelerates the response among atoms due to the inoculation of Silicon particles in the Al matrix.

The graph shows how the percentage El of composite samples for various thermal treatment temperatures can be compared as in Figure 4. With a rise in ZrC and fly ash content and thermal treatment temperature, it can be seen that the composites' elongation reduces. Additionally, there is an increase in stiffness as a result of interstitial microcores and cohesive bonding. A study by [31] found that elongation reduces with increasing strength. That is because a higher tensile and Young's modulus means a higher level of strength, which in turn leads to a higher level of stiffness in the material, which reduces the amount of strength connected to elongation. Although the critical softening that occurs as a result of thermal deformation causes a small increase in percent elongation for materials exposed to temperatures above 200°C, strain hardening accelerates embrittlement after that point, as distinguished in the work of [32], who investigated the impact of strong ceramic strengthening on the mechanical performance of comminutions.

## 4. Optimization Studies for Ultimate Tensile Strength (UTS)

Optimized wt. and percent of ZrC and fly ash in composite samples made by end route stir casting, as well as exposure temperature, were found by Taguchi-based experiments. We can also see how the reinforcements and heat treatment have a direct impact on the UTS of the composites generated by using the optimization results. Tables 5 and 6 contain response tables for SNR and means, respectively, whereas Figures 5 and 6 indicate the main-effect graphs for SNR and means for ultimate tensile strength.

This study found that HT temperature at stage 4 (200°C) and fly ash content at stage 4 (9 wt.%) were the best parameters for maximizing UTS, while zirconium carbide additions in increments of 3 wt.% improved UTS significantly from 3 wt.% all the way up to the maximum

Table 5: Signal-to-noise (S/N) ratios response for UTS.

| Level | wt.% of fly ash | HT temperature | wt.% of ZrC |
|---|---|---|---|
| 1 | 47.52 | 47.52 | 47.21 |
| 2 | 47.73 | 47.73 | 47.69 |
| 3 | 47.91 | 47.91 | 47.96 |
| 4 | 48.05 | 48.05 | 48.05 |
| 5 | 47.95 | 47.95 | 48.15 |
| Delta | 0.63 | 0.63 | 0.98 |
| Rank | 2.6 | 2.6 | 1 |

Table 6: Mean response for UTS.

| Level | Fly ash wt.% | HT temperature | ZrC wt.% |
|---|---|---|---|
| 1 | 209.4 | 209.4 | 203.8 |
| 2 | 215.6 | 215.6 | 214.4 |
| 3 | 220.4 | 220.4 | 222.6 |
| 4 | 225.0 | 225.0 | 225.0 |
| 5 | 222.6 | 222.6 | 227.2 |
| Delta | 15.6 | 15.6 | 23.4 |
| Rank | 2.5 | 2.5 | 1 |

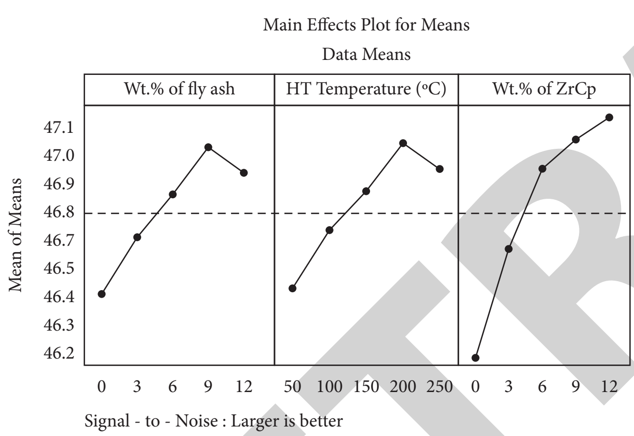


Figure 5: Main-effect plot for UTS (S/N ratios).

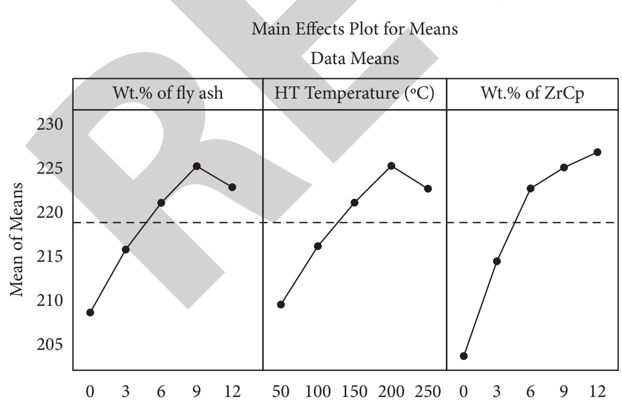


Figure 6: Main-effect plot for UTS (mean).

limit of 12 wt.% used in this study. Interactions and synthetic reactions among the particles and subatomic packing in the material, as well as their impact on properties of resulting composite resources, have been studied by [33]. Composite materials' tensile strength has been found to increase when grain epitaxy is used as material inoculants to speed up the interface response time.

## 5. Conclusions

The study of research results and statistical verifications resulted in appropriate settings for maximizing the strength of created composites, as indicated below.

(i) Precipitation hardening improved tensile and yield strengths and other properties of the composites exposed to T6 tempered exposure. Because of their inherent connection, which was enhanced by the T6 tempered, composites' elongation % decreased dramatically with the addition of reinforcements.

(ii) Further optimization of tensile strength discoveries utilizing Taguchi techniques allowed the optimal set of variables for composites to be found, including maximal ultimate tensile strength as well as yield strength.

(iii) Hence this work experimentally and statistically validated parameters for fabricating and post-treating AA 5052/ZrC/Fly Ash composites for high-quality software, such as structural mechanisms in the automotive and aviation industries, where the materials must have higher Tensile Strength, Yield Strength property characteristics.

## Data Availability

The data used to support the findings of this study are included within the article. Further data or information are available from the corresponding author upon request.

## Conflicts of Interest

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

## Acknowledgments

The authors appreciate the support from Arba Minch University, Ethiopia for providing help during the research and preparation of the manuscript.

## References

[1] H. Yigiter, S. Aydin, H. Yazici, and M. Y. Yardimci, "Mechanical performance of low cement reactive powder concrete (LCRPC)," *Composites Part B: Engineering*, vol. 43, no. 8, pp. 2907–2914, 2012.

[2] V. Mohanavel, K. Rajan, and M. Ravichandran, "Synthesis, characterization and properties of stir cast AA6351-aluminium nitride (AlN) composites," *Journal of Materials Research*, vol. 31, no. 24, pp. 3824–3831, 2016.

[3] M. Toozandehjani, N. Kamarudin, Z. Dashtizadeh, E. Yee Lim, A. Gomes, and C. Gomes, "Conventional and advanced composites in aerospace industry: technologies revisited," *American Journal of Aerospace Engineering*, vol. 5, no. 1, pp. 9–15, 2018.

[4] R. Ramesh, I. Dinaharan, E. T. Akinlabi, and N. Murugan, "Microstructure and mechanical characterization of friction-stir-welded dual-phase brass," *Journal of Materials Engineering and Performance*, vol. 27, no. 4, pp. 1544–1554, 2018.

[5] N. M. Anas, T. E. Abioye, A. S. Anasyida, B. K. Dhindaw, H. Zuhailawati, and A. Ismail, "Microstructure, mechanical and corrosion properties of cryorolled-AA5052 at various solution treatment temperatures," *Materials Research Express*, vol. 7, no. 1, Article ID 016535, 2020.

[6] V. Mohanavel, K. Ashraff Ali, S. Prasath, T. Sathish, and M. Ravichandran, "Microstructural and tribological characteristics of AA6351/Si3N4 composites manufactured by stir casting," *Journal of Materials Research and Technology*, vol. 9, no. 6, pp. 14662–14672, 2020.

[7] M. L. Bharathi, S. A. Rag, L. Chitra et al., "Investigation on wear characteristics of az91d/nanoalumina composites," *Journal of Nanomaterials*, vol. 2022, Article ID 2158516, 9 pages, 2022.

[8] B. Wang, X.-H. Chen, F.-S. Pan, J.-J. Mao, and Y. Fang, "Effects of cold rolling and heat treatment on microstructure and mechanical properties of AA 5052 aluminum alloy," *Transactions of Nonferrous Metals Society of China*, vol. 25, no. 8, pp. 2481–2489, 2015.

[9] J.-D. Chow and W.-L. Chai, "Recycling and application characteristics of the fly ashes from municipal solid waste incinerator blended with waste polypropylene," *Environmental Engineering Science*, vol. 25, no. 10, pp. 1497–1506, 2008.

[10] I. Kim, S. Akramov, H. B. Jeong, and T. K. No, "Texture development and drawability of frictionally rolled AA 5052 AL alloy sheet," *International Journal of Modern Physics B*, vol. 22, no. 31n32, pp. 5931–5936, 2008.

[11] X. Zhou, Y. Gao, Y. Wang, X. Huang, and P. Xiao, "The improved strength and ductility of ZrCp/2024Al composites with a quasi-network microstructure fabricated by spark plasma sintering and T6 heat treatment," *Materials Science and Engineering A*, vol. 841, Article ID 142675.

[12] Y. Jia, S. Chen, Y. Li, S. Wang, and H. Hu, "High-temperature mechanical properties and microstructure of C/C–ZrC–SiC–ZrB2 composites prepared by a joint process of precursor infiltration and pyrolysis and slurry infiltration," *Journal of Alloys and Compounds*, vol. 811, Article ID 151953, 2019.

[13] F. Li, Z. Xu, K. Zhao, and Y. Tang, "ZrB2-ZrC composite nanofibers fabricated by electrospinning and carbothermal reduction: processing, phase evolution and tensile property," *Journal of Alloys and Compounds*, vol. 771, pp. 456–463, 2019.

[14] Q.-F. Pan, C.-H. Liu, R. Tang, M.-Z. Jiang, and W. Yi, "Research on 310S for microalloying with addition of titanium and zirconium," *Hedongli Gongcheng/Nuclear Power Eng.*vol. 33, no. SUPPL.2, pp. 70–74, 2012, [Online]. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84879157547&partnerID=40&md5=3cb6dc17833cb0e997 4ef2d783c69c14.

[15] M. Jabłońska, A. Jasik, and A. Hanc, "Structure and some mechanical properties of Fe3AI-based cast alloys," *Archives of Metallurgy and Materials*, vol. 54, no. 3, pp. 731–739, 2009, [Online]. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-72949102593&partnerID=40&md5=f1f9c 92a9e6ffe8a5b8233dceb4f6070.

[16] J. Affi, R. Diaz, T. Nugraha, and R. Gunawarman, "Shear strength and microstructure of joints processed with free vacuum diffusion bonding," *1st International Seminar on Advances in Metallurgy and Materials (i-SENAMM 2019)*, vol. 2262, 2020.

[17] H. Kamiya, A. Kimura, M. Tsukada, and M. Naito, "Analysis of the high-temperature cohesion behavior of ash particles using pure silica powders coated with alkali metals," *Energy and Fuels*, vol. 16, no. 2, pp. 457–461, 2002.

[18] "Applied mechanics and materials," in *Proceedings of the 2012 2nd International Conference on Machinery Electronics and Control Engineering, ICMECE 2012*, vol. 313–314, Jinan, China[Online]. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84876521894&partnerID=40&md5=4d05550b4dabed4c21af28c1b9277aa8, Jinan, China, December 2013.

[19] Z. Qin, Y. Zeng, Q. Hua, Q. Xu, X. Shen, and Y. Min, "Synergistic effect of hydroxylated boron nitride and silane on corrosion resistance of aluminum alloy 5052," *Journal of the Taiwan Institute of Chemical Engineers*, vol. 100, pp. 285–294, 2019.

[20] W. Tang, X. Yang, C. Tian, and Y. Xu, "Microstructural heterogeneity and bonding strength of planar interface formed in additive manufacturing of Al-Mg-Si alloy based on friction and extrusion," *Int. J. Miner. Metall. Mater.*vol. 29, no. 9, pp. 1755–1769, 2022.

[21] E. Cinkilic, M. Moodispaw, J. Zhang, J. Miao, and A. A. Luo, "A new recycled Al–Si–Mg alloy for sustainable structural die casting applications," *Metallurgical and Materials Transactions A*, vol. 53, no. 8, pp. 2861–2873, 2022.

[22] J. Huang, X. Zhou, J. Guo, H. Liao, and J. Du, "Effect of Ni addition on the microstructure and mechanical properties of 6101 aluminum alloy with high electrical conductivity," *Journal of Materials Engineering and Performance*, 2022.

[23] A. M. A. Mohamed, M. F. Ibrahim, Y. Zedan, E. Samuel, A. M. Samuel, and F. H. Samuel, "A study on the factors enhancing the high-temperature strength of B319.2-type Alloys," *International Journal of Metalcasting*, 2022.

[24] A. P. Hekimoğlu and Ş. Bayraktar, "Experimental research on machinability characteristics of Al-9Si alloy: effect of Sr and Mg additives," *Proceedings of the Institution of Mechanical Engineers - Part B: Journal of Engineering Manufacture*, vol. 236, no. 13, pp. 1807–1816, 2022.

[25] N. Sahara, R. Ikeda, S. Wu, and M. Okayasu, "Effects of artificial aging on material properties of die-cast Al–Si–Cu–Mg–xNa alloy," *International Journal of Metalcasting*, 2022.

[26] J.-Y. Li, S.-N. Kong, C.-K. Liu, B.-B. Wang, and Z. Zhang, "Chemical composition effect on microstructures and mechanical properties in friction stir additive manufacturing," *Acta Metallurgica Sinica*, vol. 35, no. 9, pp. 1494–1508, 2022.

[27] R. Jojith, N. Radhika, and M. Govindaraju, "Reciprocating wear behavioural analysis of heat-treated aluminium ZrO2/Al7Si0.3Mg functionally graded composite through taguchi's optimization method," *Silicon*, 2022.

[28] G. Humur and A. Çevik, "Mechanical characterization of lightweight engineered geopolymer composites exposed to elevated temperatures," *Ceramics International*, vol. 48, no. 10, pp. 13634–13650, 2022.

[29] K. Nithesh, M. C. Gowrishankar, R. Nayak, and S. Sharma, "Effect of light weight reinforcement and heat treatment process parameters on morphological and wear aspects of hypoeutectic Al-Si based composites - a critical review," *Journal of Materials Research and Technology*, vol. 15, pp. 4272–4292, 2021.

[30] S. Nagaraja, R. Kodandappa, K. Ansari et al., "Influence of heat treatment and reinforcements on tensile characteristics of aluminium aa 5083/silicon carbide/fly ash composites," *Materials*, vol. 14, pp. 5261–18, 2021.

[31] S. Muthukumar, "Mechanical behaviour of silicon carbide-fly ash hybrid Aluminium alloy composites subjected to age hardening," *International Journal of Vehicle Structures & Systems*, vol. 11, no. 2, pp. 196–198, 2019.

[32] J.-C. Liu, K. H. Tan, and S. Fan, "Residual mechanical properties and spalling resistance of strain-hardening cementitious composite with Class C fly ash," *Construction and Building Materials*, vol. 181, pp. 253–265, 2018.

[33] J. Lin, J. Yu, and V. C. Li, "Mechanical properties of PVA fiber reinforced engineered cementitious composites after thermal treatment," *Fuhe Cailiao Xuebao/Acta Mater. Compos. Sin.*vol. 33, no. 1, pp. 116–122, 2016.