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Research Article

Mechanical Behaviour of Fly Ash Reinforced Aluminum Composite Prepared by Casting

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A B S T R A C T

Fly ash is a waste residual material generated by coal-burning in thermal power plants, steel plants, etc.; its hazard is no less than that so utilizing fly ash in engineering applications is a service to society. Thus developing Aluminum-fly ash composites holds great ground. The current project studies indicate that the values of compressive strength, tensile strength and hardness are improved with the addition of fly ash when the fly ash content is added from 0 % to 20 % replacement by weight of aluminum.

Keywords: Fly ash, Aluminum Metal Matrix Composite, Casting

Introduction

In the past, coal-fired fly ash was merely trapped in flue gas and stretched into the environment, creating environmental and health issues.[10] This prompted legislation that lowered fly ash emissions to less than 1% of ash generated, thus an option for the use of fly ash, especially when it is examined and as an affordable alternative tool for the growth of composite materials, is, therefore, applauded.[1,12] Since fly ash being abundantly available as waste material, so the expense of this material is negligible, but the manufacturing of composite metal matrix adds to costs.[2]

The development of composites is important as these materials have versatile properties thus fine vide applications in engineering.[11] The manufacturing method for various metal matrixes composite relies on the matrix martial, type of reinforcement used, necessary characteristics and price of manufacture, etc.[5] This research, therefore, focuses on achieving the required outcomes at a low price, for which casting processes are chosen.[9] If the sub-technologies are handled strategically, the achievement of success can be expedited or assured.[12]

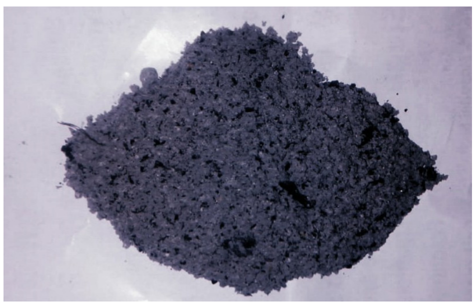

Figure 1.Fly Ash in powdered form

Experiment Convention

In this study, the Aluminum powder was and mixed with fly ash which was also in powdered form. Fly ash available from Thermal Power plant in Punjab possesses potential risks of disposal.[12] It is thus utilized by mixing in aluminum by using the casting technique as most composite productions are carried through casting technique.[3] As its a well-known fact that casting is s simplest and widely used in commercial industries.[9] The melting point of pure Aluminum is around 660 ^{0}C.[14] For current experimentation commercially available aluminum powder was used. The temperature was kept as 800 ^{0}C in a muffle furnace, so as the fly ash particles easily combine with aluminum particles to form metal matrix composite as this temperature is more than 100^{0}C above the liquidus temperature of the matrix alloy.[2] Following mechanical properties are considered of prime importance–hardness, density, compressive and tensile strength, and corrosion resistance.[14] This research focuses primarily on examining the impacts of fly ash reinforcements in aluminum metal in terms of their impact on mechanical properties

Results and Discussions

The findings of this research on fly ash-enhanced aluminum reveal significant changes in mechanical characteristics. Following results have been obtained and discussed below:

- Rockwell hardness test on samples was carried out composite specimens.[8] It was done using a 10 mm diameter Rockwell hardness test scheme at a load of 500 kg with 30 seconds charging time. In each sample, three measurements were taken and the mean value was taken as the composite's hardness.[3]

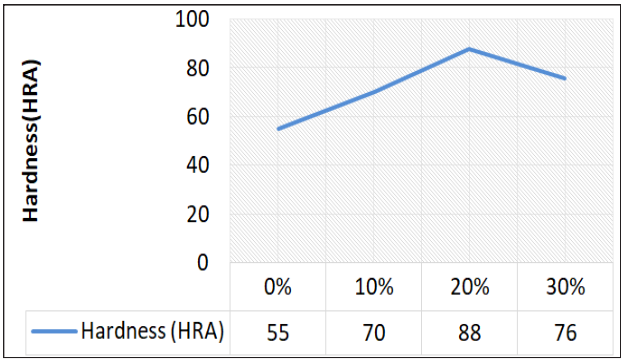

Figure 2.Hardness results of the Composites at various Wt% of fly ash particles

Compared to the base metal, the Rockwell hardness for fly ash strengthened aluminum through the casting process was discovered to rise, to 20% by weight of fly ash was added. After that, the values reduced with the addition of fly ash. The enhancement of the hardness is thus caused by the existence of particles of fly ash.

- The Archimedes principle was used to acquire the density of the composite samples.[3] Theoretical density based on the weight fraction of the strengthening was calculated applying weight fraction of reinforcement. By measuring the volume of water that was displaced by reading the water level in the graduated cylinder in milliliters (1 ml = 1 cm^3) as shown in Figure 2 and calculating the mass of the sample on weighing balance we can obtain its density from the correlation $\rho = \frac{m}{V}$ where ρ is the density of an sample m is its mass and V is volume of displaced water.

$$\rho = \frac{\text{weight in air}}{(\text{weight in air - weight in water})} \times \rho_{water}$$

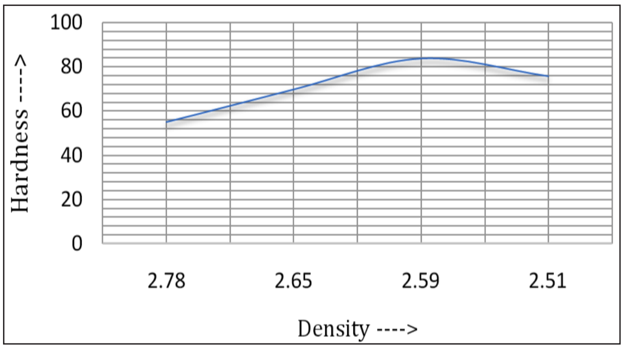

Figure 3.Density vs. Hardness of the Composites at various Wt% of fly ash particles

Density decreased in aluminum fly ash composite by the increased number of fly ash particles, consequently reducing the weight compared with base metal aluminum shown in Figure 3. Thus lightweight Aluminum fly ash metal matrix composites are effectively produced with the casting technique.

- Composites were tested for tensile and compressive strength tests. For each composition, three samples were screened and the average value of tensile and compressive strengths was considered.

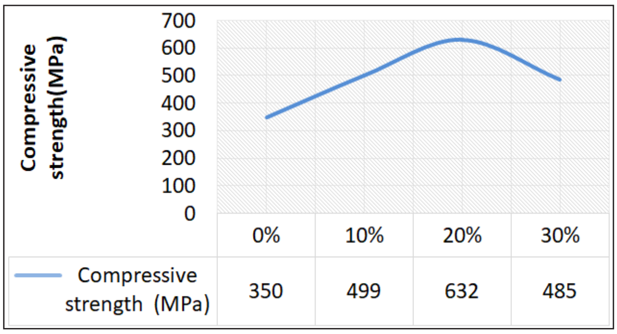

Figure 4.Compressive strength of the Composites at various Wt% of fly ash particles

The compressive strength was observed to rise by the addition of fly ash up to 20 percent by weight, as compared to the base alloy as shown in Figure 4.

The ultimate tensile strength was observed to rise by the addition of fly ash up to 20 percent by weight, as compared to the base alloy as shown in Figure 5.

- Corrosion is essentially an electrochemical process in

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which an oxidation reaction occurs at the anode and a reduction reaction occurs at the cathode.

- Corrosion is essentially an electrochemical process in which an oxidation reaction occurs at the anode and a reduction reaction occurs at the cathode.
- Corrosion resistance is another property that effects failure so composites were tested for the same.[4] Corrosion is essentially an electrochemical process in which an oxidation reaction and reduction reactions occur resulting in degradation of material.[6] A sulfuric acid solution was used for the current operation. The cylindrical specimens (1.5 cm × 0.5 cm) for diluted sulfuric acid for further measurement of weight loss due to degradation by corrosion.

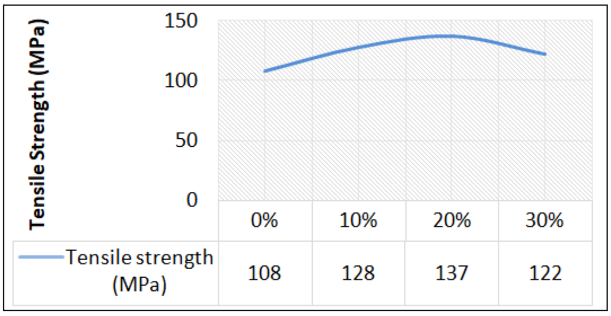

Figure 5.Tensile strength of the Composites at various Wt% of fly ash particles.

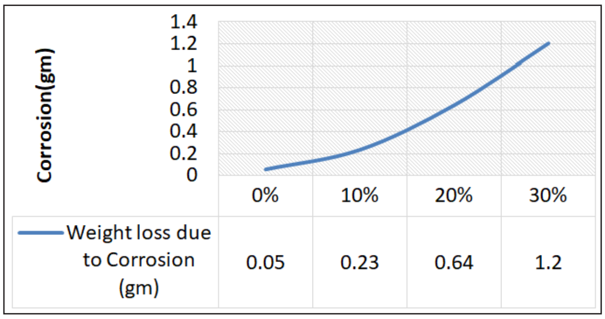

Figure 6.Corrosion behavior of composites at various Wt% of fly ash particles when kept in H2SO4 solution at 25 °C

The corrosion was found to increase gradually as shown in Figure 6, by the incorporation of fly ash particles due to the formation of pits on the surface of composite in comparison with unreinforced base alloy.

Conclusion

The fly ash weight percentage affects characteristics such as hardness, tensile strength, compression strength, corrosion resistance and many more. In general, mechanical characteristics of aluminum fly ash composite prepared by casting process improve on increasing the percentage of fly ash up to 20% by weight and on further increasing the percentage of fly ash to more than 20% by weight, the mechanical characteristics tend to degrade, thus making the material more fragile. However, in comparison with the unreinforced matrix, the addition of fly ash particles leads to increased pitting corrosion.[4] Since the fly is present in abundance for use, such research is productive and sustainable.

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