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Effect of Adhesive Type on Peel Strength of Sandwich Structures

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Abstract. This research paper deals with an investigation of the mechanical properties of sandwich structures consisting of High Pressure Laminate facing layers (HPL) and various types of cores that are produced by vacuum bagging technology. These materials are connected with different adhesive layers and quality of connection to individual materials is evaluated. Moreover, prepared sandwich structures are tested in three-point bend. Based on the results, suitable combinations of individual materials are proposed for sandwich structures with regard to the quality of the adhesive bonding.

Introduction

Sandwich structures are layered structural composite materials that find application in many sectors of industry where they replace conventionally used materials. The main application areas of these materials are aerospace, transportation and civil engineering. Individual structures consist of a light and weaker core, two thin and stiff facing layers and adhesive layers, which bond all these materials together to obtain a necessary load transfer. [1,2]

These materials stand out particularly for large flexural stiffness and flexural strength, high impact resistance, and this all with minimum weight. [3] All these properties depend primarily on the quality of the bond between individual layers and on material selection. The lack of adhesive or non-uniform application of adhesive can result in the decrease of bonding strength and thus to the weakening of the entire structure. [4,5] Many previous studies have examined the influence of adhesion quality between the facing layer and honeycomb core, however, no research has dealt with other types of core and specific types of foil adhesive. [6,7,8]

With the growing interest in the sandwich structures, the range of suitable materials for both facing layers and the core grows simultaneously. Producers are trying to adjust properties of the existing and develop new material types suitable for sandwich structures. Thus, the aim of the present paper is to design and test sandwich structures used for facing applications, focusing on the quality of adhesion between different types of core with varying densities and high-pressure laminate (HPL) facing layers. Moreover, mechanical properties of the prepared structures are tested according to ISO standards. These tests indicate the suitability of the tested foil adhesives for different material combinations.

Materials and Methods

The facings of sandwich structures were created from High Pressure Laminate (HPL) produced by Polyrey Company. This material is composed of several layers of cardboard paper, layer of decorative paper and protective surface coating. The thickness of HPL facing was 1.2 mm and density of this material guaranteed by the manufacturer was 1350 kg/m^3. As the core of sandwich structures served three materials. First of them was a honeycomb created from meta-aramid paper covered by a resin.

The cell size of honeycomb was 3.2 mm. Another used material was thermoplastic and fully recyclable polymer foam PET Airex with closed pores. The last core material was laminate prepreg Compolet containing short reinforcing fibers (100 g/m^2).
For connection of the individual materials the following adhesive layers were chosen:

1) Prepreg PH 840 reinforced with glass fibers (300 g/m^2), impregnated with 42% phenolic resin,
2) SA 70 adhesive film, toughened epoxy film on glass carrier,
3) Letoxit® KFL 130, epoxy film adhesive without fiber reinforcement.

Curing procedures for individual adhesives are shown in Table 1.

Table 1. Curing procedures for individual adhesives.

Adhesive	Curing time	Curing temperature
PH 840	90 min.	130 °C
SA 70	150 min.	100 °C
KFL 130	180 min.	80 °C

The advantage of the used foil adhesives is the prevention of problems with insufficient local adhesions, caused by nonuniformity of adhesive distribution. [5] Detailed properties of all the above mentioned materials can be traced in the manufacturer data sheets. Sandwich structures in the form of plate (500 x 1200 mm) were produced using vacuum bagging technology, where the adhesive was cured under constant vacuum in a furnace.

Testing samples were cut to specific dimensions from the prepared sandwich structures. The first conducted test was three-point bending. At this test, flat sandwich samples with dimensions of 150 x 20 mm were subjected to bending forces from a beam which on a certain arm (100 mm) caused a bending moment. The samples were placed on the supports which were distant from each other by 114 mm. The crosshead velocity was set on 20 mm/min. The test was performed and evaluated according to EN ISO 14125 on ZWICK 1456 testing machine, the values of flexural strength and flexural modulus for eleven samples were measured and arithmetic means were calculated. This statistical evaluation was also used for the remaining tests.

Coherence of individual layers of the structures was tested using a peel test. This test was also performed on ZWICK 1456 and was conducted according to ISO 4578. This standard was modified to enable testing of sandwich structures. Appropriately modified samples of dimensions 150x50 mm were pushed by the testing crosshead and a minimum force at which the separation of the outer layer from the core occurs was measured. Total of five samples were tested for each type of adhesive and core.

Results

Data measured for three-point bending test are shown in Fig. 1. As can be seen, flexural strength (σO) of structures formed by honeycomb core show the lowest value of this parameter for SA 70 adhesive. The other cores show flexural strength nearly similar for all types of adhesives. Thus, it is possible to state that the type of adhesive has almost no effect on the flexural strength of the structures made of PET AIREX or Compolet.

Flexural stiffness (E) of all structures connected by adhesive SA 70 is almost unchanged compared to the other types of adhesive; on the other hand, the highest values of this parameter are achieved for Honeycomb cores and adhesive KFL 130. Furthermore, stiffness by almost 50 % lower can be seen for the structures composed of PH 840 and Compolet.

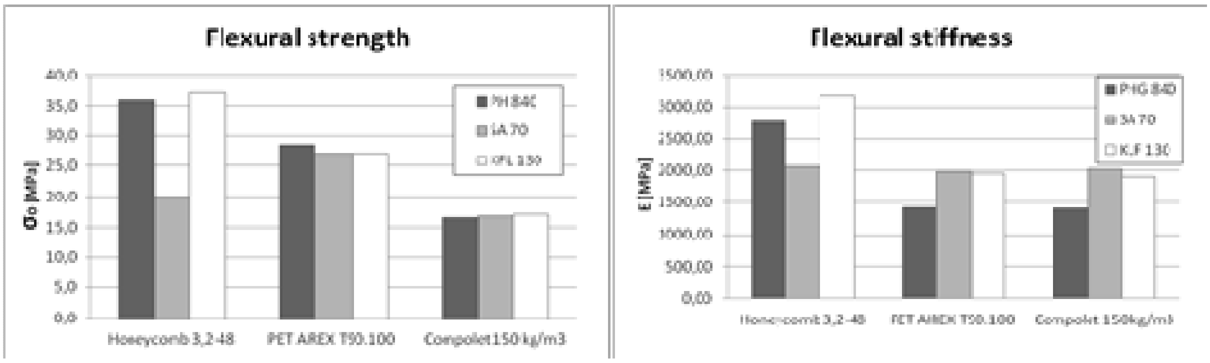

Fig. 1. Flexural strength and stiffness of individual sandwich structures.

Three-point bending test continued until the break of the distant facing layer occurred, which was evaluated by the program as the end of the test. Structures formed from honeycomb showed a considerable deflection up to the exceeding of the load capacity of the distant facing layer. In all cases, the honeycomb core returned nearly to its original height after the test. On the other hand, the creation of the cracks and their propagation to facings was observed at the core from PET AIREX After the propagation to the facings a separation occurred. Therefore, it can be concluded that this core cannot bear a high shear stress during bending. The last type of core (Compolet) was characterized by a very quick separation from the facing closer to the applied bending force and the subsequent break of the distant facing layer.

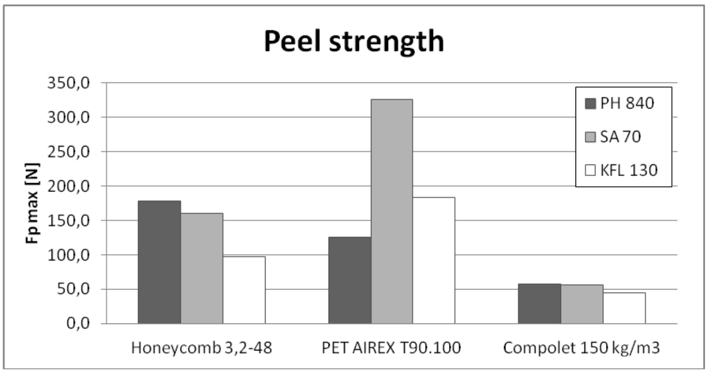

Fig. 2. Peel strength of individual sandwich structures.

Bars in Fig. 2 show the peel strength (Fpmax) of individual sandwich structures with various types of the core bonded to facings with different adhesives. As can be seen, individual adhesives provide different bond strength between the core and facing. Bond strength of prepreg adhesive PH 840 declines from its highest value for combination with honeycomb core to the lowest with Compolet core. Moreover, the core prepared from Compolet material shows the lowest values of peel strength for every adhesive, because of a delamination of this core instead of the break of the bond between the core and the facing. In contrast, PET AIREX core bond together with an HPL facing by epoxy adhesive SA 70 shows the highest value of the peel strength. In the test of this combination, a fracture of HPL facing occurred before the break of the bond. The best results for KFL 130 adhesive were measured for the same type of core. In the other cases, KFL 130 shows much lower values of measured peel strength than other types of adhesives. In general, with respect to measured data the most suitable adhesive for every type of the core seems to be epoxy adhesive SA 70.

Progress of peel forces during the test is shown in Fig. 3, where individual decreases in the graph show the cohesion damage between the facing and the core at the defined time and place from the beginning of the test.

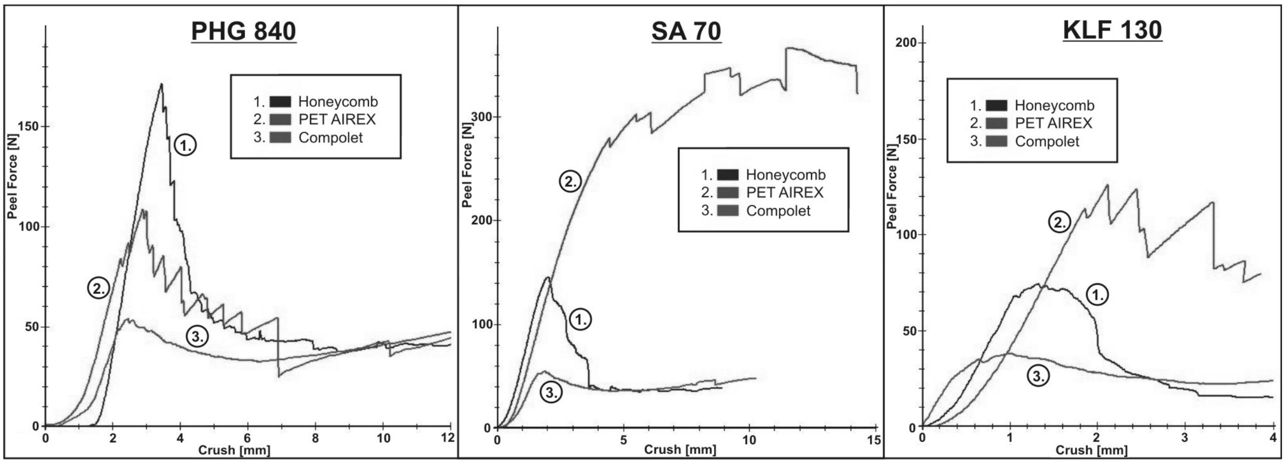

Fig. 3. Progress of a peel force for individual adhesives.

Conclusion

In the research, the bonding quality and mechanical behavior of sandwich structures connected by different foil adhesives have been investigated. From the results it can be concluded that adhesives PH 840 and KFL 130 are the most suitable for connection with a honeycomb core according to the data from three-point bending test. The best flexural strength and flexural modulus have been detected for honeycomb structure connected with KFL 130. The peel test has shown that adhesive SA 70 connecting the core from the Airex PET T90 and HPL facings provides the greatest bond strength.

This research has provided important information about the individual foil adhesives, their advantageous combinations with different cores and also their drawbacks with regard to the obtained results from performed mechanical tests. Moreover, the results suggest further possible applications for the prepared sandwich structures.

However, further research has to be conducted to obtain more accurate values and to eliminate possible measurement errors. Moreover, in order to make final conclusions, it is necessary to make additional tests of mechanical or thermal and sound insulation properties.

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References

[1] D. Zenkert, Nordic Industrial Fund, The Handbook of Sandwich Construction, EMAS Publishing, Worcestershire, 1997.

[2] F. Campbell, Structural Composite Materials, ASM International, Ohio, 2010.

[3] J. Davies, Lightweight Sandwich Construction, Blackwell Science Publishing, London, 2001.

[4] F. Campbell, Joining - Understanding the Basics, ASM International, Ohio, 2011

[5] Adhesive Bonding Technology, Information on http://www.hexcel.com/resources/technology-manuals

[6] A. Chen, J. F. Davalos, A solution including skin effect for stiffness and stress field of sandwich honeycomb core, International Journal of Solids and Structures 42 (2005) 2711-2739.

[7] J. E. Masters, Improved impact and delamination resistance through interleafing, Key Engineering Materials 37 (1991) 317-348.

[8] W.R. Gong, J.L. Chen, J. Wang, Debond Propagation in Honeycomb Structure under Pure Bending Load, Applied Mechanics and Materials 37/38 (2011) 284-287.