IMPACT BEHAVIOR OF SANDWICH COMPOSITE POLYMERIC PRODUCTS REINFORCED WITH GLASS FIBER

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ABSTRACT: Glass fibers reinforced sandwich polymeric composites represent a new materials widely used in various industrial fields, due to their special characteristics. This paper presents the results of experimental research carried out on sandwich polymeric composites reinforced with fiberglass – especially used in automotive industry.
KEY WORDS: Sandwich composite polymeric products, fiber glass reinforces, impact behavior.

1 INTRODUCTION

In the last years, rapid advances in car industry have enabled civil engineers to achieve impressive gains in the safety, economy, and functionality of structures built to serve the common needs of society. Composite materials are formed by combining two or more materials that have quite different properties. The different materials work together to give the composite unique properties, but within the composite you can easily tell the different materials apart – they do not dissolve or blend into each other. Sandwich composite polymeric are the material of choice because of their weight and strength advantages. The paper presents some impact tests results, performed on a hybrid sandwich material type, used in car industry.

The obtained results would be further applied in real cases when the sandwich material is to be “recognized” in various components of cars – such as front panel or rear door panel. The studied material (see figure 1) is a sandwich composite polymeric and consists of two plates with a core in the middle. The plates (upper face and lower face) are made of reinforced glass fibers and the core is made of extruded polystyrene.

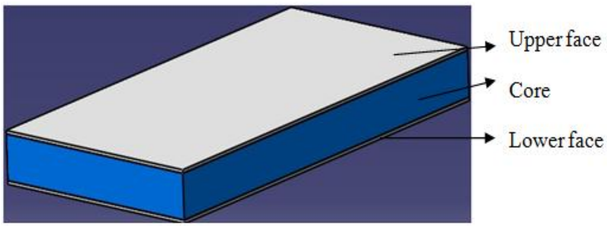

Figure 1. Elements of sandwich composite polymeric products

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2 CHARACTERISTICS OF SANDWICH COMPOSITES

Sandwich composite polymeric products used in car industry are composed by 2 faces sheets reinforced with fiber glass whose characteristics are shown in Table 1 and by a polystyrene extruded core with characteristics mentioned in Table 2. In Table 3 are presented the specimen dimensions.

Table 1. Face sheets characteristics

Material code	Face dimensions, [mm]	Thick -ness, [mm]	Density [kg/m^3]	Elastic Modulus, [N/mm^2]
EC12-2400-P207	100x200	1,5	2,54x10 3	5000

Table 2. Core characteristics

Material code	Thickness [mm]	Density [kg/m^3]	Compression resistance N/mm^2]
AplaXfoamBT	20	2,8	>300

Specimens used for experimental research on impact of sandwich composite polymeric products have dimensions shown in table 3.

Table 3. Test specimen dimensions

Plate code	Upper face thicknesses [mm]	Core thicknesses [mm]	Lower face thicknesses [mm]	Dim. [mm]
X1	1,5	20	1,5	200x100
X2	2	20	2	200x100

3 IMPACT TESTS EQUIPMENT

The impact test is most commonly used to evaluate the relative or impact toughness of materials. It is often used in quality control applications, as it is it is a fast and economical test. When the striker impacts the specimen, the e energy is absorbed until yielding. When the specimen can’t absorb all the energy, then fracture occurred. The testing machine that we used is a Instron Dynatup impact system with data acquisition and control, model 8200, figure 2.

Figure 2. The Dynatup Model 8200 Impact Test

The impact testing system has: maximum gravity mode velocity up to 5,0 m/s, maximum spring assisted high velocity up to 20 m/s, maximum physical drop height of 1,25 meters, self-id load cell for measuring drop mass. The 8200 is ideal for low energy testing of thin section or brittle plastics, composites, ceramics, and metals.

4 IMPACT ON MATERIAL MADE BY SANDWICH COMPOSITE

Table 4 presents the results obtained after impact test on sandwich composites polymeric material, and in figures 2, 3, 4, 5 there are represented the diagrams resulted after the impact test where:

m – mass used for impact [kg];

H – impact height [mm];

v – speed of impact [m/s];

E – total energy used to break through the shock the specimen in [kg m] (in the value of energy being included also the acceleration gravity);

W – total energy consumed to break through the shock specimen, in [J].

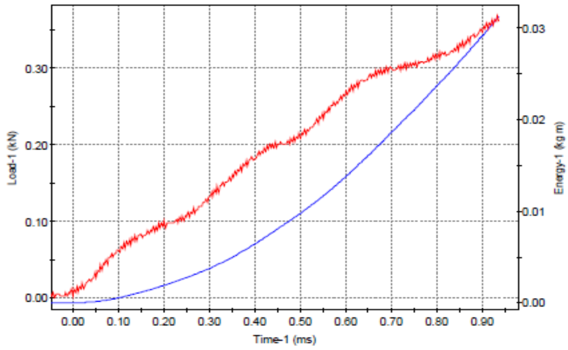

Figure 2. Specimen 1, H=100mm, 1,5 mm thickness of fiber glass face sheet

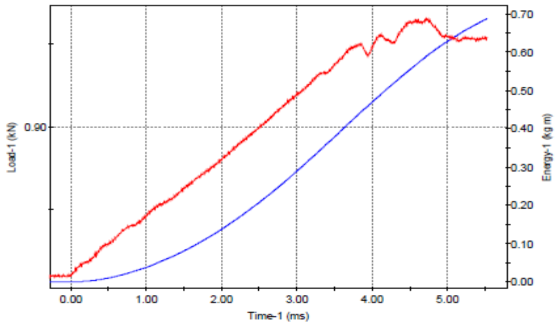

Figure 3. Specimen 2, H=150 mm, 1,5 mm thickness of fiber glass face sheet

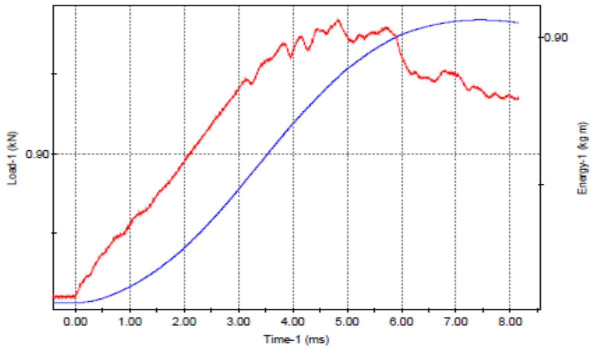

Figure 4. Specimen 3, H=200 mm, 1,5 mm thickness of fiber glass face sheet

Table 4. Results obtained after impact test

Nr.	Characteristics						Results
	m [kg]	**Thickness of fiber glass plates [mm]**	**H [mm]**	***v* [m/s]**	**E [kg m]**	**W [J]**	**Type impact**
1.	6,06	1,5	100	1,4228	0,0311	0,3049	mark of impact, not so visible from outside the thickness of the plate
2.			150	1,7397	0,6871	6,7362	mark of impact, ≈ 20 % visible from outside the thickness of the plate
3.			200	1,9758	0,9488	9,3019	mark of impact, the upper face started to break
4.			250	2,2223	1,1699	11,4696	the break is more visible and more deep, but just for the upper face
5.			300	2,4292	1,2628	12,3803	the break is more visible and more deep for the upper face

6.			350	2,6181	1,5457	15,1539	the penetration of the upper face and some millimeters in the core

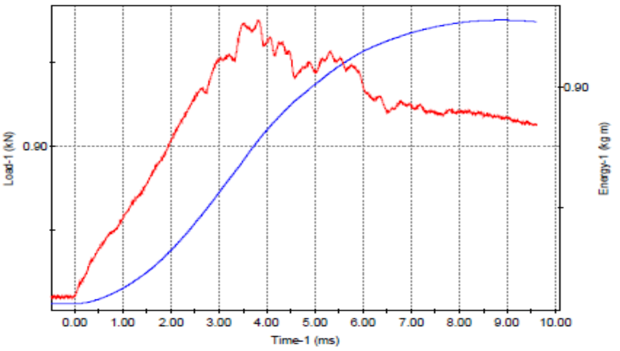

Figure 5. Specimen 4, H=250mm, 1,5 mm thickness of fiber glass face sheet

where:

E (Energy) is the total energy consumed to break through the shock specimen, in [kg m], (the amount of energy being included also acceleration gravity) (1J = 0,102 Kg m);

F (Load) – the impact force developed in kN.

Figure 6 and 7 presented a specimen after impact.

Shock resistance is the effort consumed for breaking the sample, compared to the cross section of the sample surface.

$$a_{cU} = \frac{W}{h \cdot b} \cdot 10^3 \qquad [\text{kJ/m}^2] \qquad (1)$$

Figure 6. H=300mm, 1,5 mm thickness of fiber glass face sheet

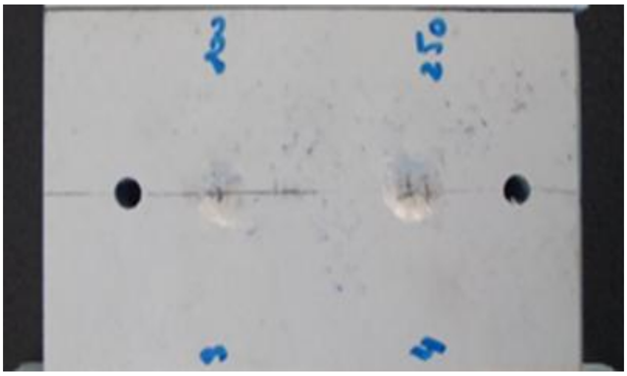

Figure 7. H=200, H=250mm, 1,5 mm thickness of fiber glass face sheet

where:

W – total energy consumed to break through the shock specimen, in [J]; *h* is the sample thickness, in [mm]; and *b* is sample width, in [mm].

Based on impact tests results, there was determined the impact strength, on the sample, using relation (1). Theoretical values calculated are shown in table 5.

Table 5. Shock resistance on the samples

Test number	H [mm]	a_{cU} [kJ/m^2]
1	100	2.9
2	150	2.93
3	200	4,044
4	250	4,987
5	300	5,383
6	350	6,589

The figure 9 shows the specimen during penetration with 350 mm high and we observe that the penetration sphere passed through the upper face and remained fixed in the core.

Diagrams below show the variation of impact speed and total energy as a function of the height of impact are presented in figure 10.

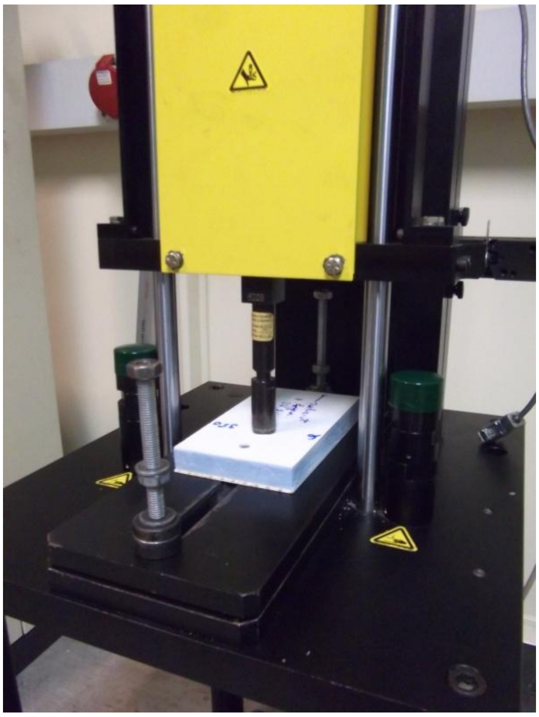

Figure 9 Specimen during impact test

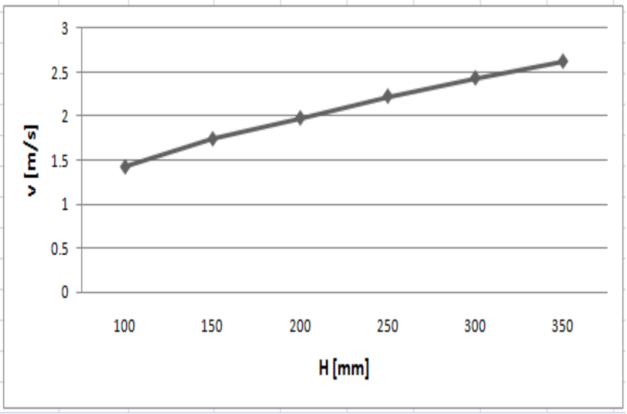

Figure 10 Variation of impact speed at different impact hights

5 CONCLUSION

The results of the experimental researches emphasize the following conclusions concerning the damage on the specimens: - for impact heights H = 100 mm and 150 mm - there are small cracks in the upper face sheet with no penetration in the rest of the specimen; - for impact heights H = 200 mm and 250 mm - the small cracks become more visible, but there still is no penetration toward the outer plate;- for impact heights of H = 300 mm - there can be noticed some detachment of fiber from the upper plate (delaminating of fiberglass), but without any penetration in the second layer (core), while for impact height H = 350 mm the impact sphere penetrated the upper face sheet and the core. Another conclusion is that the minimum values required for changes occurring to the specimen were the one that follow: m = 6,06 kg (mass); H = 23 mm (height); v = 1,4228 m/s (speed); W = 0,3049 J (energy).

Finally, there should be pointed out the aspects below: - for the studied glass fiber reinforced sandwich composite polymeric materials, there is a total fracture of the upper face sheet, followed by penetration to the face - core interface when the height value exceeds 350 mm (H ≥ 350); due to the fact that the glass fiber - component of the face sheet - is shock resistant, will absorbed the energy being proportional with the impact height; the high non-linearity of energy characteristic (plotted graphs), for the studied composite polymeric – is due to the material of the core and glass fibers characteristics. In fact, based on its various and important application, when the studied materials would be used for cars – in door panels, all the experimental values determined in this research would prove to be important

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