The 4th International Conference
"Advanced Composite Materials Engineering "
COMAT 2012
18- 20 October 2012, Brasov, Romania

FEM MODELLING OF AN AUTOMOTIVE DOOR TRIM PANEL MADE OF LIGNOCELULOZIC COMPOSITES IN CASE OF A DOOR SLAM SIMULATION

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Abstract: *The paper presents the finite element analysis of an automotive door trim panel made of lignocelluloses composites in order to determine the stresses and displacements in case of a door slam simulation. In research was investigated a new lignocelluloses composites made of polymers reinforced with woven fabrics of natural fibres and wood particles. The mechanical properties of this material were determined experimentally and used as input data in FEM simulations. The FEM results emphasized that new material improves component stiffness compare with classical materials used.*
Keywords: *lignocelluloses composites, mechanical properties, automotive, door slam, door trim panel, FEM*

1. INTRODUCTION

By reducing vehicle weight will reduce the amount of energy required for movement, which has major implications on the level of environmental pollution. An obvious way to this is to extend the use of lightweight composite materials with multiple functions in the body structure components without using one material for each of the requirements.
Current trends in the field of composite materials, due to environmental and economic considerations, focus on achieving low environmental impact materials and possible usage of waste resulting from other industrial processes. In this class is enclosed wood waste as sawdust resulting from cutting wood [6].
Usage of materials reinforced with natural fibres for vehicles construction and not only has become a challenge and a subject of great interest due to the great volume and variety of renewable resources and biodegradable materials that influence production cost of materials.
Composite materials made of natural fibres and polymer matrix provides synergistic properties, improving their strength and durability, thus recommending the use of matrices with high resistance to aggressive environmental factors [3, 6]. These materials are suitable for achieving automotive interior components, where in addition to their low weight have also high rigidity and good thermal and sound insulation. The most important vehicle elements include car door panels.

2. MATERIALS AND METHODS

Door panel materials used in FEM analysis were the classic ones, such as plastic polypropylene (PP) and also some new materials were used. The new lignocellulosic composite material is a laminate having two layers made of polyester resin reinforced with plain weave fabric of flax fibres (FUP) and one middle layer made of polyester resin reinforced with wood sawdust of oak (OUP). In order to determine the main mechanical properties of new natural fibre reinforced composite material, each layer of material has been tested to tensile stresses [1, 5]. Tensile test is known to be the most important and commonly used static test due to the procedure's simplicity on obtaining the strength and stiffness characteristics [2, 4]. Mechanical characteristics of the new material were needed to simulate the behaviour of parts made of these materials by finite element method (FEM).
Elastic properties of composite layers and the polypropylene properties are shown in Table 1. Direction of the weft yarn fabric reinforced lamina corresponds to the x direction of the part.

Table 1: Materials properties

Materials	E_1 *[MPa]*	E_2 *[MPa]*	υ_{12}	G_{12} *[MPa]*	G_{13} *[MPa]*	G_{23} *[MPa]*	Density, ρ *[Kg/m³]*
FUP	4711	2787	0.35	1800	1800	1800	1187
OUP	3041	3041	0.37	-	-	-	1077
PP	1300	1300	0.35	-	-	-	906

In Figure 1 are presented images with left front door trim panel designed in Catia V5 software.

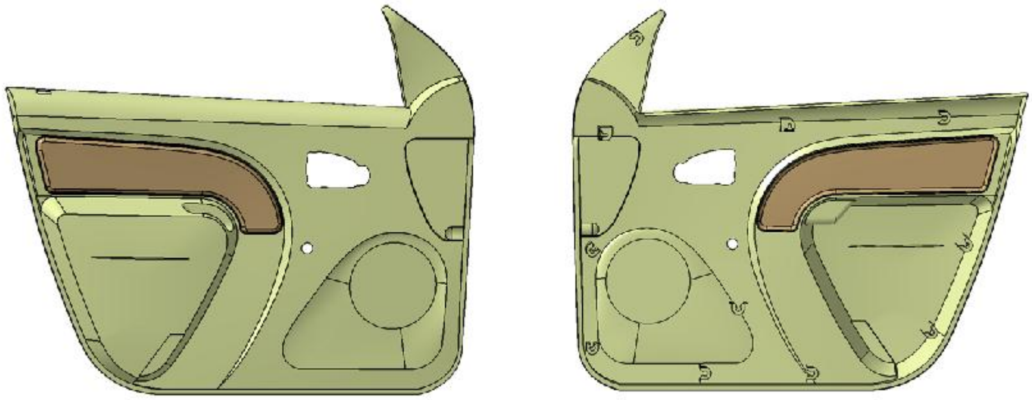

Figure 1: Door trim panel designed in Catia V5 software

Structure of the new lignocellulosic material is presented in figura2.c. According to the literature the main common mechanical stress, which affects the life of the door panels, is the shock produced by closing the door. In this case the door trim panel is loaded with an acceleration field resulting from inertia forces due to its own weight (Fig. 2.a and 2.b).
Meshing was done using shell elements with 6 graders of freedom, with dimensions of about 5 mm. As much as possible quad elements were chosen, but in areas with pronounced 3d curves triangular elements were chosen. Figure 3 presentet the door trim panel discretized in finite elements.

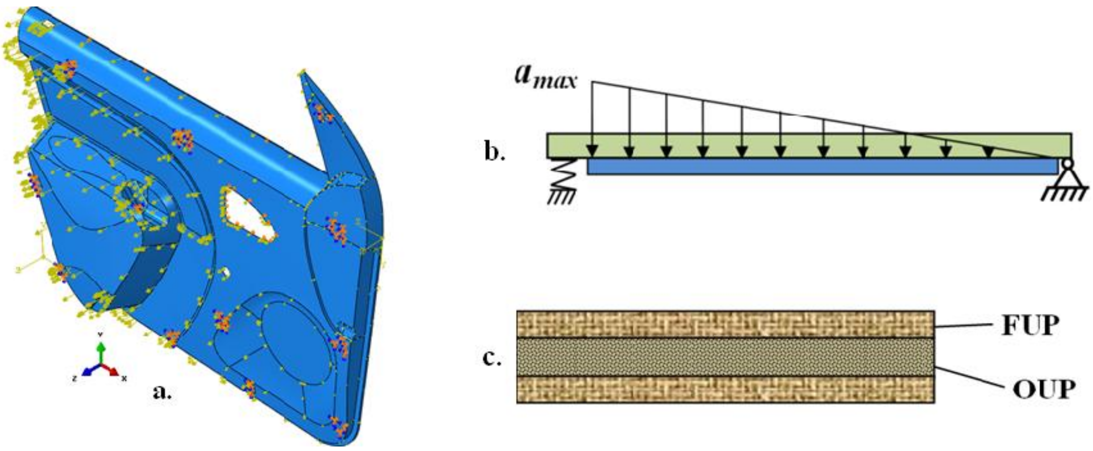

Figure 2: Acceleration distribution on door trim panel and composite material structure

Door panel has several areas where constraints are applied as follows:
• on clips systems panel mounting metal structure areas, shiftings were blocked on all 3 directions (U1, U2 and U3);
• upper part rests on a metal door structure, thus blocking shiftings on direction 2 (U2) (Fig. 6.7, b);
• in screw mounting areas shiftings were blocked on all 3 directions (U1, U2 and U3) and rotations on two directions (Fig. 4.b);

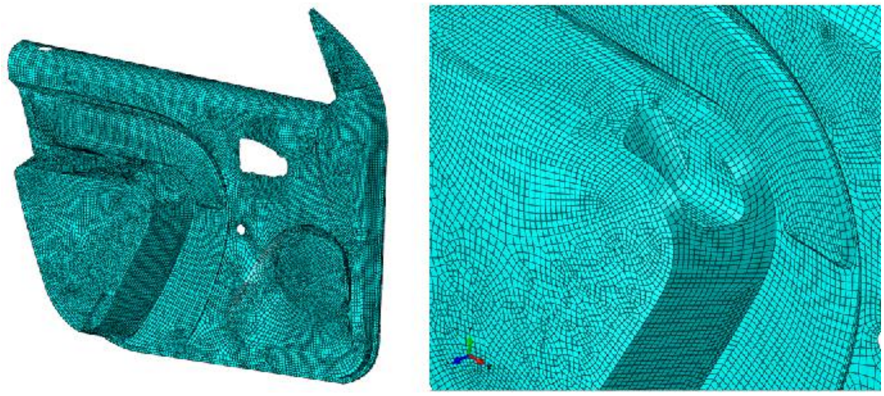

Figure 3: Discretized door trim panel

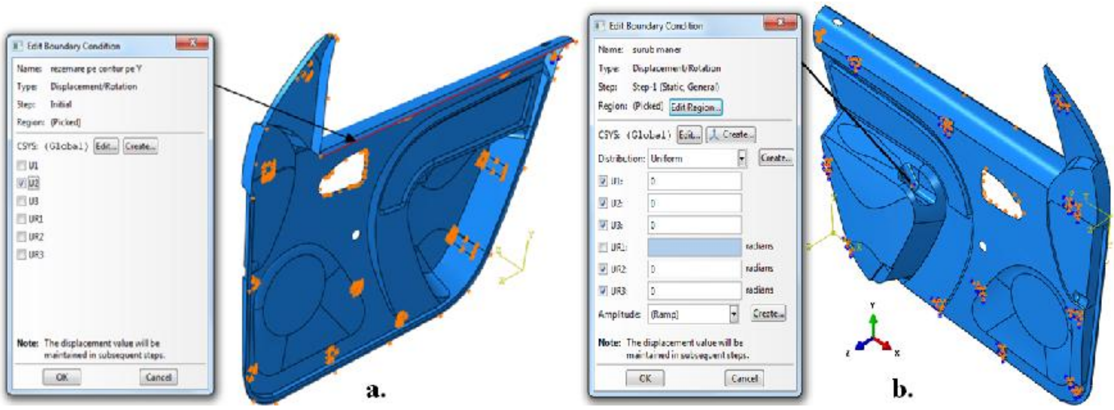

Figure 4: Setting constraints for clips fixing areas and bearing on metal structure

Figure 5 present the equivalent stress distribution on the middle surface of the layer 1 and displacements distribution on the axis z (w) and position of the maximum values.

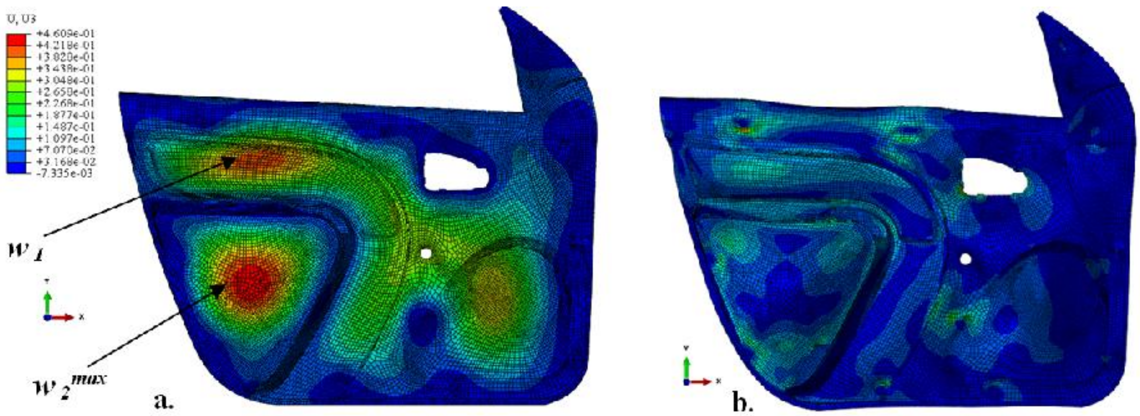

Figure 5: Displacements distribution on the z axis (w) and tensions distribution of composite laminated panel trim door

3. RESULTS AND DISCUSSION

Comparing the results obtained by finite element modelling for the two types of structures, in Figure 7 can be seen that for an acceleration of the impact of 350 m/s^2, displacements of the two points in the lignocellulosic composite moulded panel are lower by 43% than the plastic moulded panel with classic material like polypropylene. This values displacements decrease is due to greater rigidity of lignocellulose material and smaller mass of the panel, given its reduced thickness. Since when slamming door, door panel is loaded with inertial forces due to own weight, results that it's mass influence the load degree.

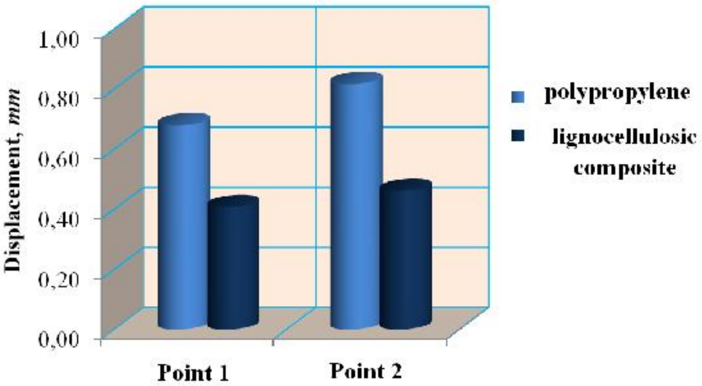

Figure 6: Displacements values in the two points of the door panel for the two materials studied at an acceleration of 350 m/s^2

4. CONCLUSION

Modelling parts with complex geometry involves the use of specialized software to achieve virtual model;
From equivalent stress distribution of analyzed component can be seen that these areas have high levels on fixing areas to metal structure;
Displacements of lignocellulose materials door trim panel obtained by FEM are smaller by 43% than those of polypropylene panel;
Small values of displacements resulting for lignocellulosic composite component are due to the high rigidity and also low weight material layer given its lower thickness of the panel, this decreasing from 1.81kg to 1.49kg;

ACKNOWLEDGEMENT

This paper is supported by the Sectoral Operational Programme Human Resources Development (SOP HRD), financed from the European Social Fund and by the Romanian Government under the contract number POSDRU/88/1.5/S/59321

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