5th International Conference
″Computational Mechanics and Virtual Engineering ″
COMEC 2013
24- 25 October 2013, Braşov, Romania

MECHANICAL BEHAVIOR OF HEMP-BASED COMPOSITE SUBJECTED TO IMPACT TEST

Maria Luminita SCUTARU[1], Marius Baba[2]
[1] *Transilvania University of Brasov, Department of Automotives and Mechanical Engineering, 29 Eroilor Blvd, 500036, Brasov, Romania, lscutaru@unitbv.ro*
[2] *Transilvania University of Brasov, Department of Automotives and Mechanical Engineering, 29 Eroilor Blvd, 500036, Brasov, Romania, mariusbaba@unitbv.ro*

Abstract: *This paper presents a study regarding the impact testing of some composite laminate panels based on polyester resin reinforced with hemp fabric. The effects of different impact speeds on the mechanical behavior of these panels have been analyzed. The paper lays stress on the characterization of this composite laminate regarding the impact behavior of these panels by dropping a weight with low velocity.*
Keywords: *Composite material, Low-velocity impact, Hemp fibers,Impact testing*

1. INTRODUCTION

Composite materials are used in a wide range of applications; however, they are used with prudence in applications where transverse loadings appear, for instance, loadings given by transverse impact with low velocity. Damage resistance is connected on the material's capability to minimize the failures' effects given by impact, while damage tolerance is given by the material's capability to maintain its properties even after failures' appearance in material. Usually, these properties are called residual properties. One of the difficulties regarding the properties and evaluation of composites is, ironically, an advantage, namely, the capability to allow users to tailor their properties to suit the design needs[1],[2]. In applications, the use of composites based on natural fibers is yet limited at the so-called non-structural components such as inner components of cars. One of the main reasons for this limitation consists in the sensitivity of these composites at impact and the difficulty in critical evaluation regarding damages caused at impact.

2. METHOD

The research has been carried out only composite panels reinforced with hemp fabric. All composite panels presenting a rectangular shape and being underpinned on all edges and have the same material's structure: *five layers of thermosetting resin reinforced with hemp fabric.*
The plies sequence has been carried out in the hand lay-up process using a roll for resin impregnation of hemp fibers. Finally, the structure's thickness has been 4 mm. The laminate panel has been maintained at room temperature for two weeks from which five specimens of rectangular shape (150 x 100 mm) have been cut. The specimens have been subjected to impact by dropping a weight according to the standard ASTM-D5420-98a .
The impact testing by dropping a weight is used to characterize the dynamic behavior of a material. The experimental setup consists in a two column frame and a weight which can be lifted and released in free fall with minimum friction by sliding along columns under own weight (Fig. 1). The indentor presents a hemispherical head with a 16 mm diameter and its mass is equal to 1.9 kg. This indentor hits the middle of the rectangular specimen. The accelerometer is fixed on the upper part of the indentor and the signal (acceleration) is taken over in computer by help of an acquisition device type NI USB 6521 BNC.
Hemp specimens were supported on all rigid plate (a test machine) and fixed price margins four screws through the rubber top pieces easily tightened by hand. Behind the projectile was set screw an accelerometer to measure the acceleration of the projectile and that the contact force during impactului.Rezultatele were recorded using a purchasing card.

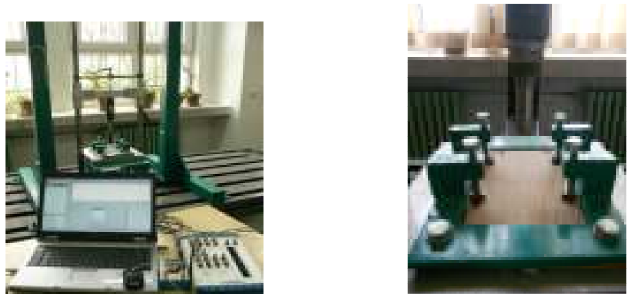


Figure 1:. Impact device and specimen trapped in device

Using this kind of testing, some data regarding the mechanical properties of a material can be obtained, namely:

- The energy, U, absorbed during impact;
- The variation of impact force, F, at the impact moment;
- The variation of indentor's displacement, d, versus time, etc.

In case of impact testing by weight falling, the only measured feature versus time is the contact force, F(t), exerted by the weight which falls on specimen while the specimen's deflection is determined as a function of time by numerical integration of the indentor's motion equation. The acquisition of experimental data (acceleration) as well as computing the response parameters described above have been carried out using a block diagram conceived by the LabView program.

3. EXPERIMENTAL RESULTS

Using the LabView program, the variation of force "F" has been computed at the impact's moment after the signal has been recorded with the accelerometer through the acquisition device. In the same way, following distributions have been represented:• The variation of impact force F versus the displacement δ at the impact's moment;

- The variation of indentor's displacement δ at the impact's moment ;
- The variation of energy U at the impact's moment.

Samples were tested at a speed of 1 m/s, 2 m/s 3 m/s or 4 m/s. (fig.2) The results obtained after the impact testing of hybrid carbon-hemp composite laminate are presented in table 1 as well.

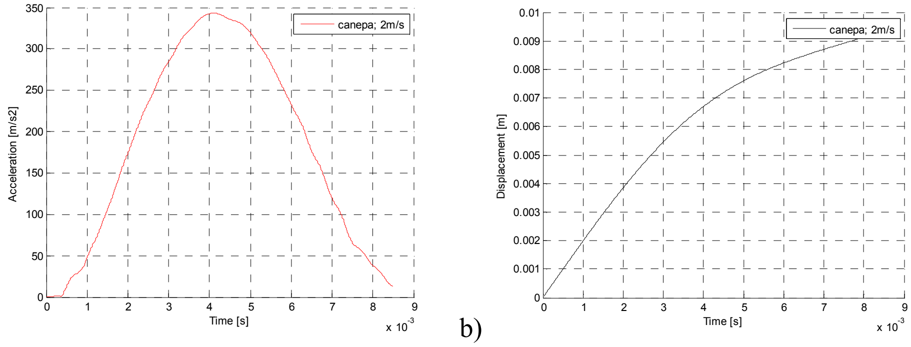
Table:1. Results of impact testing

Specimen	Results			Observations
	Specimen thickness [mm]	Falling height [m]	Impact speed [m/s]	
1	4	0.815	4	Total break
2				
3				
4				
5		0.458	3	Break at first ply
6				
7		0.203	2	Trace on specimen is slightly marked
8				
9		0.05	1	Trace on specimen is not visible
10				

Figure 2: Hemp fabric specimens after the impact loading

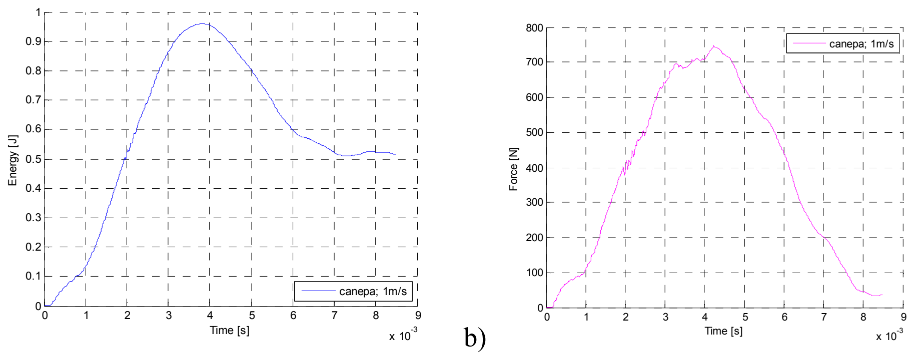
They also force-displacement curves were obtained at the point of contact and was determined BVID corresponding energy level (maximum kinetic energy projectile that damages are not visible to the naked eye).

Specimen hemp (Cnp) (v=1m/s)



a) b)

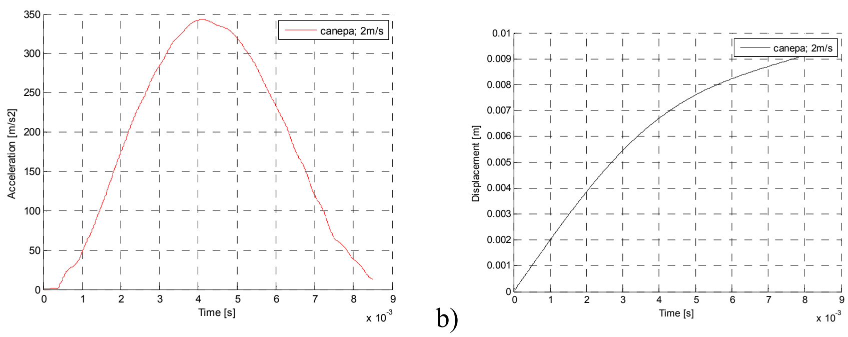
Figure 3: The variation of acceleration) of the projectile and the driving b) of the projectile on impact when the specimen



a) b)

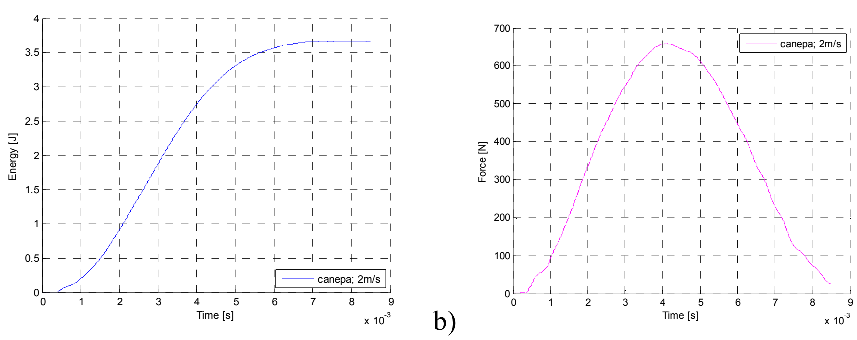
Figure 4: Variation of energy absorbed by the specimen) and force-time variation in the impact

Specimen hemp (Cnp) (v=2m/s)



a) b)

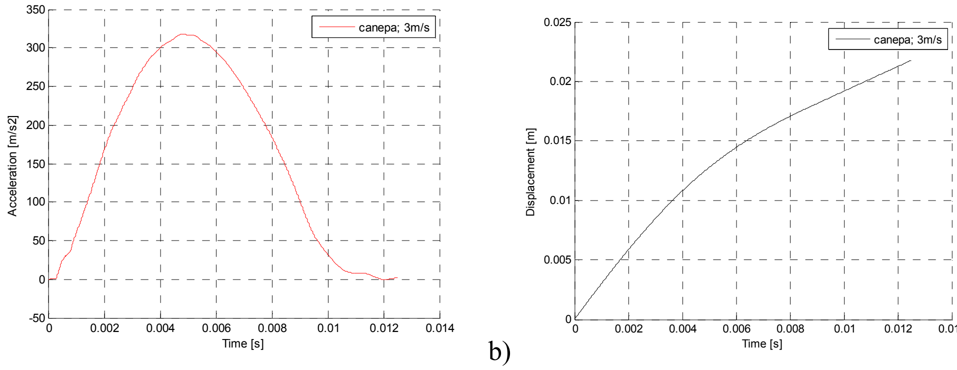
Figure 5: The variation of acceleration) of the projectile and the driving b) of the projectile on impact when the specimen



a) b)

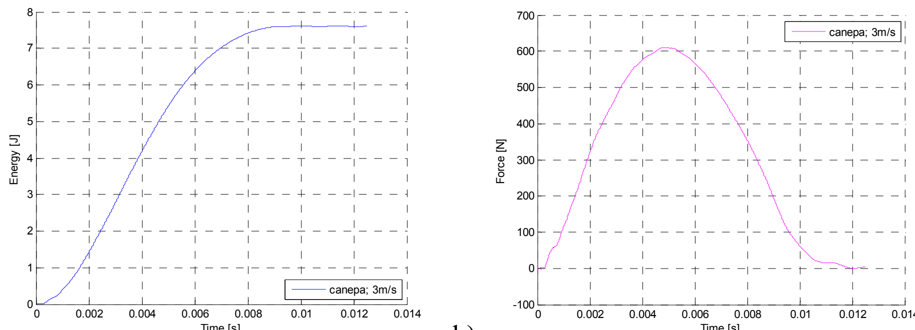
Figure 6: Variation of energy absorbed by the specimen) and force-time variation in the impact

Specimen hemp (Cnp) (v=3m/s)



a) b)

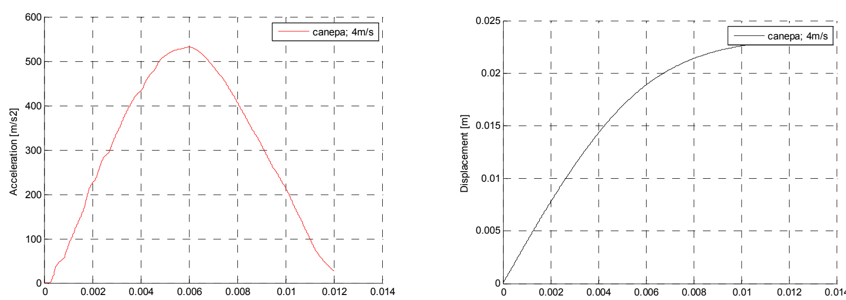
Figure 7. The variation of acceleration) of the projectile and the driving b) of the projectile on impact when the specimen



a) b)

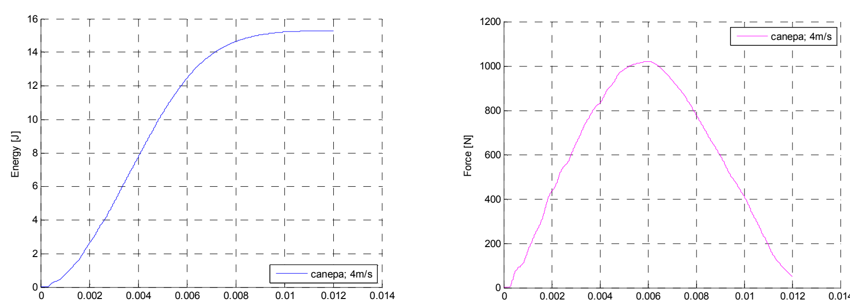
Figure 8: Variation of energy absorbed by the specimen) and force-time variation in the impact

Specimen hemp (Cnp) (v=4m/s)



a) b)

Figure 9: The variation of acceleration) of the projectile and the driving b) of the projectile on impact when the specimen



a) b)

Figure 10: Variation of energy absorbed by the specimen) and force-time variation in the impact

Given the many possibilities of breaking the problem impact behavior of composite materials is complicated enough, an alternative predictive methods to study the impact. Based on the results of dynamic analysis could highlight using finite element stress distribution σ_x, σ_y and of the τ_{xy} type occurring in the four layers of composite fabric made of hemp.

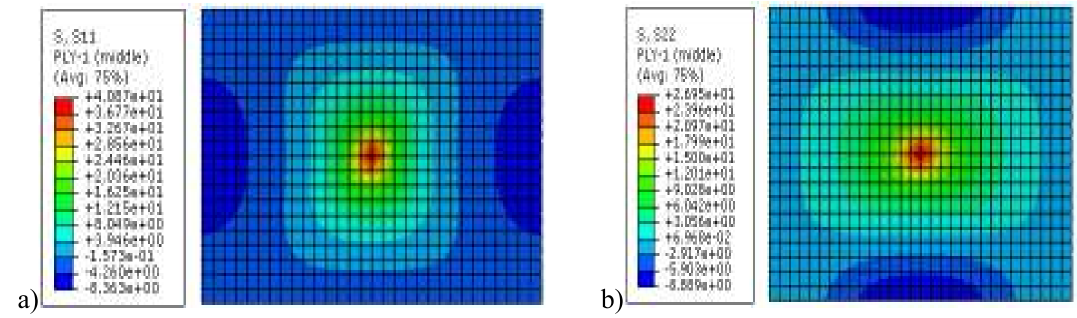


Figure 11: The distribution of σ_x stress a) and σ_y b) appears in the first layer of the composite fabric made of hemp

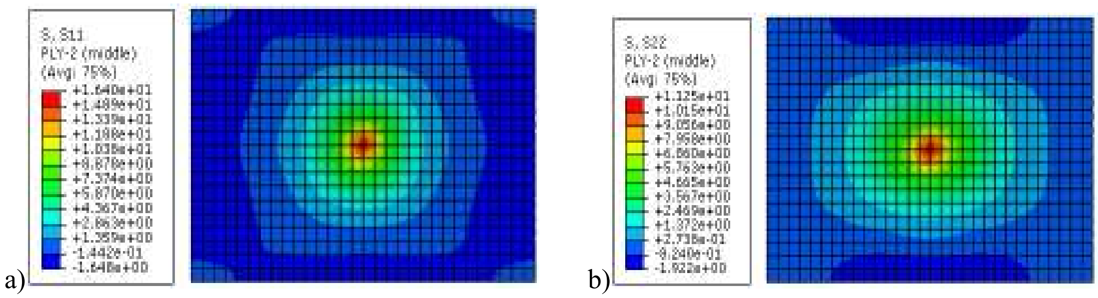


Figure 12: The distribution of σ_x stress a) and σ_y b) appears in the second layer of the composite fabric made of hemp

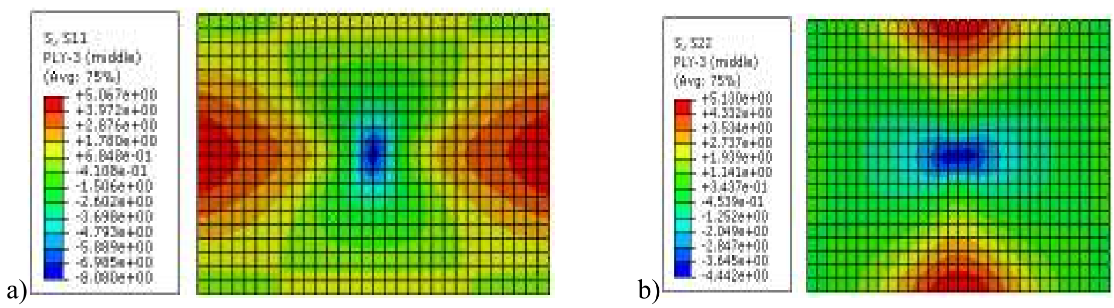


Figure 13: The distribution of σ_x stress a) and σ_y b) appears in the third layer of the composite fabric made of hemp

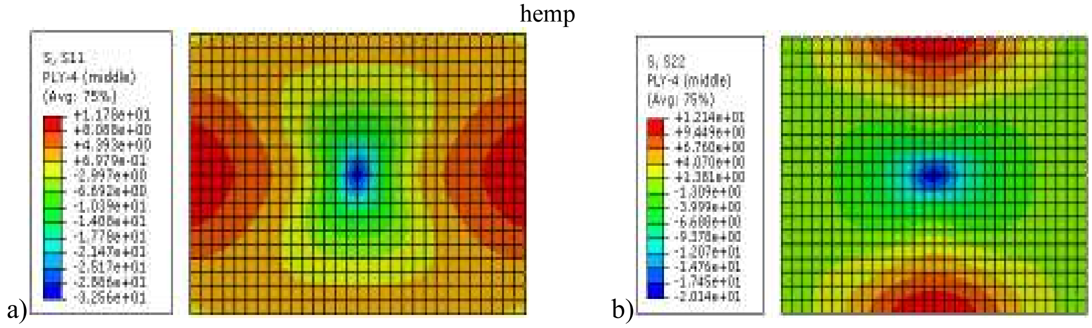
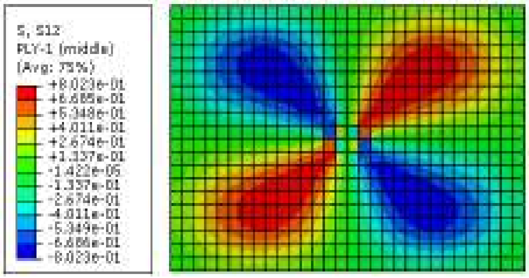


Figure 14: The distribution of σ_x stress a) and σ_y b) appears in the last layer of the composite fabric made of hemp

a) 

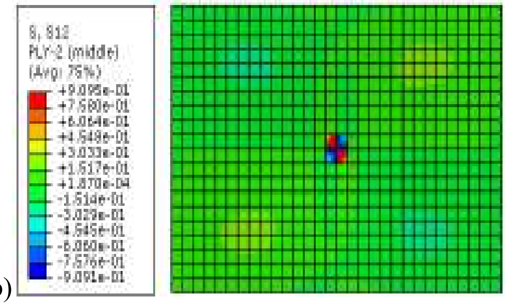
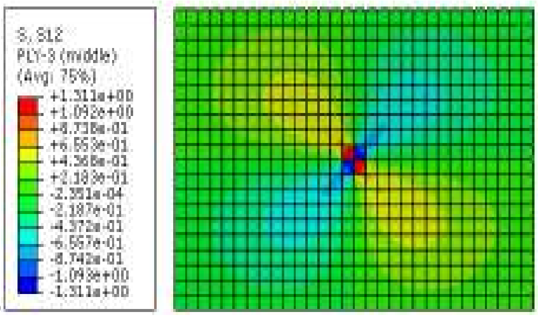
b) 

Figure 15: The distribution of τ_{xy} stresses occurring in the first layer a) and the second layer b) of the composite fabric made of hemp

a) 

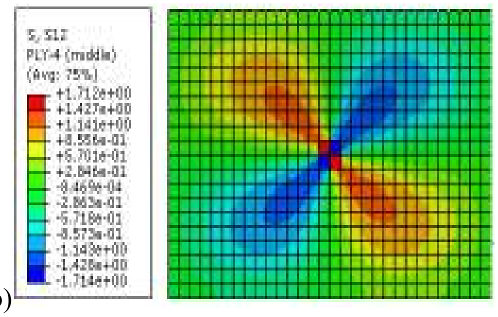
b) 

Figure 15: The distribution of τ_{xy} stresses occurring in third layer a) and the last layer b) of the composite fabric made of hemp

4. CONCLUSION

Analysing this curves we can say that these curves present leaps and inflexions due to the presence of delaminations. Integrating the area under the loading curve until the maximum value of the force (according to the first failure) the energy required to initiate the failure can be obtained. At the impact's moment, the energy accumulates in time and is direct proportional with the force and increases until reach a constant landing. After reaching a maximum value of the force, this decreases in time, the energy U being absorbed in material and the force's decrease took place after reaching the landing of U. In general, at the composite laminates the energy is frequently absorbed by creating some delamination surfaces called delamination breaks that lead to the strength and stiffness decrease. Analysing the specimens after impact testing can be noticed that the failure areas localized on the specimens' surface are smaller than those localized on the backfront. This lead to the conclusion that the cracks have been propagated from the place where the intedor hits to the backfront of the panel.

REFERENCES

[1] N.D. Cristescu, E.M. Craciun, E. Soos, Mechanics of elastic composites, Chapman & Hall/CRC, (2003);
[2] H. Teodorescu-Draghicescu, S. Vlase, Computational Materials Science, **50**(4), 1310 (2011);
[3] H. Teodorescu-Draghicescu, S. Vlase, Upper and Lower Limits in the Elastic Properties of Low-Shrink Sheet Molding Compounds, 23rd International Congress of Theoretical and Applied Mechanics (ICTAM2012), Beijing, August 19-24, China Science Literature Publishing House, pp. 136 (2012);
[4] Vlase, S. Teodorescu-Draghicescu, H. Calin, M. R. Serbina, L. Simulation of the elastic properties of some fibre-reinforced composite laminates under off-axis loading system. OPTOELECTRONICS AND ADVANCED MATERIALS-RAPID COMMUNICATIONS,Vol.5, Issue 3-4, pp.424-429, (2011).