

# The Effect of Heat treatment on Microstructure, Mechanical properties and Damping behaviour of hybrid composite of A356.0

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**ABSTRACT:** In this study, Al-Si-Mg alloys A356.0 were stir cast by liquid metallurgy route with varied percentage of Alumina and Graphite. The composites were T6 treated and tested for microstructure and mechanical properties. Microstructure revealed uniform distribution of reinforcement in the matrix resulting in improved bonding of reinforcement in the matrix which in turn improved mechanical properties and Damping behaviour compared to un-reinforced material. The ceramic reinforced alloys were found to have improvement in Mechanical properties and Damping behaviour which may be attributed to the uniform distribution and bonding of reinforcement in the matrix.

**Keywords:** Composites, MMC's, Damping ratio, Microstructure, Mechanical behaviour.

## I. INTRODUCTION

Aluminium-silicon alloy and its composite possess light weight, high specific strength and good heat transfer ability which make them suitable material to replace components made of ferrous alloys. Attempts are made to increase the strength of Al-Si-Mg by various manufacturing processes, heat treatment and reinforcement of hard and soft reinforcements etc. The damping capacity of a material refers to its ability to convert mechanical vibration energy into thermal energy. Passive damping is critically important material property from the view point of vibration suppression in aerospace and submarine structures. Estimating damping characteristics in structures made of different materials remains as one of the biggest challenges. Aluminium, its alloys and its composites is one such pioneer material which is being used extensively in Aerospace, Automotive and the manufacturing industries.

In this paper, an attempt is made to study the effect of Heat treatment on microstructure, mechanical properties and damping behaviour of A356.0 reinforced with Alumina and Graphite.

## II. MATERIALS

A356.0 alloys were reinforced with Alumina and Graphite and were cast using liquid metallurgy route in the form of cylindrical bars of length 300mm and diameter 25mm. After casting A356.0 alloy and its composites subjected to T6 Heat treatment. Cantilever beams of cross section 15mm X 3mm X 180mm for Damping test were machined from the cylindrical bars.

TABLE I  
CHEMICAL COMPOSITION OF A356.0

Element	Weight %
Si	7.25
Mg	0.45
Fe	0.086
Cu	0.010
Mn	0.018
Ni	0.025
Zinc	0.005
Others	0.028
Al	Balance

TABLE-II  
DESIGNATION OF ALUMINA AND GRAPHITE REINFORCED ALLOYS

Sl No	Alloy/Composite	Designation	Damping ratio of Heat Treated alloy and its composites
1	As cast A356.0	As cast A356.0	0.0107
2	3% A+5% G	A3	0.004088
3	5% A+5% G	A5	0.01838
4	10% A+5% G	A10	0.01033
5	3% G+5% A	G3	0.01443
6	10% G+5% A	G10	0.01880

### III: TESTING

#### A: Microstructure

The samples for microstructure examination were prepared by following standard metallurgical procedures, etched in etchant prepared using 90 ml water, 4ml of HF, 4ml H<sub>2</sub>SO<sub>4</sub> and 2g CrO<sub>3</sub> and were examined using Optical Microscope.

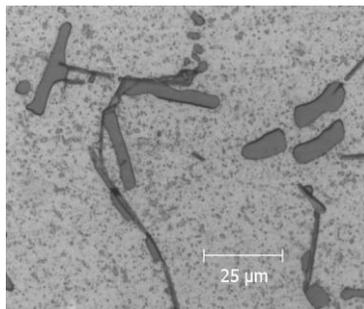


Fig.2.1  
Microstructure of As Cast A356.0

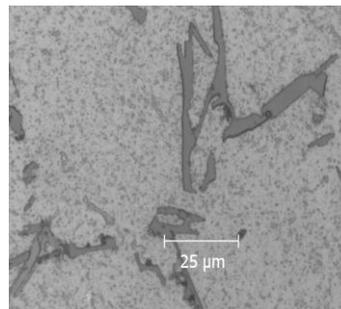


Fig. 2.2  
Microstructure of A3

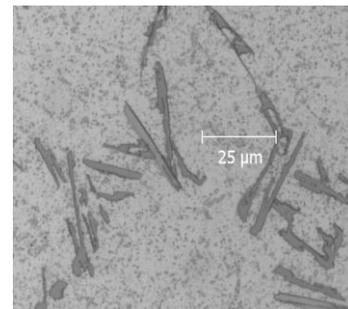


Fig. 2.3  
Microstructure of A5

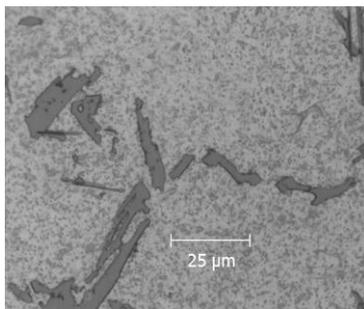


Fig. 2.4  
Microstructure of A10

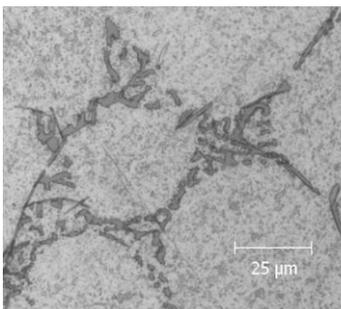


Fig. 2.5  
Microstructure of G3

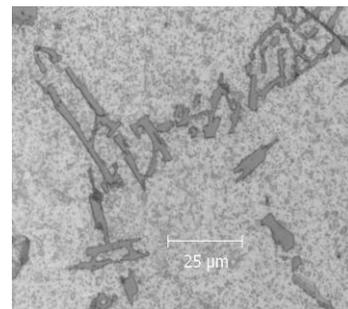


Fig. 2.6  
Microstructure of G10

Figures 2.1 to 2.6 show the uniform distribution of ceramic reinforcements namely, Alumina and Graphite in Heat treated A356.0 matrix.

**B. Hardness test**

The hardness tests were conducted as per ASTM E10 norms using Brinell hardness tester. Tests were performed at randomly selected points on the surface by maintaining sufficient spacing between indentations and distance from the edge of the specimen.



Fig.3.0: Hardness test specimens

TABLE III

Alloy Designation	Hardness (B H N)
As cast A356.0	54
A3	62
A5	42
10A	44
G3	45
G10	47

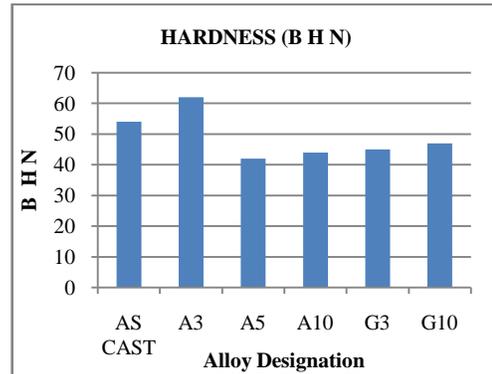


Fig.3.1: Hardness of Heat treated alloy and its composites.

Figure 3.0 and 3.1 shows Hardness test specimens and Hardness of Heat treated as-cast alloy and its composites. Table III Shows the hardness values of Heat treated As cast A356.0 alloy and its composites. The hardness of A3 (3% Alumina + 5% Graphite) is found to be 62 compared to as cast alloy with hardness 54 indicating 14.8% increase in hardness. A5 (5% Alumina + 5% Graphite) has least value of 42. G10 has hardness of 47.

**C: Tension test**



Fig.3.2: Tension test specimens

Alloy Designation	UTS untreated	UTS Heat treated	Elongation un treated material	Elongation heat treated material
As cast A356.0	78.05	136.0	1.2	1.8
A3	87.99	145.04	0.76	1.25
A5	79.79	132.17	4.08	4.95
A10	65.39	119.17	1.68	2.20
G3	65.74	115.15	2.28	2.58
G10	62.27	109.94	3.32	4.70

Table IV gives the ultimate tensile strength (UTS) and ductility of Heat treated A356.0 and its composite.

Table IV shows UTS and Elongation of Untreated and Heat treated as cast and its composites. UTS of both As cast and alloy reinforced with ceramics showed quantum rise in UTS increased with heat treatment .The UTS of As cast increased from 78.05 to 136 MPa showing 74.24% increase. Heat treated composite A3 indicating UTS of 145.0MPa indicating 64.8% compared to untreated composite.

The ductility increased substantially with heat treatment with A5 and G10 showing 21.35% and 41.6% increase compared to the same composite in untreated state.

D: Damping test

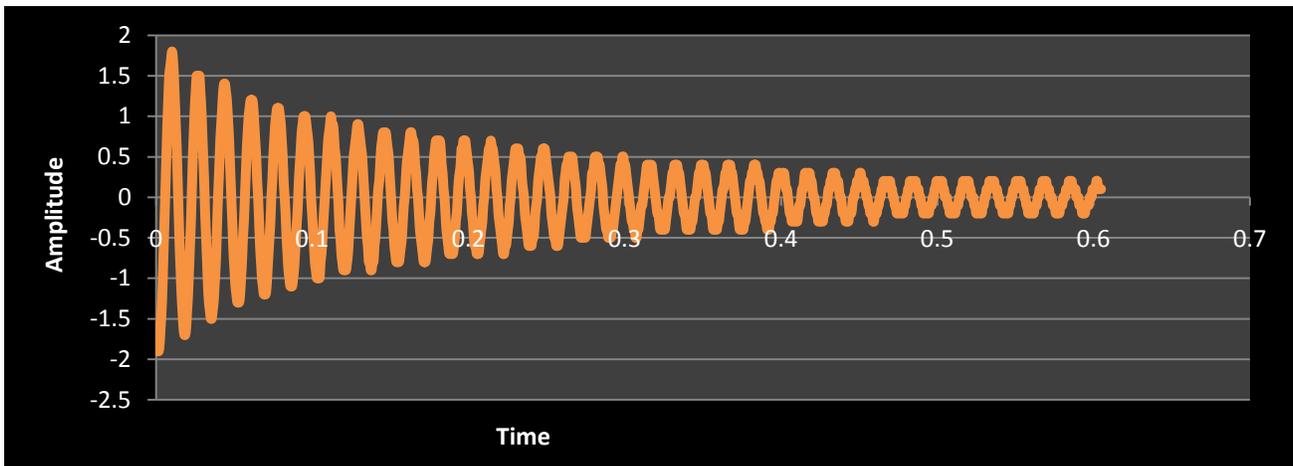


Fig.3.1: Free vibration response of SDOF Heat treated As-cast alloy.

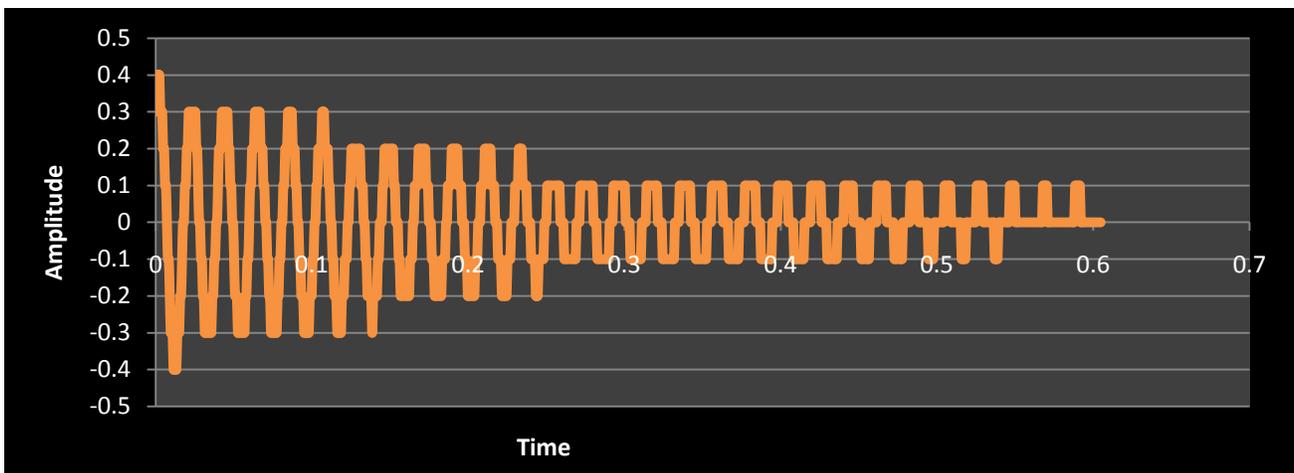


Fig.3.2: Free vibration response of SDOF G10.

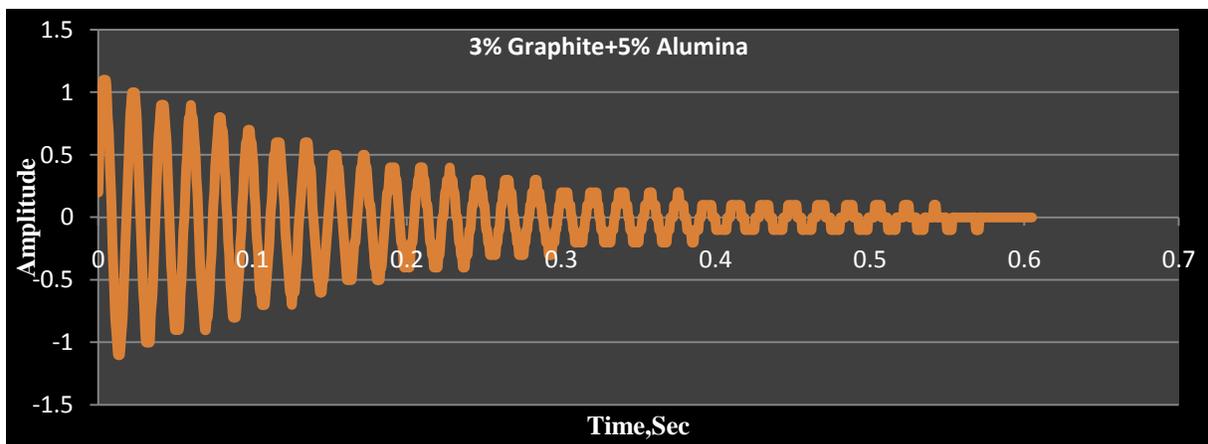


Fig.3.3: Free vibration response of SDOF A5

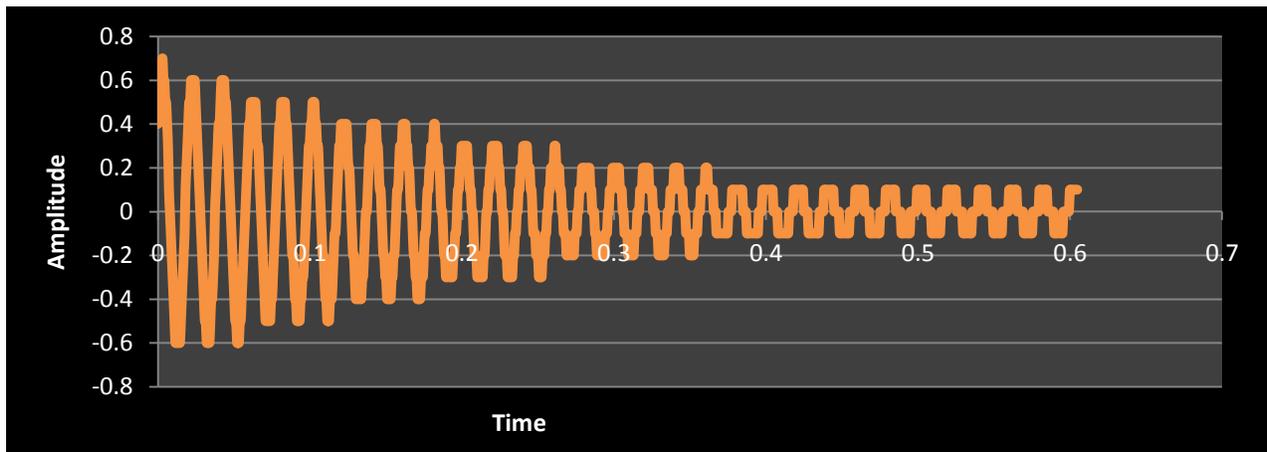


Fig.3.4: Free vibration response of SDOF A10

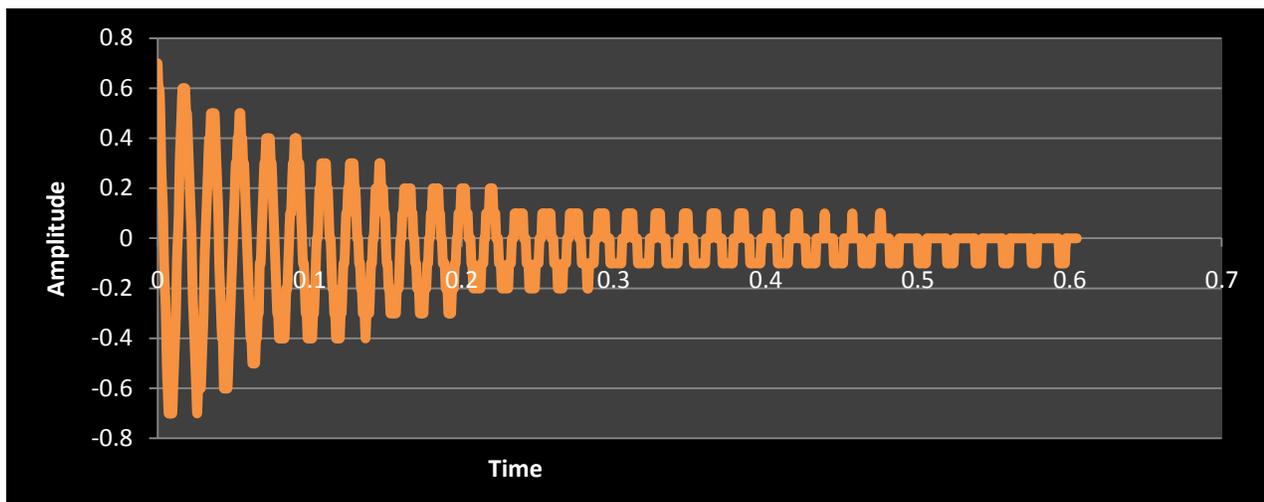


Fig.3.5: Free vibration response of SDOF G3

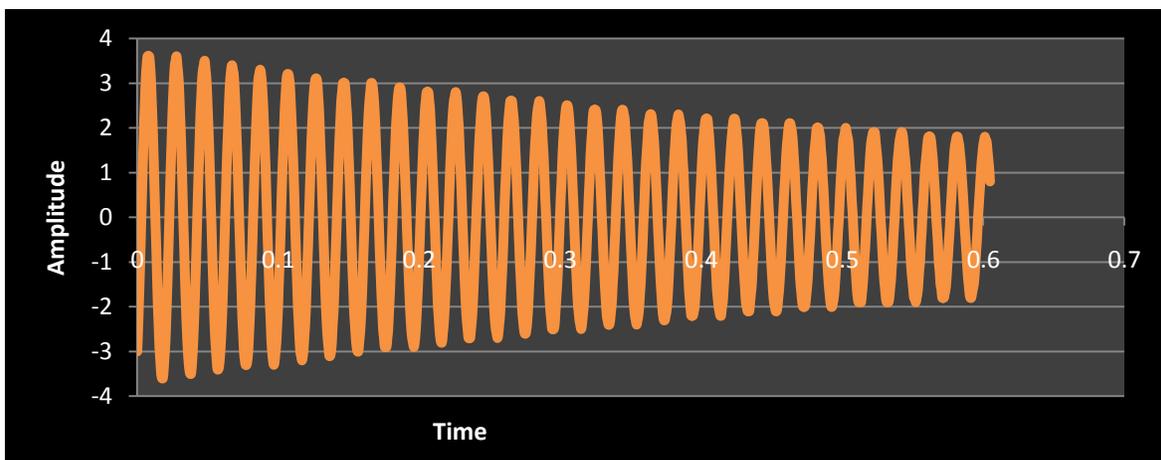


Fig.3.6: Free vibration response of SDOF A3

Fig 3.1 to 3.6 shows the free vibration response of SDOF of Heat treated A356.0 reinforced with varied percentage of Alumina and Graphite particulates, where best damping ratio was observed for composite with 10% Graphite +5% Alumina.

#### IV. CONCLUSION

Microstructure indicates uniform distribution of ceramics in the matrix resulting in good bonding of the particulates. The composite with 3% Alumina & 5% Graphite has highest hardness and UTS. Composite with equal % of Alumina and Graphite (5%) has highest ductility. The composite with 10% Graphite +5% Alumina showed highest damping ratio and is a good damping material compared to as cast alloy and its Composites. Graphite particles are better reinforcement material compared to Alumina.

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#### REFERENCES

- [1]. Feest, E. A., Exploitation of the metal matrix composites concept. *Met.Mater.*, 1988, 4, 273-278.
- [2]. Rohatgi, P., Cast aluminum-matrix composites for automotive applications. *J. Met.*, 1991, 43, 10-15.
- [3]. Saka, N., Pamies-Teixeira, J. J. and Suh, N. P. Wear of two-phase metals. *Wear*, 1977, 44, 77-86.
- [4]. Friction properties of Al-1 .SPct Mg/SiC particulate metal-matrix composites. *Metall. Trans. A*, 1989, 2QA, 1564-1566.
- [5]. Zhang, Z. F., Zhang, L. C. and Mai, Y.-W., Scratch studies of Al-Li alloy reinforced with SiC particles. *Proc. 4th Int. Tribology Confi (Austrib 94)*, 5-8 Dec.1994, Perth, Australia, pp. 249-254.
- [6]. R.J.Perz, J.Zhang, E.J.Lavernia, "Strain amplitude dependence of 6061Al/graphite MMC damping", *Computational Materials Science*, vol.27, pp.1111-14, (1992).
- [7]. S.C.Sharma, A.Ramesh, Effect of heat treatment on Mechanical properties of particulate reinforced Al6061 composites, *Journal of Materials Engineering and Performance*, vol.9(3) (2000) pp.344-349.
- [8]. S.C. Sharma, B.M. Girish, R. Kamath, & B.M. Satish, "Fractography, Fluidity, and Tensile Properties of aluminum/Hematite Particle composite", *Jour. of Mat. Engg. & Perf.*, vol.8(3), 1999, pp.309-314.
- [9]. Joseph E. Bishop and Vikram K.Kinra, "Analysis of Elastothermodynamic Damping in Particle-reinforced Metal-matrix composites" *Metall. Trans.* vol. 26A(1995) pp.2773-2782.
- [10]. G.J.C. Carpenter and SHJ Lo; "Characterization of graphite-aluminium composites using analytical electron microscopy", *Jour.Mater. Sci.* vol. 27,(1992) pp. 1827-1841
- [11]. H C Lin, S K Wu, and M T Yeh, Damping Characteristics of TiNi Shpae Memory Alloys, *Metallurgical Transactions*, vol. 24 A (1993), pp. 2189-2782.
- [12]. E. Carreno-morelli, N. Chawla, R.Schaller, Thermo-mechanical characterization of 2080 Al/SiCp composites by mechanical spectroscopy technique, *Journal of Materials Science Letter*, (2001), vol.20, pp.163-165.
- [13]. N Srikanath, d. Saravananathan, M. Gupta, L.Lu, and M O Lai, "Modelling and determination of dynamic elastic modulus of magnesium based metal matrix composites" *Material Science and Technology*, March 2000, vol.16, pp.309-314.
- [14]. J B Shamul, C Hammond, and R F Cochrane, "Comparative characterisation of damping behaviour of aluminium alloy composites produced by different fabrication techniques", *Material Science and Technology*.
- [15]. Hsu-Shen Chu, Kuo-Shung Liu, and Jien-Wei Yeh, "Damping behavior of in situ Al-(graphite, Al4C3) composites produced by reciprocating extrusion, *Journal Material Research*, vol.16, no.5(2001) pp.1372-1380

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