Investigation of Corrosion Characteristic of Al6063 Reinforced with Al₂O₃-CBA by Using Stir Casting

Nithyanandhan T¹*, Sivaraman P², Prabhu M K³, Nedumaran C⁴, Narendran J⁵, Naveen P S⁶
¹, ², ³ Asst.Professor, Sri Krishna College of Technology, Coimbatore
⁴, ⁵, ⁶ UG Students, Sri Krishna College of Technology, Coimbatore
Email ID: anandhan8.mech@gmail.com

Abstract: This work critiques an examination method to investigate the corrosion characteristic of composite materials with guide of Aluminium oxide and chicken bone ash as reinforcements. The weight percentage of aluminium oxide are 6%, 5%, 4%, 3% and 2% and Chicken Bone Ash are 2%, 3%, 4%, 5% and 6% have been covered for this investigation. This composite casting method became made with the help of the stir casting method. The “Aluminium chloride” solution is used to examine the detail corrosion behaviour of the metal matrix composite by using of the immersion test. The result of this research work produce the corrosion rate would be decreased with increase of the weight percentage of Reinforcements. This work concluded that the estimation of rate of corrosion free with increment in maximum weight percent of hybrid composites.

Keyword: Al (6063), Aluminium oxide, chicken bone ash, Aluminium Chloride, Immersion test

1. Introduction
Aluminum and aluminum-primarily based metal matrix composites (MMCs) were exceedingly studied with the aid of diverse professionals lately, parallel to the growing needs to substances with decrease weight in combination with higher mechanical properties along with wear resistance, hardness, impact toughness and Corrosion resistance. Corresponding to the expanding requests to substances with decrease weight in mixture with higher mechanical homes, for example, put on obstruction, hardness, sway sturdiness and ballistic competition. Due to those prevalent houses, MMCs are becoming fascinating in designing packages, for instance, protect, car industry, aviation, athletic equipment and digital bundling. The hybrid composite overall performance is a considered sum of the separate additives in which there may be a greater favorable stability between reinforcement introduced and the advantages and downsides of its feature. Materials which are consolidated of in any occasion special substances, which enhance their properties. The article deals with the Al-4.5% Cu blend were used because the Matrix was bonded with ash and silicon carbide (SiC) as support. The combination metallic community composite became introduced utilizing everyday foundry methods. The ash and SiC were incorporated 5%, 10%, and 15% by using weight to the fluid metal. (K. V. MAHENDRA, 2010). The effects of welding boundaries had been reviewed with the guide of mechanical and microstructural levels. The microstructure of the composite and dispersing of particle fortresses had been tried by means of optical amplifying focal point for example Optical magnifying instrument and also the properties of yield quality, extreme elasticity and extension had been completely investigated the utilization of all-inclusive testing machine. The upgraded grinding mix weld boundaries have been perceived for 20% weight division fortified cross breed composites (B.SURESHBABU, 2018). In this modern-day research, Al/Chicken Bone Ash (CBA) metal community composites (MMCs) have been created via vortex technique. Distinctive weight portions of fortification have been utilized to produce the composites. Checking electron microscope furnished with energy dispersive X-ray analyzer is applied for the microstructural characterizations. The residences like thickness, hardness, and severe elasticity
have been researched (D. SIVA PRASAD, 2011). The paper deals with the fabrication of aluminium based hybrid metal matrix composite and then characterized their chemical properties which are recently developed modification of stir casting has been used in the present investigation to produce aluminium (6063) alloy reinforced with Silicon carbide (Sic). In this paper, Aluminium (6063) alloy is used as a base metal and Silicon carbide (SIC) is been used as reinforced material with the hybrid reinforcement as chicken bone ash (HARIDASS.R, 2018). This study focuses on the Mechanical properties of Al6063 with reinforcement of coconut shell ash and Aluminium oxide particulates are prepared by stir casting techniques. In this experimental, reinforcement Aluminium oxide has various altitude of 5,8&3 wt% and other one coconut shell ash has1.1 & 2 wt% for all specimens. The result concludes that the tensile strength and fracture toughness would be improved in reinforcement material compared to pure aluminum alloy. (T. NITHYANANDHAN, 2017). Metal matrix composites represent a new generation of engineering materials which combine metallic properties of matrix alloys with the properties of reinforcements, which is desired for the industries today. Among various particulate reinforcements like SiC, Al2O3, Al2O3, SiC, TiC, AlN, fly ash etc, fly ash presents as a natural source, low cost, toxic industrial waste particulate reinforcement. Reinforcement of fly ash particles in the aluminium melt diminishes the cost of the composites, incorporation of hybrid particle reinforcement shows couple the properties of primary and secondary reinforcements (K. KAVIYARASAN, 2018).

2. Material Used
1. Aluminium 6063
2. Aluminum Oxide (Al2O3)
3. Chicken Bone Ash (CBA)
4. Aluminium Chloride (ALCL3)

2.1 Aluminium 6063
Al 6063 is an aluminum compound, with magnesium and silicon as the alloying components is shown in Fig 1. 6063 is the most widely recognized combination utilized for aluminium expulsion. It permits complex shapes to be shaped with smooth surfaces fit for anodizing as is famous for obvious engineering applications, for example, window outlines, entryway casings, rooftops, and sign edges.

2.2 Aluminium Oxide Al2O3
The vast majority of the aluminum oxide delivered is utilized to shape aluminum metal. Oxygen regularly catalyzes consumption in response with the metal aluminum. Nonetheless, when reinforced with oxygen to shape aluminum oxide, a defensive covering structures and forestalls further oxidation. This includes quality and makes the material less defenseless against decay regularly delivered by the Bayer cycle, which means refining bauxite to create alumina. Bayer measure this cycle begins by drying squashed and washed bauxite, ordinarily containing 30–55% Al2O3 is shown in Fig 2. The bauxite is disintegrated in scathing soft drink to frame a slurry, warmed to temperatures of around 230–520 °F (110–270 °C). The aluminium oxide which would increase the hardness of the materials, for that the different weight percentage of aluminium oxide was added to the aluminium alloy 6063.
2.3 Preparation of CBA
Chicken bone Ash (CBA) is the burning buildups of chicken bone and the impact of different elements as contact time, measure of CBA, arrangement pH and beginning focus on adsorption cycle such of metal particles was learned at room temperature to improve the conditions for most extreme adsorption. Bone debris is a white material created by the calcination of bones. Commonplace bone debris comprises of about 55.82% calcium oxide, 42.39% phosphorus pentoxide, and 1.79% water. The specific structure of these mixes fluctuates relying on the kind of bones being utilized, however by and large the recipe for bone debris is: Ca5 (OH)(PO4)3. Bone debris typically has a thickness around 3.10 g/mL and a dissolving purpose of 1670 °C (3038 °F) is shown in Fig 3. Most bones hold their cell structure through calcination. Chicken bone ash is the natural waste agriculture product which would increase the mechanical properties of the materials, in this paper the different weight percentage of the CBA was added to improve the corrosion resistance of the Aluminium composites.

![Fig.3 Aluminium CBA](image)

2.4 Aluminium Chloride (AlCl₃)
Aluminum chloride (AlCl₃) is the arrangement which is utilized to analyze the consumption wear rate for the aluminium composite. It is white, however tests are regularly sullied with iron chloride, giving it a yellow shading. It is chiefly delivered and devoured in the creation of aluminum metal, however huge sums are likewise utilized in different regions of concoction industry. Aluminum chloride is made for an enormous scope by the exothermic response of aluminum metal with chlorine or hydrogen chloride at temperatures between 650 to 750 °C (1,202 to 1,382 °F)

\[
\begin{align*}
2 \text{Al} + 3 \text{Cl}_2 & \rightarrow 2 \text{AlCl}_3 \\
2 \text{Al} + 6 \text{HCl} & \rightarrow 2 \text{AlCl}_3 + 3 \text{H}_2 \\
2\text{Al} + 3\text{CuCl}_2 & \rightarrow 2\text{AlCl}_3 + 3\text{Cu}
\end{align*}
\]

Aluminum chloride may be formed via a single displacement reaction between copper chloride and aluminum metal.

\[
\text{Al (H}_2\text{O)} 6\text{Cl}_3 \rightarrow \text{Al (OH)} 3 + 3 \text{HCl} + 3 \text{H}_2\text{O}
\]

3. Experimental Process
During preheating degree, the fortresses are warmed freely towards number one cycle temperature of 400°C simultaneously as aluminium is disintegrated in a remarkable cauldron at a temperature of 830°C. The chicken bone ash and Aluminium oxide and their combo were preheated to 280°C for 60 Minutes to discard soddeness. Unadulterated aluminium becomes softened creation utilization of obstruction heater. The mollify temperature become raised to 750°C and later on the melted aluminum changed into joined with the assistance of a mix projecting Technique. The blending got kept up between 3 to 5 min at a mix speed of 200 rpm. The softening temperature kept up was to 700°C for the term of extension of AL₂O₃ and chicken bone ash blend particles. The mollify with fortified particulates had been filled the preheated interminable metallic shape. The pouring temperature got set aside at 700°C. The dissolving aluminium composite was then licensed to solidify inside the structure. The stir casting setup was shown in Fig 4. The Process parameters which are used in this setup were noted in table 1. Table 2 shows the different composition of composite materials which are solidified from the casting.
The testing method of this paper was done by immersion test. The consumption register turned with completed in aluminum chloride arrangement with pH estimation of 2.5 with 1N arrangement which had been readied following typical normalized approaches. The composite materials were sliced to the components of ø 30x32mm. The examples were de-lubed with acetone after which flushed in refined water sooner than inundation inside the readied regardless arrangements of AlCl₃ with 1N. The answer for example surface area proportion turned out to be around 80 ml cm⁻². The erosion rates have been assessed through weight decrease and further more consumption rates are estimated by one day spans. The examples were uncovered inside the aluminum chloride in environmental factors condition for 48 hours individually. Consumption charge and erosion hindrance execution for each example become assessed from the weight decrease estimations observing Standard methodologies.

| Table.1 Process Parameters |
|---------------------------|
| Speed of stirrer          | 200-250 Rpm               |
| Stirrer Time              | 3 to 5 mins               |
| Preheat Temperature       | 300°C                     |
| Stirrer Temperature       | 750°C                     |

| Table.2 Composition of Composites |
|-----------------------------------|
| Sample No | Weight Percentage of AL6063 | Weight Percentage of Al₂O₃ | Weight Percentage of CBA |
|-----------|-----------------------------|---------------------------|-------------------------|
| Sample 1  | 100                         | 0                         | 0                       |
| Sample 2  | 92                          | 6                         | 2                       |
| Sample 3  | 92                          | 5                         | 3                       |
| Sample 4  | 92                          | 4                         | 4                       |
| Sample 5  | 92                          | 3                         | 5                       |
| Sample 6  | 92                          | 2                         | 6                       |

4. Experimental Procedure

The 600 Grams of pure aluminium was melted in a resistance heated muffle furnace and casted in a clay graphite crucible. For this the melting temperature was raised to 800°C and then the Aluminium oxide (5%, 7.5%) and chicken bone ash (5%, 7.5%) reinforcement was preheated in the preheater for about 300°C to remove the moisture for two hours. Then reinforced materials were added in the ratio of 0.1:1.1:1.0 to the 5% weight of aluminium matrix for the production of three different composites and also reinforced materials were added in the ratio of 0.1:1.1:1.0 to the 7.5% weight of aluminium matrix for the production of another three different composites. Commercial pure aluminum was melted by raising its temperature to 800°C and then the melt was stirred using a mild steel stirrer. Reinforcement particles were added to melt at the time of vortex in the melt due to stirring. The soften
temperature was kept up between 750°C-800°C during the expansion of fortified particles. At that point
the soften was poured in to the predetermined kick the bucket to get cooled. The composite was expelled
from the bite the dust. The consumption attributes of Al-Al2O3-CBA composites were controlled by
plunging the six examples of composites in AlCl3 (Aluminum chloride) with ordinariness of 1N, for
this AlCl3 were taken in six Glass holder and these six examples of composites were dunked in the
AlCl3 answer for three days. Weight reduction of composite is resolved from beginning and last loads.
Erosion rates and consumption inhibitor efficiency of the samples were assessed.

5. Result and Discussions

5.1 Result

Corrosion inhibition efficiency and Corrosion rate of Al6063 with Al2O3 and CBA at room temperature
was listed in Table 3.

Table 3. Corrosion inhibition efficiency and Corrosion rate

| Sample. No | Weight Of Alloy (Mg) Before (Wb) | Weight Of Alloy (Mg) After (Wl) | Weight Difference (Mg) | Corrosion Inhibition Efficiency [IE = (Wb- Wl)/Wb*100] | Corrosion Rate (Mmpy) |
|------------|---------------------------------|---------------------------------|------------------------|---------------------------------------------------|-----------------------|
| Sample 1   | 55.66                           | 54.23                           | 1.43                   | 0.02570                                           | 0.1372                |
| Sample 2   | 56.24                           | 55.92                           | 0.32                   | 0.56899                                           | 0.0307                |
| Sample 3   | 56.73                           | 56.26                           | 0.47                   | 0.82848                                           | 0.0451                |
| Sample 4   | 57.21                           | 57.98                           | 0.23                   | 0.40202                                           | 0.0220                |
| Sample 5   | 57.53                           | 57.48                           | 0.05                   | 0.08691                                           | 0.0479                |
| Sample 6   | 57.78                           | 57.75                           | 0.03                   | 0.05192                                           | 0.0287                |

Above results shows that, the sample 4(4%of Al2O3 & 4% of CBA) has less corrosion rate compare to
the other reinforced and non-reinforced aluminium alloy. In the sample 4 component have a high
percentage of reinforcements. The above results show that the maximum percentage of the CBA in the
aluminium alloys has less corrosion rate compare to the others.

5.2 Discussions
Figure 5. Weight loss of sample 1

Figure 6. Weight loss of sample 2

Figure 7. Weight loss of sample 3

Figure 8. Weight loss of sample 4
In the Figure 5, shows that the weight loss gradually decreases for the sample 1 starting from 55.66 to 54.23 mg ranging between initial and final weight because of weight percentage of Reinforcements was not considered. In the Fig 6, it is observed that the weight loss decreases slightly from 56.24 to 55.9 mg which is from initial weight to final weight for sample 2 because of weight percentage of Aluminium oxide (6%) higher than the CBA (2%) but the difference between the weight percentage of two reinforcements is higher than sample 1. In the Fig 7, it is observed that the weight loss decreases from 56.73 to 56.26 mg which is from initial weight to final weight for sample 3 because of weight percentage of Aluminium oxide (5%) less than the CBA (3%), the reason for more weight loss due to more difference percentage of reinforcement content in this sample. In the Fig 8, it is observed that the weight loss decreases from 57.21 to 57.98 mg which is from initial weight to final weight for sample 4 because of weight percentage of Aluminium oxide (4%) and the CBA (4%), due to the same percentage of...
Reinforcement compare to the other samples. In the Fig 9, it is observed that the weight loss decreases from 57.53 to 57.48 mg which is from initial weight to final weight for sample 5, because of weight percentage of Aluminium oxide (3%) higher than the CBA (5%) but the difference between the weight percentage of two reinforcements is less. In the Fig 10, it is clear that the weight loss decreases very minute from 57.78 to 57.48 mg which is from initial weight to final weight for sample 6, because of weight percentage of Aluminium oxide (2%) less than the CBA (6%), the reason for more weight loss due to more percentage of CBA content in this sample. In the Fig 11, it is clear that the corrosion rate increased to 0.1372 mmpy at sample 1 (0% Aluminium oxide & 0% CBA), the corrosion rate decreased to 0.03 mmpy at sample 2 (6% Aluminium oxide & 2% CBA), the corrosion rate increased to 0.045 mmpy at sample 3 (5% Aluminium oxide & 3% CBA), the corrosion rate decreased to 0.02 at sample 4 (4% Aluminium oxide & 4% CBA), the corrosion rate increased to 0.047 mmpy at the sample 5 (3% Aluminium oxide & 5% CBA), the corrosion rate decreased to 0.028 mmpy for the sample 6 (2% Aluminium oxide & 6% CBA).

6. Conclusion

The erosion characteristics of composites materials have been finished by distinctive weight percent like 6%, 5%, 4%, 3% and 2% wt of Aluminium oxide and reinforcement with 2%, 3%, 4%, 5% and 6% of chicken bone ash. The rate of corrosion and corrosion resistance was carried out by Aluminium chloride solution through the usage of immersion test. The end result as follows:

- About the paper it is miles found that we can utilize farming waste like chicken bone debris, rice husk debris for the composites assembling and ready to change over industrial squanders into business riches.
- The Erosion rate was decreased in the reinforcement with 4% of Aluminium oxide and 4% of CBA with the correlation of unadulterated Aluminium 6063.
- The Erosion resistance of Reinforced composites have been improved with increased in of 5% Aluminium oxide and 3% chicken bone ash.
- The Maximum Percentage of reinforcements is extended the corrosion resistance and decreased the corrosion rate.

REFERENCE

[1] Kandpal B C, Kumar J and Singh H 2014 Production technologies of metal matrix composite: a review International Journal of Research in Mechanical Engineering & Technology, 4, 27–32
[2] Mr.Kaviyarasan.K, 2018 “Extensive Review on Properties of Metal Matrix Composites Reinforced with Fly Ash”, International Journal of Mechanical Engineering and Technology (IJMET), 9, 0976-6340.
[3] Kainer, K.U., 2006. Basics of metal matrix composites. Wiley-VCH GmbH & Co. KGaA, Weinheim, Germany.
[4.] Deuis, R.L., Subramanian, C. and Yellup, J.M., 1997. Dry sliding wear of aluminium composites—a review. Composites science and technology, 57(4), 415-435.
[5] T.Pridhar, C.Boopathi 2016, “The effect of particle hybridization on micro structure analysis and mechanical behavior of metal matrix composites: an experimental approach” Digest Journal of Nanomaterials and Biostructures, 3, 845 – 852.
[6] Christy TV, Murugan N, Kumar S, 2010, “A comparative study on the microstructures and mechanical properties of Al 6063 alloy and the MMC Al 6063/TiB2/12p”, JMMCE, 9, 57–65.
[7] Macke A, Schultz BF, Rohatgi P, 2012 “Metal matrix composites offer the automotive industry an opportunity to reduce vehicle weight, improve performance” Adv Mater Processes, 170, 19–23.
[8] Pridhar T, 2019, “Evaluation on properties and characterization of asbestos free palm kernel shell fibre (PKSF)/polymer composites for brake pads” Materials Research Express, 6, 11-19.
[9] Siva Prasad D, Rama Krishna A, 2011,” Production and mechanical properties of A356.2/ CBA composites”, International Journal of Advanced Technology, 33, 51–57.
[10] Nithyanandhan T, 2017, “Investigation of Mechanical Properties on Aluminium Based Hybrid Composites”. International Journal of Innovative Research in Science, Engineering and Technology, 7, 118-126.
[11] Haridass R, 2018, “Determination of corrosion behaviour of Al6063-Sic-CBA metal matrix composites”, International Journal of Pure and Applied Mathematics, 118, 907-915.
[12] Pridhar T, 2018, “Mechanical properties and characterization of zirconium oxide (ZrO2) and coconut shell ash(CSA) reinforced aluminium (Al 6082) matrix hybrid composite” Journal of Alloys and Compounds, 765, 171-179.
[13] Murthy K S, Girish D P, Keshavmurthy R, Varol T and Koppad P G 2017 ‘’Mechanical and thermal properties of Al6063/bone ash hybrid composites obtained by hot forging’’ Progress in Natural Science: Materials International, 27, 474–81
[14] Nithyanandhan T., Sivaraman, P., Ramamoorthi, R., Kumar, P.S., Kannakumar, R. and Kumar, A.N., 2020. Enhancement of corrosion behaviour of AL6061-B4C-RHA reinforced hybrid composite. Materials Today: Proceedings.
[15] Nithyanandhan T, 2020,” Mechanical Properties and Tribological Behaviour of Reinforced Aluminium Metal Matrix Composites”, International Journal of Recent Technology and Engineering, 8, 1191-1195