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The influence of different types of core materials on the impact behaviour of sandwich composites

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Abstract

Sandwich structures are popular in applications in which the weight of the component affects the efficiency, especially in the aviation and aerospace industries. This study aims to understand the impact behaviour of sandwich structures with different core materials. Sandwich structures are manufactured with glass fibre reinforced polymer skins and balsa wood, polyethylene terephthalate (PET) and polyvinyl chloride (PVC) core through resin infusion under flexible tools. Three different core materials were tested and compared using the damaged area of the back face of the sample. The effect of the core materials on the mechanical behaviour of the structures is crucial. The results showed that the microstructure of the core materials plays an important role, because althoughthe density of balsa wood is greater than the density of PET and PVC, the structures having PVC and PET as core materials undergo less damage than those having balsa wood as a core material.

Keywords: Sandwich composite, impact behaviour, core materials.

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1. Introduction

Sandwich composite structures have become very popular because of their static and dynamic mechanical properties. These structures are very popular in aerospace, automotive and wind energy industries where the weight of the components are crucial [1–8].

One of the biggest concerns of the wind energy, aerospace and automotive industries is the strength and rigidity of the components. These kind of components faces low velocity impact most frequently due to dust impact, bird strikes or dropped tools in service. Sandwich composite structure has an ability to absorb more energy due to core materials. Glass fibre reinforced polymer or carbon fibre reinforced polymers (GFRP–CFRP) are commonly used as a skin material in sandwich structures, and polymeric foam – such as polyvinyl chloride (PVC) or polyethylene terephthalate (PET), balsa wood and hybrid core (Tycor) – are used as a core material. These material combination improve the mechanical properties, rigidity and strength of the sandwich composite structures such as high strength to weight ratio, energy absorbing and bending stiffness [9–15].

In the research, the effects of changing core materials and different surface finishing options on the low-velocity impact behaviour have been investigated by performing low velocity drop weight impact tests. Three different polymeric foams and five different surface finishing options with PVC were used as core materials. The damage area of the samples and the comparison of the samples with each other are presented in the following sections.

2. Materials and testing

Three different core materials were performed under low velocity drop weight test; PVC, PET foams and balsa wood. The foam cores were supplied by AIREX AG. The mechanical properties of PVC are shown in Table 1.

Table 1. Mechanical properties of the cores [16, 17]

Core materials	Density (kg/m^3)	Shear strength (N/mm^2)	Shear modulus (N/mm^2)
PVC foam	60	0.85	22
PET foam	110	0.8	20
Balsa wood	148	2.6	187

Gurit XE603, which is a +/– 45 biaxial E-glass reinforcement fabric, was used as the reinforcing material of the skins. A mixture of Prime 20 LV epoxy resin and slow hardener (which is suitable for the production of sandwich composite structures) was used as a matrix material of the skins [18]. The manufacturing process of the sandwich composite structures was explained in the previous studies [7, 19]. The dimensions of low velocity drop weight impact samples are 100 × 100 × 18 mm (as in length (direction x) × width (direction z) × thickness (direction y)).

The low velocity drop weight impact test machine was used with 16-kg mass and a 12 mm diameter hemispherical projectiles which was used in the previous research [7, 19]. The projectile is shown in Figure 1.

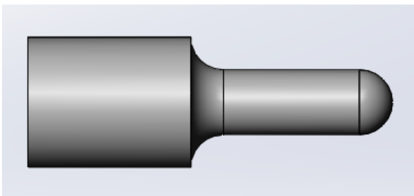


Figure 1. Projectile used in the low velocity drop weight impact tests

The samples were clamped by using the test rig depicted in Figure 2. The low velocity drop weight impact was performed by applying 40, 50, 60, 70 and 80 J in accordance with ASTM D7766 .The applied energy was calculated as

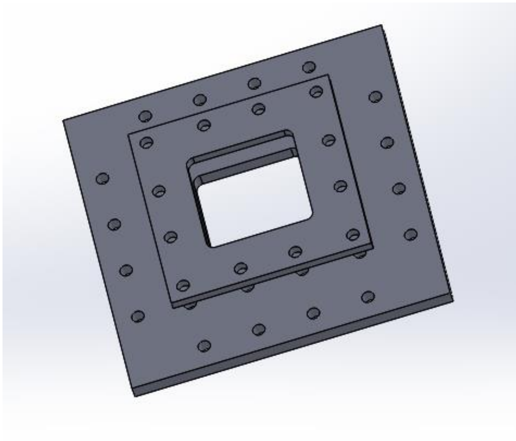


Figure 2. The assembly picture of the test rig

$$E = m \times g \times h \tag{1}$$

where E = potential energy (J); m = mass (kg); g = gravitational constant (m/s^2) and h = height (m).

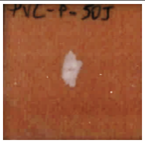
After the test, the delaminated area of the back surface of the samples was measured. The measurement process is explained in the previous research [7, 19]. That process was applied for this study.

3. Results

In Table 2, the comparison of the damaged areas of the back surface of the samples tested with different level of impact load are depicted. Balsa wood cored sandwich composite structures damaged at all applied energies. The first damage appeared on the distal face of the PVC and PET cored sandwich composite structures at an energy of 50 J. The perforation impact energy was 80 J for both types of sample. Debonding damage was observed in all cases for the balsa wood cored sandwich composite structures.

The propagation of the failure on the back surface of the sandwich composite structures is different as seen in Table 2. The first failure of PVC and PET cored sandwich composite structures was observed and propagated horizontal through the axis of the sample; however, the failure of balsa wood cored sandwich composite structure propagated circular on the back surface of the structures as seen in the back surface picture of the sample in Table 2.

Table 2. The damaged area of the PVC cored sandwich composite structure

	Applied energy				
	40 J	**50 J**	**60 J**	**70 J**	**80 J**
PVC	 Damaged area: 0%	 Damaged area: 1.4%	 Damaged area: 6.5%	 Damaged area:10.7%	 Damaged area: 13.1%
PET	 Damaged area: 0%	 Damaged area: 1.2%	 Damaged area: 4.3%	 Damaged area:8.6%	 Damaged area: 11.6%
Balsa wood	 Damaged area: 5.2%	 Damaged area: 16.1%	 Damaged area: 26.6%	 Damaged area: 41.9%	 Damaged area: 54.2%

4. Discussion

In the research, three different core materials for sandwich composite structures have been investigated in terms of the effect on the impact behaviour, by performing low velocity drop weight impact tests and measuring the damaged area at the back face of the samples.

The effect of different core materials on the mechanical behaviour of the structures is crucial. Balsa wood cored sandwich composite structures behaved in a very brittle manner as can be seen in Figure 3. Therefore, balsa wood cored sandwich composite structure had damage on the distal face of the samples; and its failure was observed as debonding for all applied impact energies. At an impact energy of 80 J, the percentage of debonding on the distal face of the balsa wood–plain cored sandwich composites is around 60% and the percentage of debonding on the distal face of PET and PVC cored sandwich composite structures is nearly 10%. It can be reported that the microstructure of the core materials plays an important role, because even the density of the balsa wood is greater than the density of the PET and PVC, the structures which have PVC and PET as core materials have less damage than the structures which have balsa wood as a core material.

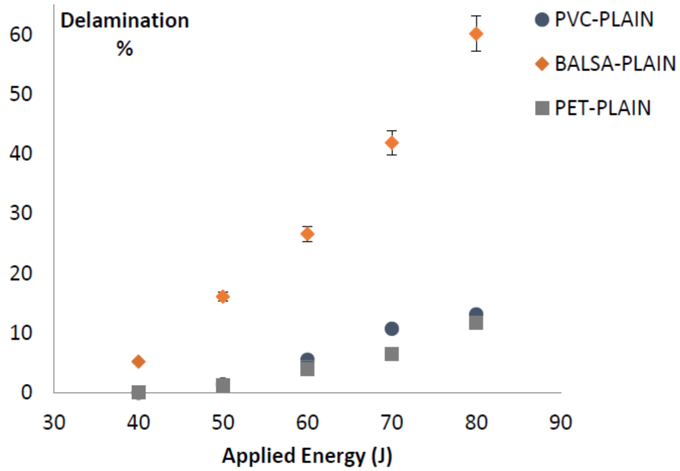


Figure 3. Comparison of the damaged area of the PVC–plain, PET–plain and balsa wood–plain cored sandwich composite structures

5. Conclusion

In this study, the effect of the core materials on the impact behaviour of the sandwich composite structures has been investigated. The following main conclusions can be drawn:

- The microstructure of the core material influences the impact behaviour of the structure independent of the density of the core materials. Therefore, ductility of the core material has great effect on the impact behaviour of the structures.
- The density of the core material is a very important property for predicting the impact behaviour of the structure whose core has same microstructure. Thus, the impact behaviour of the structure becomes better with an increase of the strength and density of the core considering the polymer cores.

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