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Recycled Plastic Scraps-Based Composite Reinforcement

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Abstract. The degradation of human and animal livelihoods has been exacerbated by environmental contamination caused by the inappropriate disposal of plastic trash. The article describes the process of reinforcing scrap metal using polyethylene terephthalate (PET) bottles. The stir-casting process was used to create the composite material. The hardness, microstructure, and tensile strength of the samples were measured. Tensile strength improves with a 4% PET addition and hardness steadily decreases with increasing reinforcement composition, according to the results. Be that as it may, mechanical strength decreases with reinforcement levels beyond 8%.

1 Introduction

Recycling as a way of reusing materials is now a common thing in different countries of the entire planet. Institutions and governments have come up with innovative and long-term strategies for trash disposal and recycling. There is an urgent need to implement long-term recycling plans in light of the current state of environmental deterioration. There has been environmental devastation due to the disposal techniques employed for the majority of recycled items, which include plastic, metal scraps, and technological trash [1]. Shredding plastics into pallets and then remelting them to make a new product is a typical method of recycling plastics. In engineering, plastics are sometimes used to create composite constructions. Both metals and polymers have been used as reinforcing elements in various applications. According to Adeniyi and Ighalo's assessment of reinforced plastic composites [2], aluminum is the most common metal used to reinforce polymers. The production of metal-reinforced plastic composites often involves hand mixing, casting, and laying up. In the sandwich approach, which has also been documented in the literature, the base material and plastic reinforcement are stacked in interlayer form [3]. Yang et al. [4] found that compared to using only metals, a sandwiched hybrid composite of metal, carbon fiber, and glass fiber increased mechanical strength by about 30% while decreasing weight. Using a combination of carbon fiber-reinforced plastic and hybrid metal, Fonseca et al. [5] were able to reduce the weight of an engine cradle by 36%. Although the automobile section was mostly metal, it did include plastic ribs. Despite its reputation as one of the most cost-effective manufacturing approaches, there is a dearth of material on the topic of metal-plastic reinforcement utilizing the stir-casting process [6-8]. The study also looked at potential methods for plastic disposal that wouldn't add to environmental dangers. Thus, the purpose of this study is to find a new method of reinforcing metals utilizing plastic items.

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2 Experimental procedure

Composed of basic aluminum, 5.71% zinc, 2.47% magnesium, 0.87% iron, 1.52% silicon, 0.095% copper, and 0.37% other elements, the aluminum-zinc (Al-Zn) scraps were collected, crushed with hammers, and remelted in a furnace. After being cleaned and shredded, the PETs were checked for dirt and other organic debris. To get rid of any moisture, they were dried in a furnace set at 105 °C for four hours. Prior to adding the aluminum cans, the furnace was brought to a temperature of 500 °C. After that, it was heated to 800 °C for 45 minutes while being stirred at 450 rpm [6]. After the metal had cooled to 500 °C and the slags had been removed, the shredded PET bottles were added to the molten metal in accordance with the % composition shown in Table 1. Before being put into the mold, the composite was mixed well.

Using the universal testing machine M500-100AT, the cast samples were machined to conform to the ASTM E8 standard [9]. The cast samples were subjected to a Vickers hardness test with a dwell length of 15 seconds and a force of 4.9 N. Optical microscopy was also used to record the materials' microstructure and calculate their densities.

Table 1. Composition of composite

SN	Sample no.	Al-Zn Alloy (wt %)	PET (wt %)
1	AZ1	100	0
2	AZ2	96	4
3	AZ3	92	8
4	AZ4	88	12
5	AZ5	84	16

3 Results and discussion

3.1 Microstructure

In Figure 1a, we can see the microstructure of the batch that was cast. In terms of microstructure, intergranular crystallization and intergranular eutectic are seen [10,11]. The intragranular and grain border residual phases are shown in Figure 1b-e [12]. Since the PET is completely melted, its presence or agglomeration inside the microstructure could not be detected. The predicted degradation temperature range for PET is between 450 and 550 °C, as stated by Singh et al. [13].

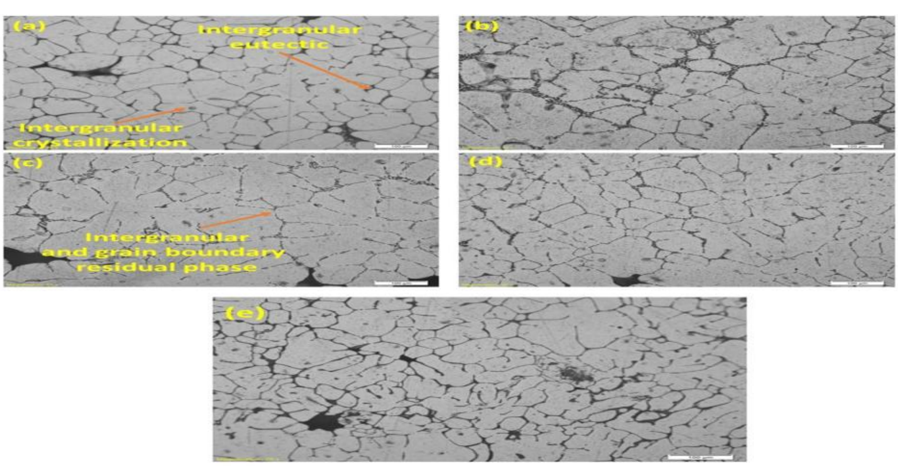

Fig. 1. Optical micrographs of composites (a) as-cast, AZ1 (b) AZ2 (c)AZ3 (d) AZ4 (5)

AZ5

3.2 Tensile strength

Figure 2 displays the samples' ultimate tensile strength. In comparison to both the base material and other PET-reinforced samples, those that were 4% PET showed significantly greater strength. A decrease in strength might be caused by insufficient material cohesion or bonding when the reinforcing % rises. The microstructure likewise shows this trend, with more and more holes and pores appearing as the amount of PET rises. These are thought to be caused by the fact that samples reinforced with more PET have a lower tensile strength [14].

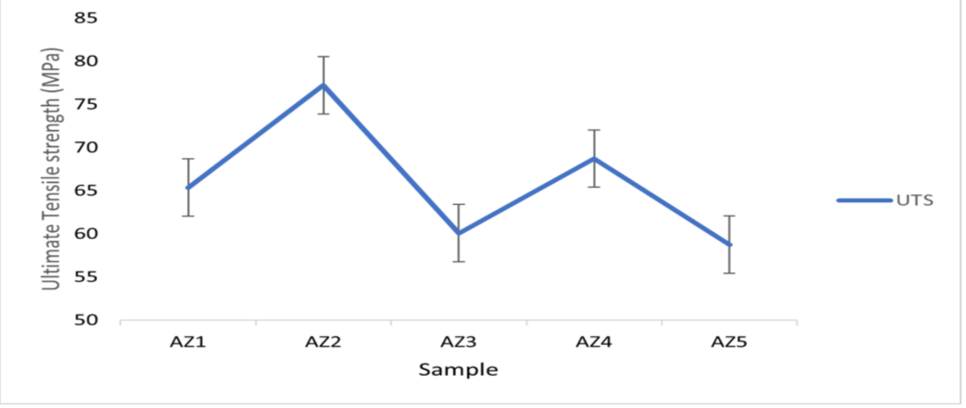

Fig. 2. Tensile strength of produced samples

3.3 Hardness

Figure 3 shows the microhardness of the samples. An average of three indentations were made on each sample. The results show a reduction in hardness as the percentage of PET increases in the composite. This could be attributed to increased voids/pores within the samples. It could also be attributed to alloying elements such as Mn, Cr, V, and Zr, which have been reported to reduce hardness in aluminum alloys [15].

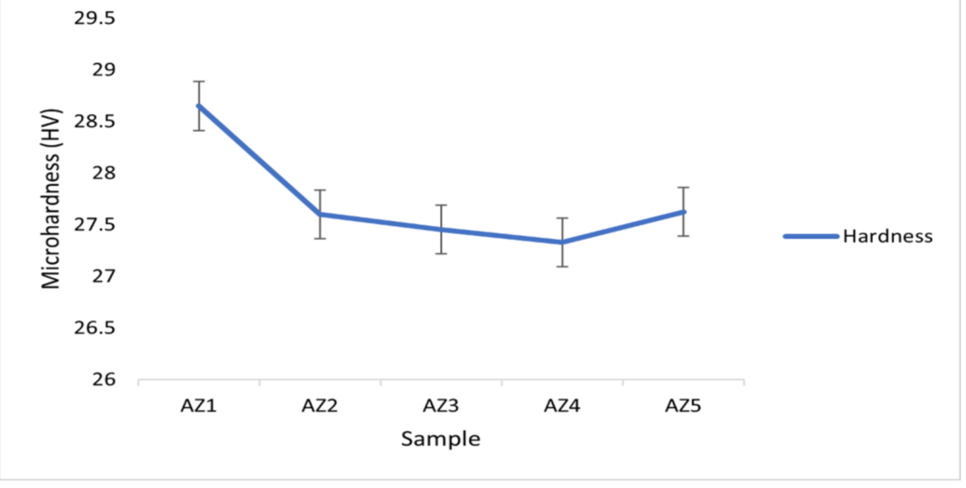

Fig. 3. Hardness distribution within the composite

4 Conclusion

Researchers have looked at the possibility of recycling PET by using stir casting to create Al-Zn. The microstructure of the composite was not substantially altered by the addition of PET, according to the study's findings. Even Nevertheless, porosities became more noticeable as the PET fraction in the composite rose. Additionally, when the amount of PET in the composite grew, the tensile strength fell. The last point is that a lower proportion of PET results in a softer material. Researchers have proposed an inert atmosphere for stir casting as a means to prevent the PET components from burning off or degrading throughout the process. Additional research on the relationship between porosity and PET addition % is required.

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