Effect of Fe_2O_3 Particulate Reinforcement on Thermal and Damping Properties in an Aluminum Alloy: A Review

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Abstract: ***Aluminum alloy is popular due to its high strength - to - weight ratio. In this review, we have provided an overview of the effect of damping and thermal properties by the addition of Fe_2O_3 in the aluminum alloy by stir casting. Very few articles were found that explain the behavior of aluminum alloy due to the addition of Fe_2O_3. Although Aluminium alloy has good damping properties it can be increased furthermore by the addition of Fe_2O_3. The biggest disadvantage of aluminumisthat it has a high thermal expansion coefficient but it can be reducedbythe addition of Fe_2O_3.***

Keywords: Fe_2O_3, Aluminum alloy, thermal damping, vibration, composite material reinforcement, ceramic particles

1. Introduction

A composite material is made up of two or more distinct materials with an obvious contact in between. Due to their high strength - to - weight ratio, low weight, and affordable price, composites are employed today. For a certain application, the most efficient use of contemporary composite materials is to attain property equivalency. The first is the matrix, which encloses and connects bits of the other substance, known as the reinforcement. The fact that current composite materials are both light and strong is their main benefit. Because many of them may be shaped into numerous shapes, composite can be easily adjusted. Aluminum is the most chosen matrix material for creating composites because of its low cost and lightweight. Because of its greater hardness, aluminum 7075 alloys arefavored in the aircraft and automobile industries. Compared to conventional materials, composites can satisfy design specifications regarding weight and high strength. The usage of composite materials in the automobile, trucking, and mass transportation industries will all require fuel. Transporting or shipping composite - made products requires less energy than doing so with traditional materials. Although composites are valuable as weight - saving materials, the current focus is on making them affordable. The composites sector today uses several manufacturing techniques as a result of the attempts to make composite components. When designing sporting equipment, it's important to consider a material's strength, tensile stress resistance, modulus (damping), and cost.

The material's damping qualities help during cyclic loading to absorb and dissipate mechanical vibrations. Due to the requirement for structural stability and subsequent performance, vibrations are undesirable for engineering applications [1]. High - damping capacity materials are therefore essential for engineering applications. Most metals and their alloys typically have low damping capacities, which restricts their use and performance in dynamic structures. As composite technology advanced, it became possible to create metal matrix composites by combining metals and alloys with reinforcing particles to change their physical, mechanical, and damping properties (MMC). According to a study [2], processing method, porosity, interfacial bond, volume fraction, size, shape, and type of the particles all have an impact on the damping capability of AMMCs.

Thermal Characterisation

According to recent research findings [3], the thermal expansion coefficients of composite samples are seen to be lower when compared to Al (7075) alloy. When compared to the monolithic alloy, the dimensional stability of the composites is improved, which is due to the inclusion of relatively hard reinforcements. Here, Thermal expansion coefficients have been measured with the usage of the thermo - mechanical analysis device, and the measured values were compared with that the theoretical values calculated based totally on the rule of thumb of mixtures. Aluminum matrix composites reinforced with ceramic particles are widely used in the automotive industry due to their excellent wear resistance, such as automotive engine pistons and cylinder liners. SiC and Al2O3 are the most commonly used reinforcements for AMC due to their high hardness and high chemical and thermal stability [4].

Researchers [5] used a dilatometer to quantify the coefficients of thermal expansion (CTEs) of hollow fly ash particles (cenospheres) with an average size of 125 mm that are present in commercially available pure aluminum and aluminum alloy composites. The pressure infiltration technique was used to create three different types of composites at applied pressures and infiltration times of 35 kPa for three minutes, 35 kPa for seven minutes, and 62 kPa for seven minutes. Around 65% of the composites' volume is made up of fly ash cenospheres. The composites' CTE is lower than that of pure aluminum. The CTE of the composites is discovered to be influenced by the infiltration processing conditions. A lower CTE is caused by a higher applied pressure and a longer infiltration time.

Al6063 is taken into consideration as the matrix in the experiment [6], and rice husk ash (RHA) is chosen as the reinforcement material (Fe_2O_3 1.62%). In the investigation, stir casting was used to produce RHA reinforcement material and AA6063 matrix material in various weight proportions. To determine whether a material was suitable for a high - temperature environment, the thermal expansion property was discovered. Each sample's dimension was maintained constant. By increasing the weight percentage of uncarbonized rice husk ash composite, the shrinkage rate of samples is seen to steadily increase. This finding indicates that uncarbonized rice husk ash is not a suitable reinforcing to create a composite for use in thermal expansion.

Damping Properties

Each material has different dampening features because of its structure. The ability of damping considers the capacity of a cloth to resist mechanical electricity at some stage in the software of vibration.

The findings of research [7] Al 6063 alloy is reinforced with a variety of elements, including industrial waste met coke ash (MCA), two types of ceramic mortar ash (MA) and nano fibrillated composite (NFC), and agricultural waste straw ash, at a constant rate of 5 weight percent for each reinforced ingredient. Results indicate that along with a significant impact on mechanical characteristics like tensile strength and hardness properties like damping were enhanced. In a study [8] of metal, ceramic, and metal - matrix composite materials' damping capacities. It was found that continuous fiber - reinforced MMCs exhibit an equivalent or slightly superior damping capability when compared to matrix metals and alloys. However, MMCs reinforced with particles have significantly better damping behavior. Although 6061 aluminum alloy is often utilized as the matrix of MMCs in structural applications, it essentially has minimal damping. It was also discovered that various MMC processing procedures had significantly improved the damping behavior of the 6061 aluminumalloy. A high - damping reinforcement can be combined with a low - damping matrix using the MMC procedures to create a high - damping material.

The obtained results of the study [9] showed that the damping factor of specimens of iron oxide - reinforced aluminum matrix composites increased by 2 weight percent, to 4 weight percent, and decreased when the composition is increased to 6 weight percent. Here iron oxide particulates were used as reinforcements with aluminum used as a matrix material composites processed by a stir casting process. The iron oxides were pre - oxidized at 650° C for two hours before being added to the liquid matrix and continuously agitated. Iron oxide was manufactured in three different weight fractions, 2%, 4%, and 6% by weight percentage of aluminum. For the examination of the variation in particle percentage, the average particle size was 500 nm and 40 m. The obtained results also showed that the damping factor increased by roughly 1.7% for particle sizes between 40 nm and 500 nm compared to composites with the same volume fraction. The relationship between volume fractions and the damping factor was explained by the reinforcement particles' ability to absorb external forces by fracturing the continuity of the force working line. By lengthening the force working line, the effect of the external force is lessened and the damping factor is raised. The findings demonstrate that smaller particulate composites (500 nm) have a higher natural frequency than larger particulate composites (40 m). A measurement of a material's elastic response is its storage modulus (E'). The energy reserves are measured. The elastic solid behavior is the storage modulus. The storage modulus is a measure of how elastically composite materials can store deformation energy. The outcome demonstrated that the storage modulus of the 500 nm is greater than that of the composite 40 m.

2. Conclusion

It was observed that the addition of Fe_2O_3 was associated with a decrease in the thermal expansion coefficient. The shrinkage rate of samples is shown to continuously increase as the weight percentage of uncarbonized rice husk ash increases, showing that uncarbonized rice husk ash is not an appropriate reinforcing to build a composite for use in thermal expansion. The damping capacity of the as - received aluminum has a more significant increase withthe addition of the Fe_2O_3particles. A strong relationship can be seen between particle size and damping capacity.

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