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Behavior of Damping Properties of Cloisite 10A Blended Epoxy Resin Aluminium-Glass Fiber Reinforced Sandwich Sheets

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Abstract: ***Sandwich structures made of Aluminium-Glass Fiber Reinforced sheet layers find application in aerospace structures because of their high strength to weight ratio. This paper discusses on the work done to find how the damping properties of Aluminium-Glass Fiber Reinforced sandwich sheets varied at various impact velocities due to blending Cloisite 10A nano material with the epoxy resin. The damping factor was found by drop weight technique. Results show that blending Cloisite 10A with epoxy resin increases the damping factor at fixed impact velocity. The damping property is found to be higher at greater impact velocities. Upto blending of 3% of Cloisite 10A, it is found that the damping factor rises at a greater rate and for more than 3% blending it is observed that there is only a marginal increase.***

Keywords: Cloisite 10A, drop weight method, damping factor.

1. Introduction

Aluminium-Glass Fiber Reinforced sandwich sheets are composed of aluminium sheets bonded on either side of Glass Fiber Reinforced layer. Such sandwich sheets show the good properties of both Aluminium metal and glass fiber [1]. Aluminium possesses better specific stiffness, ductility, impact properties and fiber reinforced plastic exhibit good specific strength, corrosion and fatigue resistances. Such sandwich sheets are used in structures that desire light weight and to replace metals like aluminium so that the good strength to weight ratio is maintained to a larger extent. These sheets find replacement in structures that are subjected to tensile and impact loads. The amount spent towards fuel cost are greatly reduced over a long period of time due to the reduction in weight, especially in aerospace and automobile structure [2]. Generally, the damping property influences the impact property. The impact property assumes a greater significance because such sandwich sheets are always prone to hit by run way debris, hit by tool dropped while maintenance work is being done, impact of service cars and cargos on the structure, bird hits, tyre ruptures and hail storms when the sheets are put into use in aerospace and automobile structures [3]. The thickness of metal layers, the percentage of fiber used, the fiber materials used, orientation of fiber, the material used for bonding and the impact velocity influence the damping property and therefore the impact property also. In these sandwich sheets, the layers on the outer sides are always the metal sheets such that the number of metal sheets is always one more than the number of fiber layers used [4].

Various researches have been carried out in the past to observe the effect of the thickness of metal layers, the percentage of fiber used, the fiber materials used, orientation of fiber, the material used for bonding on the mechanical strength of such Aluminium-Glass Fiber Reinforced sandwich sheets.

G. D. Lawcocket al. [5] carried out experiments to find the influence of fiber matrix adhesion on the impact strength of carbon fiber reinforced aluminium laminates. They carried out experiments on impact test for quasi static, low velocity and high velocity impacts. It was found by them that the damage zone area was greater for laminates that had weaker fiber/matrix adhesion in spite of the fact that for a given impact energy the back face crack length and permanent indentation after impact were lesser. The untreated fiber laminates had more residual tensile strength after impact because of increase in fiber/matrix splitting in the composite layer. Studies on the effect of low and high velocity impact on aluminium – glass fiber epoxy laminates, aluminium-aramid fiber epoxy laminates and aluminium – carbon fiber epoxy laminates was made by A.Vlot [6] . He found that for glass fiber laminates the impact energy required to make the first crack in the outer aluminium sheet on the non-impacted side was more than that of laminates made of carbon and aramid fibers. A fiber or aluminium critical failure mode was observed for glass fiber hybrid laminate. The depth of the dent for the hybrid laminate was found to be comparatively equal to or lessthan that of monolithic aluminium alloy. Further, the area of damage after the impact was observed to be greatly lesser than plain glass fiber or carbon fiber laminates. As the glass fiber has more tensile strength, the tensile strength of aluminium glass fiber hybrid laminates markedly increased with increasing rate of strain as the glass fiber is strain rate dependent. Low velocity impact studies were made by F. Ashenai Ghasemi et al. [7] on Aluminium/Steel on Glass/Carbon fiber epoxy hybrid laminates. They found that the dynamic behavior of the impacted laminates was greatly affected by parameters such as layer sequence of metal layers, type of metal layers and the E_{11}/E_{22}ratio of composite medium. The impact behavior of carbon reinforced aluminium hybrid laminate was studied by S. H. Song et al.[8]. They carried out both experimental and numerical studies. They observed that no critical damage occurred on the specimen impacted by 2.35 J energy and absorbed about 64% of the impact energy. When the specimen was impacted by 9.40 J it was observed that the CFRP layers showed fiber and matrix failures with a shear crack on the aluminium layer. It was observed that 83% of the impact energy was absorbed. Hence less failure mechanism was found when the specimen was impacted by 2.35 J. The scaling effects of Aluminium alloy-polypropylene hybrid laminates were studied by S. Mckown et al. [9]. They found that with respect to the tensile and flexural properties no significant scaling effects were observed. However, they found that the impact force and damage threshold energy followed the scaling law. Blast loading tests on Steel/Aluminium alloy-GFRP hybrid laminates were carried out by G. S. Langdon and L. A. Rowe [10]. They observed that similar to that of Aluminium-GFRP laminates the blast loaded laminates showed large inelastic deformation and debonding failure of the steel-composite interface. It was also observed that the non-dimensional displacement of Steel-GFRP panels were lower than that of Aluminium-GFRP laminates. Moslem Najafi et.al.[11] studied about the effect of hygrothermal aging on mechanical properties of fiber metal laminates (FMLs) and E-glass/epoxy (GE) composites. They carried out Hygrothermal aging simulation on both specimen types in distilled water at a constant temperature of 90 °C for 5 weeks. They observed that because of the protective role of aluminum layers, FML specimens showed remarkably lower water absorption after hygrothermal aging compared to the glass/epoxy composites. They also observed that whereas the flexural properties of both the FML and GE laminates were affected by the hygrothermal aging, a lower level of deterioration in impact strength was noticed. Kartik Balakumar et.al [12] investigated the significance of input variables in a low velocity impact analysis performance of FML. They conducted experiments to find out the influence of parameters affecting the response characteristics like residual velocity of impactor and impactor geometry. They observed that the impactor geometry was a major influencing factor followed by FML thickness. The configuration of fiber was found to be not significant when compared to fiber orientation relating to low velocity impact analysis performance of the fiber metal laminate plate. In spite of various researches have been done on such sandwich panels only a small amount of information is available on the influence of adhesive composition over the impact and damping properties.

This paper discusses on the work done to find how the damping properties of Aluminium-Glass Fiber Reinforced sandwich sheets varied at various impact velocities due to blending Cloisite 10A nano material with the epoxy resin.

2. Experimental

The following materials were used to make the test specimens

1) Aluminium alloy sheets – AA 1050 H 14;
2) E-glass fiber reinforced in epoxy resin
3) Epoxy resin as adhesive. (LY 556 and HY 951)
4) Cloisite10A particles of size 2 to 10 micrometer, a nano clay organically modified with Quaternary dimethyl, dehydrogenated t allow, ammonium salt with CEC of 90 meq/100g

The specimens were made to square shape of size 300 × 300 mm. The outer layer thickness of aluminium sheet is 0.4mm and the thickness of GFRP layer is 1.7mm. This yields analuminium thickness fraction of 0.32. The fiber fraction by volume in the GFRP layer is maintained at 35%. Hand layup technique was used to make the specimen. A mold made of acrylic was made to the shape of the specimen. Using acetone, the surface of aluminium was cleaned. The aluminium sheet is first placed in the mold. Different percentage by weight (1, 2, 3, 4 and 5) of Cloisite 10A was blended with resin by mechanical shear mixing for one hour at ambient temperature. Sonication of the mixture was done for 6 hours after shear mixing. Hardener (HY 951) is then mixed and stirred for about 20 minutes. The aluminum surface is coated with this mixture. E-glass fibers in unidirectional orientation are placed in the coated mixture. Then the outer aluminium sheet was placed and the mold cavity was closed by wax coated acrylic sheet. Curing for six hours is carried out at room temperature. The specimens were then tested for their damping properties.

For each type of Aluminium-Glass Fiber Reinforced sandwich sheet the number of specimens tested is 3 and the number of specimens for each testing condition is also 3. An instrumented drop weight impact testing machine was used to carry out impact testing of the specimens under low velocity (< 11 m/s). Horizontal clamping of the specimens on all sides of the fixture was done. Sharp nose shaped steel indenter was used to impact the specimens. The mass of the impactor was 4.91 kg. The impact velocity was kept at 3.2 and 4.1 m/s. The rebounding of the indenter after the first impact will create multiple strikes and this is prevented by pneumatic actuator in the machine. For measuring the amplitude- time response using labviewan accelerometer is fixed underside of the specimen and the accelerometer is also connected to dynamic signal analyzer. Logarithmic decrement method is used to find the damping factor of the laminate for a particular impact velocity. The formula for calculating the damping factor ζ by this method is given by the relation $\zeta = \delta / (4\pi^2 + \delta^2)^{1/2}$ where δ, the amplitude reduction factor is found by using $\delta = [1/n] [\ln (x/x_{n+1})]$. For n=1, $\delta = \ln (x_1/x_2)$.

3. Results and Discussion

Table 1 shows the damping property of the Aluminium-Glass Fiber Reinforced sandwich sheets for different weight percent Colisite10A loading and different impact velocities.

Table 1: Damping factor variation for different Cloisite 10A loading and impact velocities.

S.No	*Cloisite 10 A loading %*	*Impact Velocity (3.20 m/s)*	*Impact Velocity (4.10 m/s)*
1	0	0.03331	0.03963
2	1	0.04186	0.04826
3	2	0.05349	0.06146
4	3	0.06341	0.07321
5	4	0.06714	0.07842
6	5	0.07126	0.08341

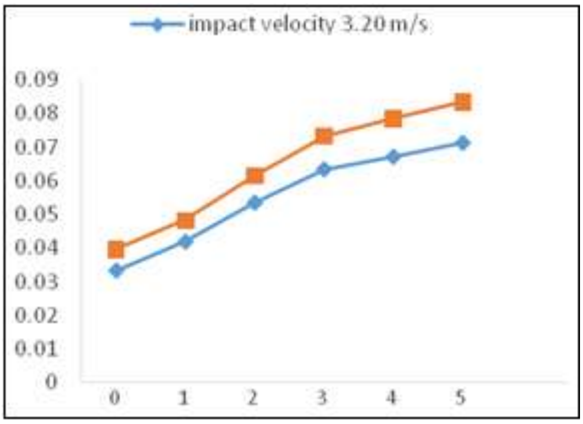

Figure 1: Damping factor variation for different Cloisite10A loading and impact velocities.

It is observed that blending of Cloisite 10A results in the increase of damping factor (Figure-1) for both the impact velocities. The damping factor is 0.03331for an impact velocity 3.20 m/s and 0% Cloisite 10A addition. For 5% addition of Cloisite 10A, the damping factor increases to 0.07126 which is about 2.25 times than that of neat epoxy. This shows that addition of Cloisite 10A in the Aluminium-Glass Fiber Reinforced sandwich sheet controls and reduces the vibration. It is also found that the damping factor for impact velocity 3.20 m/s is less than that of 4.10 m/s. The reason for this behavior is that at low velocity of impactthe contact time between the impactor and the specimen is more than that of higher velocity of impact. Therefore, at low velocity of impact most of the energy is converted into vibration resulting in low damping factor. In case of higher impact velocities, the amount of damping increases due to low contact time and more energy is used for penetration with less remaining energy for vibration in the Aluminium-Glass Fiber Reinforced sandwich sheet. Also it is observed that the damping factor increases at a faster rate up to 3% of Cloisite10Ablending. For higher blending percentage it increases only marginally.

4. Conclusions

Small amounts of weight percentage of Cloisite 10A in the epoxy resin were blended in the Aluminium-Glass Fiber Reinforced sandwich sheet successfully and the effect of addition of these particles in different weight percentage on the damping property behavior of the sandwich sheets at two different impact velocities was studied. It is found that increasing the percentage of Cloisite10A in the epoxy resin increases the damping property of the sandwich sheets. At higher impact velocities the damping factor is found to be higher. It is also found that the damping factor increases at a faster pace up to 3% blending of Cloisite 10A. For higher additions it increases only marginally.

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