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Development and Testing of Shock Absorption Special Carbon Composites

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Abstract: Composite structures are now increasingly used for their properties in all areas of industrial production. They gradually replace metal parts and components not only because they are lighter, but above all for their comparable and in many ways even better mechanical properties. This paper presents description and compilation of experimental analysis of composite tube. Compares the theoretical and real output of sample produced from CF prepreg specially designed for absorbing the energy during crash impact.

Keywords: Carbon Composite; Prepreg; Deformation; Impact Energy; Break.

1 Introduction

The aim is to develop a composite based on carbon and two-component resins suitable to thwart impact energy an object or a person on the outside, respectively on the inner parts of cars. In practice, the ability to use structural components plastically deform, break with refraction, resistance to exhaust their loss of stability or combinations of these and other dissipative mechanisms physical phenomena both in materials and in structures [1–3]. Evaluation of energy absorption will be considered according to the mechanical energy expended on its deformation in bend – mechanical energy is determined by the following equation:

$$U = \int_{x1}^{x2} F(x)dx \tag{1}$$

In the preceding formula represents: U - mechanical energy [J], $F(x)$ - function of the force-deformation of the test piece [N], x - deformation of test [m].

2 Description of the Solution

Specially produced cylindrical composite tube 30 mm in diameter consisting of a core, on which the wound prepreg is composed of carbon fibers wound longitudinally to the axis of the cylindrical core test composite tube (Fig. 1). The matrix was epoxy two component [3]. The prepreg was wound on a core in two layers. The layers were fitted with very fine stainless steel mesh. The fabric was applied two more layers of the prepreg with the fibers parallel to the axis of the cylinder core. This song was pressure load and heat fixed. Matrix filled eye in stainless steel mesh.

The wall thickness after curing was 0.3 mm. Composite tube was attached to the product for three points bending Fig. 2 and 3. Support points are firmly secured to a frame on the measuring board at a distance of 200 mm. The middle section was placed at fast hydraulic cylinder. The cylinder piston will default exact position sensor rod. Further, the cylinder piston mounted load cell. The speed of the cylinder rod has been selected on the basis of possible applications of this product in practice. The movement of the piston rod has been adjusted so that the test area was kept constant speed servo valves 10 mm.s^{-1}. Measurements were performed using a system DEWETRON DEWE 5000. Record the measurement data including the synchronized recording of speed camera was performed on this disk device. First, it was necessary to correct the force measured dynamometer open circuit. It was found that these forces cannot be ignored. Repeat several rounds open circuit and comparing records, we concluded that the records are identical and reproducible. Values influence weight parts on the rod were then subtracted from the measurement was corrected.

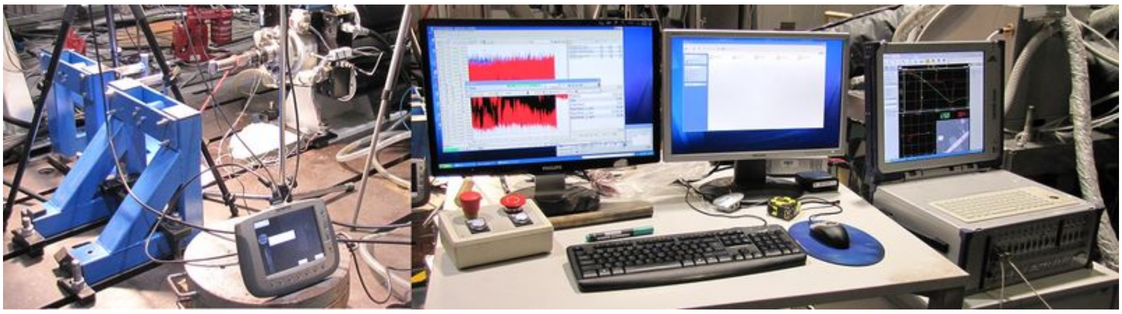

Fig. 1: Experimental device (right), Data and camera synchronization (left).

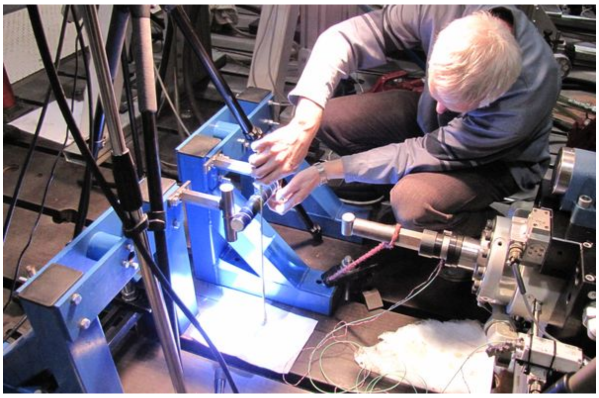

Fig. 2: Preparing the measurement.

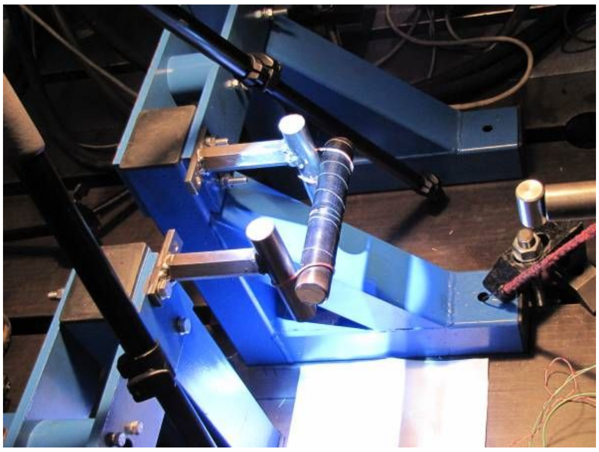

Fig. 3: The sample on the holder of 3PB.

3 Material Sample of Special Carbon Composite

The composite tube of the carbon prepreg was prepared by the procedure described. For the production of the sample was used a prepreg from HEXCEL company, HexPly®M10R / 38% / UD150 / CHS epoxy matrix. The areal weight of the prepreg is 150 gcm^{-3}, the matrix consolidation temperature is 120 °C / consolidation time 60 minutes. Parameters of the prepreg are shown in Tab. 1.

Fig. 4: Carbon prepreg.

Fig. 5: Carbon composite tube with metal reinforcement.

Tab. 1: Parameters of carbon prepreg (m^c, M^f, M^m, V^f, V^m and h represent prepreg area weight, nominal fibre content, nominal matrix content, fibre volume fraction, matrix volume fraction and thickness of the sample, respectively).

	m^c [gm^{-2}]	M^f [%]	M^m [%]	V^f [%]	V^m [%]	h [mm]
HEXPLY®M10R/38 %/UD 150	242	62	38	52	48	0.22

4 Results and Summary

The composite tube was fixed in a holder as in the three point bending. Impactor crashed into the second tube speed of 10 ms^{-1} as see (Fig. 6). After impact, the composite skin broke in the longitudinal direction; in the same direction with the orientation of the fibrous layer. Fibers broke up only in the area of direct impact of the impactor to the composite skin. Metal reinforcement molded between fiber layers destroyed the same mode as the fibers layer (Fig. 7). Metal reinforcement broke away from the composite skin at the point of impact, the place is marked with a red circle (Fig. 8). Supporting core separated completely from the composite. The data evaluated in the program DEWESoft are shown in Fig. 9. Energy transformation depends on displacement of the impactor is shown in Fig. 10. The results indicate that the material is consumed on its deformation 3 mJ. The graph (Fig. 11) shows the force of the initial contact of the impactor with the tube to destruction (maximum force peak 2.74 kN). After the tube breaking force value has fallen. Parametric graph (course of impact the impactor to the tube at time horizon) is shown in Fig. 12. The results show that the sample due to its deformation is able to absorb some energy and become a material usable in structural applications.

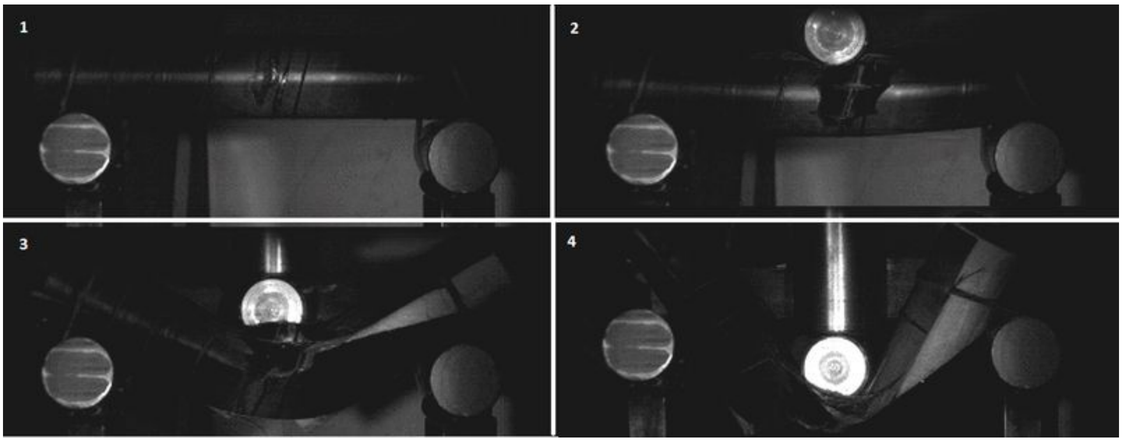

Fig. 6: Time response: Pictures from high-speed camera.

Fig. 7: Point of impact.

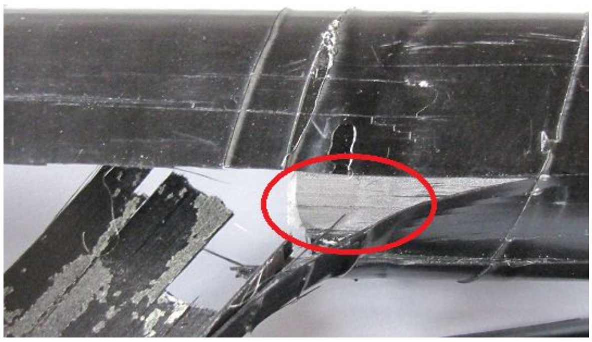

Fig. 8: Separation of fibers and metal layers.

5 Conclusion

The article describes the course of experimental analysis of the mechanical properties of the carbon prepreg composite specially adapted to absorb energy during rapid crash impact. The results confirmed that the sample during impact plastically deforms and absorbs the impact energy. Prepregs are due to its characteristics very well usable for structural applications.

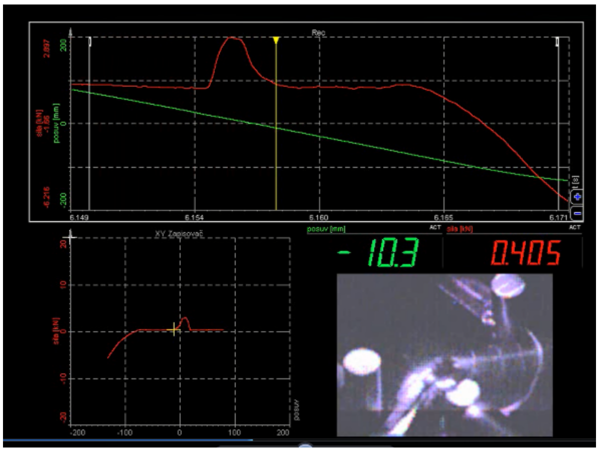

Fig. 9: Evaluating data in DEWESoft.

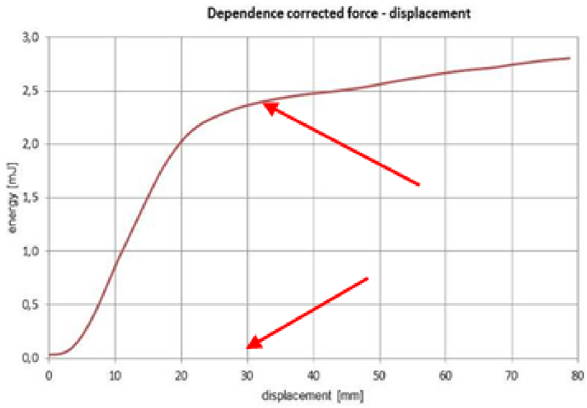

Fig. 10: Energy vs. displacement.

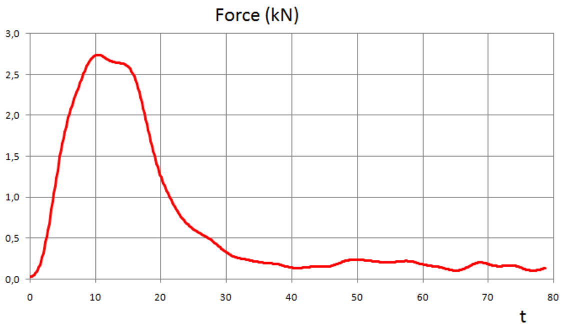

Fig. 11: Time response of force.

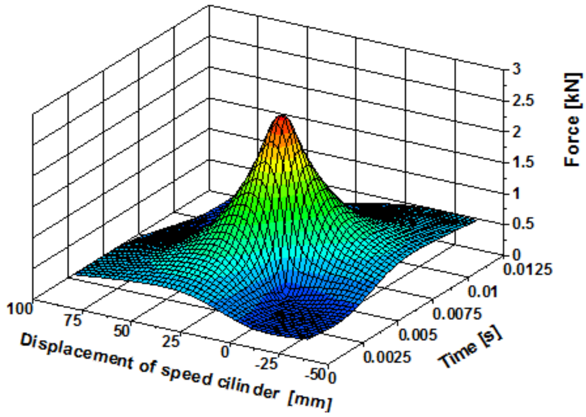

Fig. 12: Force vs. displacement vs. time.

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