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Impact performance of sandwich structures produced by Crush-Core technology

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Abstract. This research paper deals with an investigation of the influence of honeycomb core compression on the impact properties of sandwich structures. These structures consist of prepreg facing layers and two different material types of honeycomb and are produced by modified compression molding called Crush-Core technology. Produced structures are subjected to low-velocity impact and Charpy impact test.

Introduction

Honeycombs are very often used inside the sandwich structures as core materials. These structures then find application due to their light weight and very advantageous mechanical properties in many branches of industries such as transportation, aviation and aerospace. [1] The mostly used materials for honeycombs are aluminum, Nomex® paper and in recent years also of polymeric materials like polypropylene. [2,3] Sandwich structures are produced by a multiple technologies, where one of them is compression molding. This technology is highly productive method that allows processing of finished sandwich structure during one cycle within minutes in dependence of used material for facings and adhesive. [1,4] If the honeycomb is compressed during the compression molding that technology is then called Crush-Core technology. This modified technology is used especially by huge aircraft producers, namely Boeing and Airbus. Moreover, it is the assumption that this compression will increase the contact surface of honeycomb cells, which results into better adhesion and thus improved mechanical properties. [5] Previous research in this area has concentrated mainly on the behavior of honeycomb core itself especially in compression and on the character of cell walls deformation itself, where the behavior is also numerically modeled; however none of the previous studies have dealt with the behavior of sandwich structures with the compressed honeycomb core. [6,7]

The aim of this work is to investigate the influence of the compression of honeycomb cells on mechanical and impact properties of sandwich structures. The compression is performed on two different material types of honeycomb with different values of this compression.

Materials and methods

Researched sandwich structures were composed of facings from prepreg materials (inner and outer layer) and honeycomb core. Totally, three different types of E-glass prepreg impregnated with phenolic resin and two material types of honeycomb were used. Namely, prepreg PH840-F300-42 from the Gurit Company in combination with Nomex® honeycomb core and coarse prepreg PHG840N-G213-40 together with fine prepreg PHG840N-F300-47 from the same company in structures with aluminum honeycomb core. Prepreg

PHG840N-F300-47 was used for better connection of first mentioned prepreg to the aluminum honeycomb. Important parameters of used materials show following tables (Table 1 and Table 2).

Table 1: Properties of used prepreg materials

Type	Prepreg weight [g/m^2]	Resin content [%]
PH840-F300-42	525	42
PHG840N-G213-40	1367	40
PHG840N-F300-47	560	47

Table 2: Properties of used honeycomb cores

Type	Cell size [mm]	Density [kg/m^3]	Thickness [mm]
COREMASTER C2	3.2	48	7 and 9
COREMASTER C2	4.8	48	10
Aluminum ECM	6.8	82	9 and 16

Sandwich structures were compression molded in a laboratory press with heated plates. The temperature of plates was set to 160°C and the curing time was 10 minutes according to the material data sheets. Samples of structures were produced in following configurations; Prepreg PH840-F300-42 together with core COREMASTER C2-4.8-48 compressed from thickness 10 mm to 9 mm (Sample A1), same prepreg in combination with uncompressed core COREMASTER C2-3.2-48 of thickness 9 mm (Sample A2), prepregs PHG840N-G213-40 and PH840-F300-42 together with core COREMASTER C2-3.2-48 compressed from thickness 9 mm to 7 mm (Sample A3) and the same prepregs with uncompressed core type as former of total thickness of 7 mm (Sample A4). Next sample set was prepared from prepreg PHG840N-F300-47 in combination with aluminum core ECM-6.8-82 in compressed variant from thickness 16 mm to 10.5 mm and uncompressed variant of thickness 10.5 mm. Constant thickness of the panels was ensured by steel distance bars of appropriate size (Fig. 1).

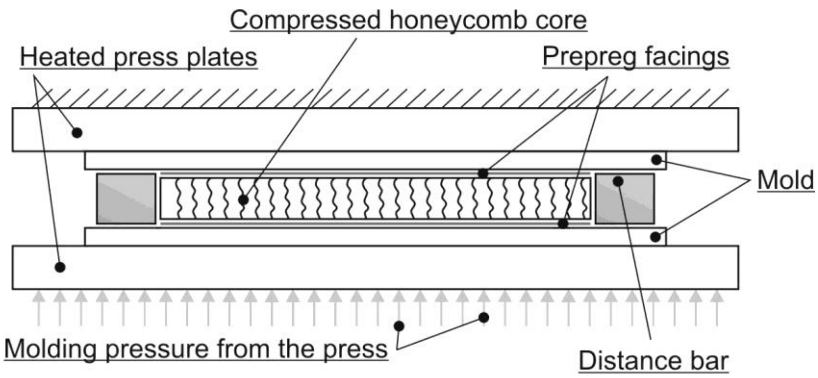

Fig. 1: Scheme of the production of sandwich panels

Compression molding of the core generate wrinkling of the cells of honeycomb on the opposite side to the acting pressure force and cause an increase of a cell area on their edges that might result to the better bonding strength between facings and core. Wrinkling of the cells was observed especially in the case of aluminum honeycomb due to the high value of core compression.

Prepared sandwich structures were tested at Charpy's impact test and low-velocity impact test. Impact toughness was tested according to the standard ISO 179 on specimens with a size of 15 mm x 70 mm. Low-velocity impact was based on the standard ISO 6603-2 where test was carried out on square specimens with 100 mm edge length,. Total weight of hemi-spherical steel impactor was 23.17 kg and the fall height was set on 440 mm. All mentioned test were conducted at the ambient temperature.

Results and discussion

Results from low-velocity impact test are shown in Fig. 2. Samples of structure consisting compressed Nomex® honeycomb core (Sample A2) showed a growth of both impact force and impact energy needed for penetration through the structure. As can be seen, maximum impact force rose by 16.5 % and impact energy by 15 %. Values of before mentioned parameters remain barely unchanged for samples A4 compared to A3. The highest increase of low-velocity impact performance compared to uncompressed structures (Sample B1) show structures consisting compressed aluminum honeycomb core (Sample B2). This increase was namely of 75 % in case of maximum impact force and 30 % in case of impact energy needed for penetration.

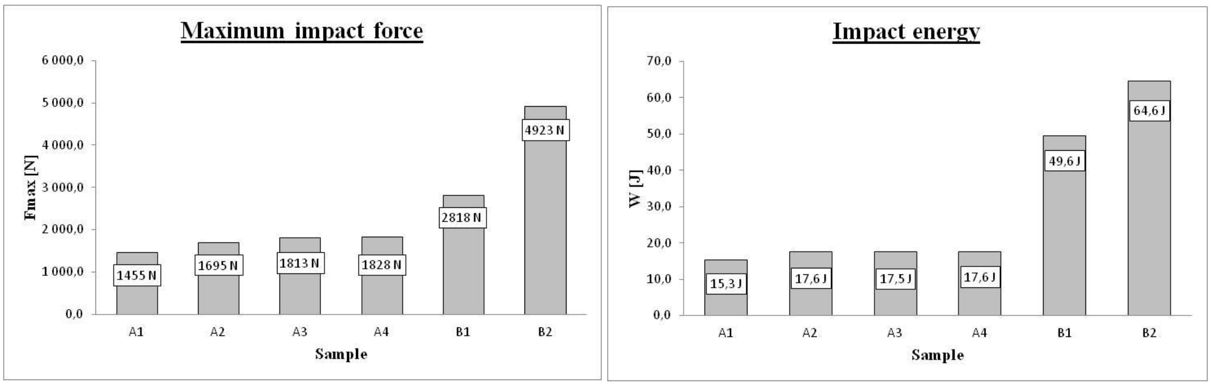

Fig. 2: Low-velocity impact performance of tested samples

Charpy impact toughness expressed by resilience (R) of tested samples is depicted in Fig. 3. Compression of Nomex® honeycomb in structures (Sample A1 – A4) caused a drop of the resilience, namely by 12 % in the case of Sample A2 (compared to A1) and by 24 % for Sample A4 compared to A3. Nevertheless, structures with compressed aluminum honeycomb (Sample B2) showed a large increase of resilience. Measured resilience was about 117 % higher compared to resilience of Sample B1. Moreover, structures of Sample B1 showed a delamination of distant facing layer after the test, contrary to structures Sample B2, which showed a significant crush of the core in the place of impact without any delamination.

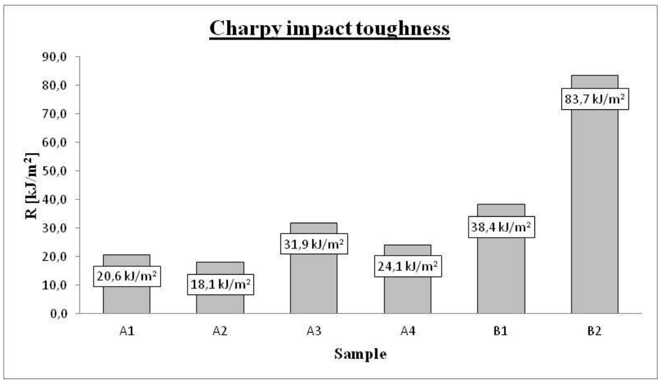

Fig. 3: Charpy impact toughness of tested samples

Conclusion

The mechanical behavior and impact performance of sandwich structures with compressed and uncompressed honeycomb core have been evaluated. Due to the measured results, the compression of aluminum honeycomb core in sandwich structure considerably increases the values of measured parameters at low-velocity impact test. Other investigated structures did not show higher growth of impact properties.

Compression of the Nomex® honeycomb in prepared structures decreases resulting impact resilience in all cases. On the other hand, compression of aluminum core has a large effect on the resilience and increases it of significant value.

After summary of above mentioned facts, it is necessary to conclude that the compression in the case of Nomex® honeycomb has no effect and deteriorate properties of resulting sandwich structures. On the other hand, the compression has proved to be very interesting for the structure with the aluminum honeycomb.

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