FABRICATION AND CHARACTERIZATION OF BAGASSE ASH PARTICLE (BAP) REINFORCED MAGNESIUM (AZ91E) ALLOY COMPOSITE BY VACUUM STIR CASTING

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Abstract: The present study is to fabricate AZ91E alloy matrix composite by varying the Bagasse ash particle (50μm) content (0, 5, 7.5, and 10wt%) via vacuum stir casting technique. The samples were characterized for its mechanical and microstructure properties. The mechanical properties of BAP reinforced composites were evaluated as per the ASTM standard and compared to unreinforced AZ91E alloy. The effect of reinforcement and distribution of BAP has been examined through a scanning electron microscope. The results of AZ91E magnesium alloy with 10wt% of BAP have found to have maximum tensile strength. The impact strength and hardness shows a marginal increase with increasing bagasse ash particle.

Keywords: AZ91E alloy, Bagasse ash, Vacuum stir cast, Mechanical properties, SEM.

1. Introduction:

Magnesium alloy based metal matrix composites were good prospects for automobile, aerospace, and marine applications because of its superior mechanical properties and lightweight and high strength ratio comparable to aluminium base MMC [1-2]. It has fabricated by liquid metallurgy [3], thermal cycling [4], powder metallurgy route [5], Squeeze casting [6], semisolid stirring [7, 8], and stir casting. Among the various techniques listed above, many researchers have suggested that the stir casting technique is effective and economical for mass production [9-11]. Shen et.al.[7-8] prepared the AZ31 magnesium alloy composite reinforced with SiC particles via semi solid stir casting route to study the effect of reinforcement. They observed that the presence of SiC particles improve the yield strength of the composite. Viswanath et.al.[9] studied the characteristics of SiC reinforced AZ91 Magnesium alloy composite for automobile and aerospace applications. They reported that the reinforcement (SiC) has enhanced the creep resistance of the composite. Aravindan et.al.[10] developed AZ91 magnesium alloy composite incorporated with SiC particle by stir cast. They found increased mechanical properties with increase in SiC particle. Aathisugan et.al.[11] prepared the AZ91D magnesium alloy hybrid composite via stir cast technique. They reported that the porosity of composite was controlled by uniform stir speed leading to an increase in the load-bearing capacity and wear resistance. Imran et.al.[12] studied the characteristics of aluminum matrix hybrid composite reinforced with graphite and bagasse-ash particle for aerospace applications. They observed increased mechanical properties of composite on adding bagasse-ash particles. Abdulwahab et.al.[13] developed low cost Al-Si-Mg composite reinforced with melon shell ash. Asgari et.al.[14] prepared AZ91 magnesium alloy composite with the combinations of waste magnesium chip and SiC particles by stir cast method. They observed that the yield strength of composite has increased with 5 vol% of SiC. Jayabharathy et.al.[15] reported that the mechanical characteristics of AZ91 magnesium alloy hybrid composite. They found increased hardness, yield strength and wear resistance on 2 wt% of TiO2/0.5wt% of graphene. However, there is no reports available on...
the fabrication of bagasse ash reinforced AZ91E magnesium alloy composite by vacuum assisted stir casting. In the present work AZ91E alloy composite was prepared by vacuum stir cast with different weight percentages (0, 5, 7.5, and 10 wt%) of bagasse ash particles. The fabricated composites were subjected to physical, mechanical and micro structural studies.

2. Experimental procedure

Figure 1 show the melting furnace set up with vacuum pump.

![Magnesium melting furnace setup with stir and vacuum pump](image)

Figure 1. Magnesium melting furnace setup with stir and vacuum pump

The AZ91E magnesium alloy ingots was preheated to 600°C through the muffle furnace for one hour and melted at 800°C in an inert atmosphere. The temperature of molten metal was reduced to 550°C. It helps to reduce the floating of particles and to provide better wettability. Then preheated bagasse ash particles (50 μm) were added into it under the uniform stir speed of 400rpm for 10mintues. It helped to improve the mixing ratio and to create a uniform dispersion of fine particle in the metallic structure. The rectangular-shaped casting die was preheated at 300°C for 30 minutes. The stirred molten composite metal was poured into the preheated rectangular die and 1x10³ Pa vacuum pressure was applied to prepare AZ91E magnesium alloy composite. The prepared composite was cleaned and machined as per ASTM test standards. The tensile test was carried out as per ASTM E8 standard using Universal Testing Machine (FIE-UTN 40). The impact strength was determined as per ASTM E23 using Charpy Impact Tester (IT-30). Hardness was measured using Vickers hardness tester (FIE -VM50). The surface morphology was studied using Scanning electron microscopy (ZESIS EVO18).

3. Results and Discussions

3.1. Density and porosity

The density and porosity of the prepared composites were investigated by the rule of mixture and Archimedes’ principle. Figure 2 shows the density and porosity levels of the AZ91E alloy composite reinforced with BAP. The density of BAP reinforced AZ91E magnesium alloy
composite has varied from 1.77g/cc to 1.78g/cc. The porosity level of BAP reinforced AZ91E magnesium alloy composite is higher than the porosity level of casted AZ91E magnesium alloy. It was due to the discontinuity of stir speed and oxide formation during the casting of the composite. A similar tendency has reported by Aravindan et.al.[10] and Aatthisugan et.al.[11] during the fabrication of AZ91D/SiC and AZ91/B4C alloy composite. They have notified that the porosity of composite has increased due to unrated stir speed and improper wetting of molten metal.

Figure 2. Density and porosity level of AZ91E Alloy Composites

3.2. Impact strength
The impact strength of bagasse ash particle reinforced AZ91E magnesium alloy composite with the expected trend line is shown in Figure 3.

Figure 3. Impact toughness of AZ91E Alloy Composites

The impact strength of unreinforced magnesium (AZ91E) alloy was found to be 25.37J/mm². The impact strength of composite has increased significantly, with increasing the BAP content into AZ91E magnesium to improve its capability of energy-absorbing. The impact strength has varied from 25.37J/mm² to 29.13 J/mm²as the bagasse ash content increases from 0 to 10 wt.%. Sample with 10Wt% BAP has excellent impact strength of 29.13 J/mm²having 15% improvement of its impact strength when compared to unreinforced AZ91E alloy.
3.3. Tensile Strength

Figure 4 shows the tensile strength of AZ91E magnesium alloy composite. The tensile strength of casted AZ91E magnesium alloy composite was found to be 197.65 Mpa.

![Tensile strength of AZ91E Alloy Composites](image)

The tensile strength of 2.5wt% BAP reinforced magnesium alloy composite has decreased to 162.32 MPa. It may be due to the presence of void or porosity leading to an increase in particle dislocation. Aravindan et.al [16] reported the following reasons for decreasing ultimate strength: a) the coefficient of thermal expansion between the reinforcement and the matrix differ considerably induce defect around the reinforcement particle resulting in debonding which reduces the ultimate strength. b) When the reinforcement content reaches the critical level, it reacts with the matrix and forms layer. This layer weakens the bond between the reinforcement and matrix resulting in decrease in tensile strength. Further addition of BAP into AZ91E magnesium alloy composite shows the marginal improvement in tensile strength. The 10wt% of BAP reinforced AZ91E magnesium alloy composite showed optimum tensile strength of 213.99 MPA. It has increased 7.63% compared to unreinforced AZ91E alloy.

3.4. Vickers hardness number

Figure 5 shows a Vickers hardness of AZ91E magnesium alloy composite tested with diamond indenter. The hardness of developed AZ91E magnesium alloy composites gradually increases with increasing the content of BAP into AZ91E magnesium alloy. It has observed that the hardness of cast AZ91E magnesium alloy was lower than the hardness of AZ91E magnesium alloy composite. It has varied from 68.38 Hv to 83.33 Hv. The 10wt% BAP reinforced AZ91E magnesium alloy composite was found to have a maximum hardness value of 83.33 Hv. It has increased by 18% compared to casted AZ91E magnesium alloy. The hardness of composite was attributed to the particle distribution and interfacial bonding of composite [8].
3.5. Micro structural studies

The properties AZ91E magnesium alloy composite mainly depends on the distribution of BAP. Figure 6 shows a SEM microstructure image of AZ91E magnesium alloy composites.

It is evident from SEM micrograph 6[b-d] that BAP are well distributed throughout the matrix. It also shows good bonding of bagasse ash particle with AZ91E Mg alloy matrix.

4. Conclusion

The varied weight percentages of (0, 5, 7.5, and 10wt%) bagasse ash particle reinforced AZ91E magnesium alloy composite was successfully prepared by vacuum stir casting. The density of composite shows marginal improvement compared to unreinforced AZ91E alloy
composite. So, it is suitable for light weight applications. The results obtained from AZ91E magnesium alloy composites shows enhanced mechanical properties. The 10Wt% of AZ91E magnesium alloy composite gives highest mechanical properties, of about 13% increase in impact strength, 7.63% increase in ultimate strength and marginal improvement in hardness value compared to unreinforced magnesium alloy (AZ91E). The presence and distribution of BAP was confirmed through Scanning electron microscope.

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