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White Layer – A significant effect on damping capacity

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ABSTRACT

Damping is the material's ability to dissipate elastic strain energy during cyclic loading. Materials with high damping capacity are significant in the present day scenario for transportation and other industrial applications. The development of materials with high damping capacity is one of the efficient measures to reduce vibrations, thereby noise. Low weight materials like aluminum and magnesium have excellent mechanical properties, but poor in damping.

Introduction

Metal matrix composites are a better choice to develop high damping capacity with good mechanical properties.

Although there are different equipments to measure the damping capacity of the alloys and its composites, dynamic mechanical analyzer is one of the versatile equipment used by many researchers and reported that the damping capacity of composites is due to generation of plastic zone, dislocation density, thermoelastic damping etc. Moreover the specimens for damping measurements will be machined by spark machining (Wire cut electric discharge machining) due to the size of the specimen is 1 to 4 mm thick, which is difficult to obtain by other processes especially when machining metals or metal matrix composites. When the specimens are machined using Wire cut EDM process a thin layer in the order of few microns is formed called white or recast layer on the surface which results from the current generated during the process that melts the material and cannot be expelled and has instead been rapidly quenched by the dielectric oil.

Hu et. al. [2], studied the effect of heat treatment on the stability of damping capacity in Mg- Si alloy. The author fabricated the specimens for damping measurements using spark machining and the experimental results indicated that the heat treatment has a great influence on the damping capacity and observed some peaks at certain temperatures. The possible mechanisms responsible for damping peaks include the interaction between dislocations and impurity atoms, grain boundary sliding. However the author has not studied the effect of white layer which results from spark machining, on the damping capacity.

In the present work, a case study has performed to investigate the effect of heat treatment on the white layer and its effect on the damping capacity of aluminum metal matrix composites and the results are compared. Damping measurements were performed using a dynamic mechanical analyzer (GABO Eplexor). All damping tests were performed under a static load of 50N, a dynamic load of 40N and strain amplitude (ε) of $1x10^{-5}$ using three point bending for the frequencies ranging from 1Hz to 25Hz at room temperature. A rectangular beam of 30 x 12 x 1.5 mm^3 were machined using an Ultra cut 843/Ultra cut f2 CNC wire electric discharge machine for damping measurements. T6 heat treatment was carried in an inert gas environment for the heat treated samples, which involved heating the sample to 540°C for 5-6 hours in a furnace followed by quenching in cold water and the ageing temperature was maintained at 155 °C for 6–8 hours. JSM-6610LV scanning electron microscope (SEM) was used to study the microstructural characterization of the specimens.

The effect of the white layer on the damping capacity had studied and presented in earlier works [3]. The results confirmed that the wire cut EDM machined specimen exhibits low damping values due to the formation of white layer which acts like a protective layer to dissipate elastic strain energy and this contributes about 8–15% of the overall damping.

The present analysis aims to find the effect of heat treatment on the white layer and its simultaneous effect on the damping capacity. Fig 1 and Fig 2 shows the damping capacity of the un-heat treated and heat treated samples respectively. From Fig 1 it is observed that the damping capacity is increasing with the percentage of reinforcement without distinct peaks. Fig 2 shows further improvement in the damping capacity with distinct peaks. It is evident from Fig. 3 that the formation of the white layer is obvious with an average thickness of 21µm. The scanning electron micrograph of the white layer for the heat treated specimen is shown in Fig. 4. The average thickness of the white layer is found to be 15 µm. The decrease in the thickness of the white layer of the heat treated samples is due to the shrinkage of the re-solidifying layer at T6 heat treatment conditions. As damping is the material's ability to convert mechanical energy to heat energy, the white layer thus formed acts like a protective layer to dissipate strain energy during cyclic loading and hence an increase in damping has been observed for the composites. Also, when the samples were heated to 540°C followed by quenching in cold water more cracks were formed on the white layer which remains even after the samples are subjected to ageing temperature of 155 °C for 6–8 hours and this is the reason for certain peaks in the damping at certain frequencies.

The present study shows how the damping capacity depends on white layer which results from spark machining and the results from Hu [2] are therefore 8-15% more than they reported and hence the effect of the white layer on the damping capacity

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should be considered for more accurate results.

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