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Microstructure and dynamic characterization of hybrid reinforcements on aluminuim metal matrix composites

Ramesh K [1*], Sermaraj M [2], Abiseik R J Vinifer[3], Gowthamrishi R[3], Jaswanth Krishna B[3]
[1]Department of mechanical Engineering, SRM University, Chennai.
[2]Department of mechanical Engineering, SRM University, Chennai.
[3]Department of mechanical Engineering, Panimalar Engineering College, Chennai [3]
***Corresponding author: ramesh.k@ktr.srmuniv.ac.in**

ABSTRACT

Aluminium and aluminium alloys have wide applications in aerospace and automotive industry for its high stiffness to weight ratio. In addition aluminium has good malleability, formability and high corrosion resistance. Improvisation in the microstructure essentially enhances its mechanical properties which are found to be degraded during the manufacturing of aluminium and aluminium composites. This research work investigates the hybrid reinforcements in composites aiming in improvement in vibration damping characteristics. Damping materials acts as structural materials in addition to its inherent property. Graphite and silicon carbide are the reinforcement elements used in the composite. The composite is made by stir casting route and is investigated for its microstructure, mechanical and vibration characteristics on reinforcement of Silicon Carbide and Graphite in Aluminium. The microstructure investigation shows distribution of the reinforcements and further tests exhibits the vibration properties with respect to un-reinforced material.

Keywords: Metal matrix composites, Microstructure, vibration, damping.

1. INTRODUCTION

Stability of structures are greatly influenced by the vibration behaviour. The cause for vibration ranges from internal to external influence disturbing the structural stability and integrity. The near resonance conditions of all dynamic structures are to be investigated for their behavior in standard test and operational conditions of machines and structures. All materials dissipates energy during vibration there by aiding in structural damping [2]. Damping of vibratory motion is done by active and passive methods. Passive damping is simple and no external energy is needed. Passive damping methods are by the inherent structural property to absorb energy and dissipate in every cycle of vibration. Metals suits best in its capability to act as structural support and also to damp vibration [3].

Domain specific applications demands special characteristics and hence forth composite materials complements the need. Reinforcement is the secondary phase of an MMC where the reinforcement material is embedded into the matrix. The damping characteristics identified in this paper is calculated through the logarithmic decrement.

2. MATERIALS AND METHODS

Stir casting route is followed to prepare the specimens of aluminium hybrid composites of size 100 mm length 20 mm wide and 5mm thickness. The mould is preheated to 150–200 °C. The refractory material is used as a coat to the mould cavity. Coating improves the mould life. The metal is to be placed into the furnace at 800°C for more than 1 hour. Then the reinforcement is infused to the molten matrix composite. Caution is taken to minimize hot tears.

Table.1.Composition of Aluminium 6061

Element	Mg	Si	fe	Cu	Zn	Ti	Mn	Cr	Al & others
% Wt.	0.8	0.6	0.7	0.25	0.25	0.15	0.15	0.20	96

Table.2.Specimen designation

Aluminium (%)	Graphite (%)	Silicon Carbide (%)
100	Nil	Nil
92	8	Nil
94	5	1
90	8	2

3. PHYSICAL AND DYNAMIC PROPERTY INVESTIGATION

Microstructure test and hardness test: The specimen prepared is examined with SEM to identify the microstructure. The infusion of the hybrid elements are examined. Figures shown below are as per the designation shown in table 2.

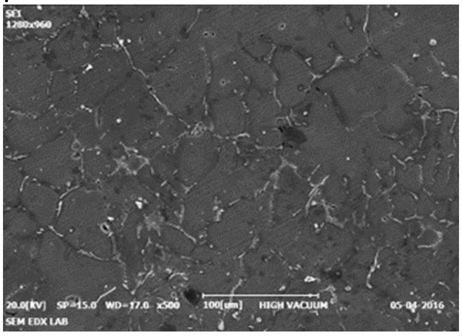

Fig.1.Scanning electron microscope pictures of S1 formulation

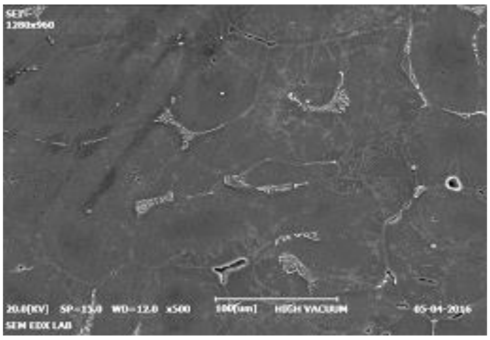

Fig.2.Scanning electron microscope pictures of S2 formulation

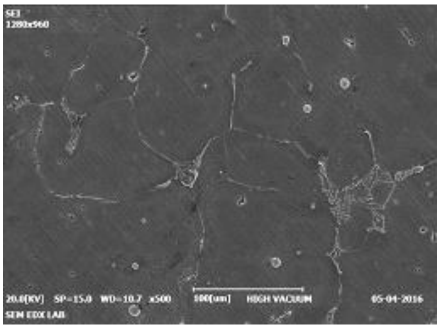

Fig.3.Scanning electron microscope pictures of S3 formulation

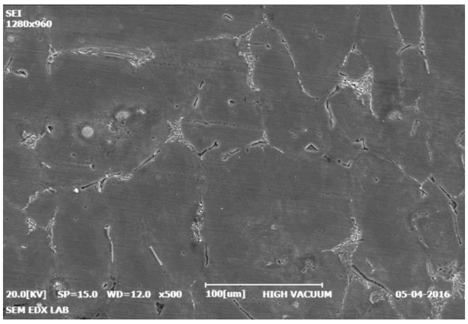

Fig.4.Scanning electron microscope pictures of S4 formulation

The microstructure reveals the manufacturing influence on the metal matrix composites and the integrity of the microstructure. Influence of the Graphite and silicon carbide on the microstructure in the hardness properties are shown in table 3.

Table.3.Hardness evaluation

Sample ID	Hardness Values in HV5Kg
Aluminium 6061(100%)	58.2,57.9,57.7
Aluminum 6061(92%), Graphite(8%)	58.8,58.2,59.7
Aluminium 6061(94%), Graphite (5%), SiC (1%)	36.4,35.9,36.1
Aluminium 6061(90%), Graphite (8%), SiC (2%)	42.3,43.3,42.9

Free Vibration test: Free vibration tests to predict the damping characteristics were conducted by clamping the specimen in a cantilever beam support setup. The instruments shown in figure 5 are used for free vibration test. An impact hammer (Kistler, Germany) with a load rating of 500N, a tri-axial accelerometer (Kistler, Germany) with a sensitivity of 2.mv/g, measuring range -2000g to +2000g, 16 channel DAQ system with vibration module from National Instruments and Lab View software.

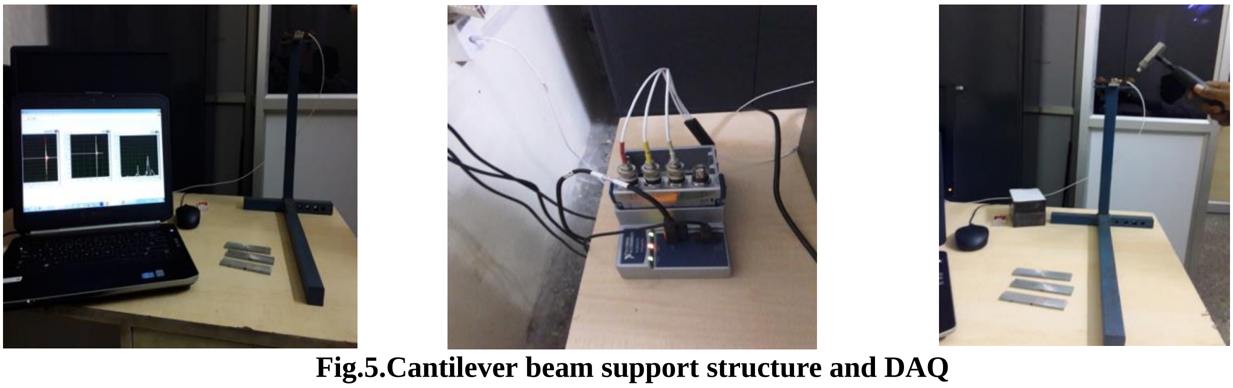

Fig.5.Cantilever beam support structure and DAQ

Free vibration test with an impact hammer of 500 N. The accelerometer is attached to the specimen for a cantilever beam consideration at the free end. The DAQ system enables the signals to be processed. LabView software is used to minimize the noise in signals and to handle the FFT process. Time based signals obtained are converted into frequency domain signals using the spectrum analyzer. The amplitude - frequency plot obtained from the free vibration test for pure aluminium is shown in figure 6. Lower frequencies are shifted in the plot, which can be understood as the influence of fixity conditions during the free vibration test.

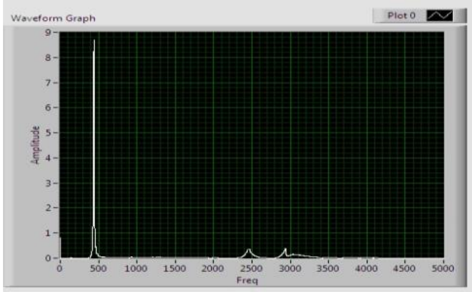

Fig.6.Frequency spectrum of S1 formulation

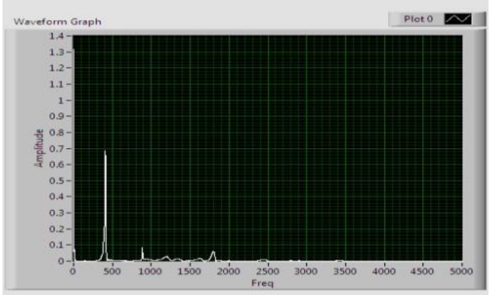

Fig.7.Frequency spectrum of S2 formulation

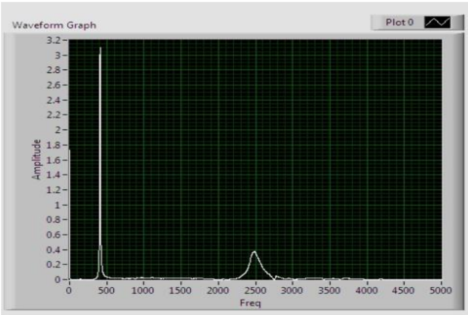

Fig.8.Frequency spectrum of S3 formulation

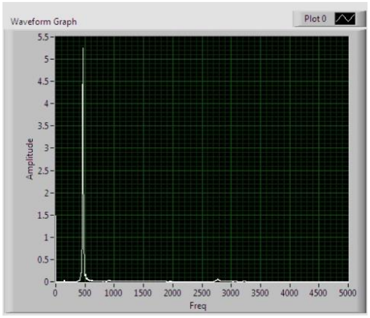

Fig.9.Frequency spectrum of S4 formulation

Figure 8 of S3 formulation when compared with S1 formulation shows a second frequency of 2500Hz and this can be attributed to the shift in the frequency. Further investigation of the formulation S4 reveals there is further sift in the frequency which can be above 5000Hz.

4. CONCLUSION

Structural damping, tailor made by composites shows good damping characteristics. From frequency plots it is evident that higher frequencies can be shifted to larger values by adding high damping materials. By shifting the frequencies to very large values the resonance condition can be avoided, thereby, increasing the survivability of the machines and structures. As graphite percentage increases the higher frequency also increases, which shows metal matrix composite to be stiffer. Significant contribution of silicon carbide increases the stiffness of the composite.

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