

# Impact comparative study of phone carcasses behavior by FEM

Cărașu Constantin<sup>1</sup>, Simona Plăvănescu and Nedelcu Dumitru

Technical University “Gheorghe Asachi” of Iasi, Romania, Blvd. Mangeron, No. 59A, 700050 Iasi, Romania

E-mail: c\_carausu@yahoo.com

**Abstract.** A constant concern of scientific research is based on plastics replace with biodegradable materials that reduce the adverse impact of waste on the environment. A biodegradable material that arouses interest lately is Arboform which is made of lignin, a component of wood and woody plants. Replacing plastic with Arboform in carrying components of products requires technical and economic studies on the implications of such replacement. Numerical simulation methods are a fast and economical way of analyzing the behavior of a product in various mechanical, thermal, electromagnetic and so on. The paper presents comparative results of numerical simulation using the software package SolidWorks impact behavior through the “Drop Test” of half shells made of High Density Polyethylene (HDPE) and of the Arboform LV3 Nature. Simulation watched the half-carcass behavior in three cases of accidental impact, “head”, “corner” and the “back side”. We analyzed the size and location of the maximum voltage and maximum deformation resulting from impact. Simulations have shown for all three cases a maximum voltage increase when using Arboform to use PEDH 93% for impact “forward” and “corner” and only 48.77% “back side” impact. If the maximum displacement, it increasing from carcasses of Arboform 4% for impact “head” and 6% for impact “corner”, but fell by 2.7% for the “back side” impact. The significant increase of stress can be attributed to the higher density of Arboform to PEDH, which led to different weights of the two half-carcasses.

## 1. Introduction

The use of plastics is increasing and in a continuous diversification. If in 2007 the production of plastics was 260 million tons, in 2011 it had reached 280 million tons and was estimated an increase of 4% annually until 2016 [1]. New manufacturing technologies, such as 3D printing, have been implemented.

Many uses of plastics refer to the consumer goods industry characterized by a high volume production and reduced life cycle. Many of the plastics used are made from petroleum products. A direct result of this trait is the generation of large amounts of waste which represent a complex socio-economic and political problem with direct implications on the environment [2].

One solution to reduce this problem is the use of biodegradable materials [3]. It results from the use of biomass in the composition of some material.

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<sup>1</sup> Address for correspondence: Cărașu Constantin, Technical University “Gheorghe Asachi” of Iasi, Romania, Blvd. Mangeron, No. 59A, 700050 Iasi, Romania. E-mail: c\_carausu@yahoo.com.



“Liquid wood” made from lignin - a component of biomass represented by wood and other woody plants - is an alternative replacement of petroleum products manufactured from plastic. Arboform, trade name of the new material, presents a number of properties that makes it suitable to manufacture a wide range of products [4] such as covers for mobile phones.

To check the behavior in exploitation, mobile phone carcasses are subject to a number of mechanical stresses (accidentally) including the impact with a flat surface. To verify this test, carcass behavior is subject to the so-called “drop test” which, consists in observing the consequences to a certain speed impact between the carcass and a plan.

Drop test can be simulated using finite element software packages.

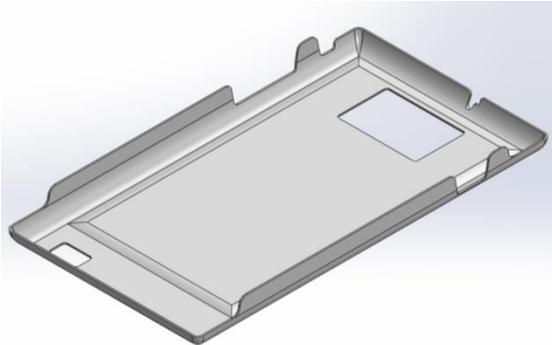
In the following is presented the simulation results using “Drop Test” from SolidWorks software [5], the test is done on a mobile phone half-carcass made of High Density Polyethylene (HDPE) and, respectively, Arboform LV3 Nature.

## 2. Methodology

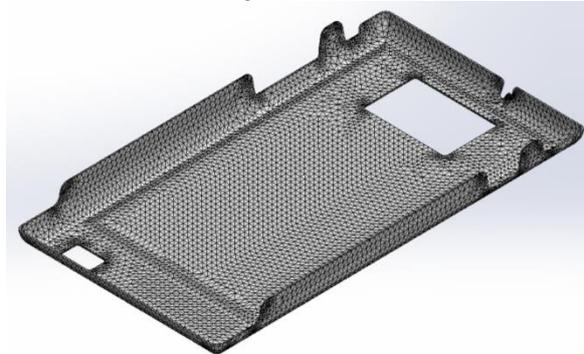
The 3D model of half-carcass made in SolidWorks is presented in figure 1.

The properties of the two materials, PHDE and Arboform are shown in Table 1. Data for PHDE were taken from the database of the SolidWorks package, and those relating to Arboform are taken from [4, 5]. It is noted that the value of longitudinal and transverse elastic modulus of Arboform is double that of HDPE. Arboform's density is bigger with 29% than that of the HDPE.

Figure 2 presents the discretized model of the half-carcass. Was used a uniform mesh with tetrahedral elements, being involved 63.195 nodes and 73.195 elements. The goal of the simulations was to determine the stress and strain on the half-carcasses impacted with the plan in three situations: a. the impact of the half-carcasses “head”; b. the impact with a corner; c. at the back side. Figure 2 shows the meshed model of the half-carcass. The impact speed was set at 20 m/s. Weight of half-carcass made from HDPE was calculated at 6.9 g and for Arboform 9.8 g.



**Figure 1.** Solidworks half-carcass model.



**Figure 2.** Discretized model of the half-carcass.

**Table 1.** Fizico-mechanical properties of Polyethylene High Density (PEHD) and Arboform.

Material	Elastic Modulus [N/m <sup>2</sup> ]	Poisson Ratio	Shear Modulus [N/m <sup>2</sup> ]	Tensile Strength [N/m <sup>2</sup> ]	Density [Kg/m <sup>3</sup> ]
PEHD	1.07.10 <sup>9</sup>	0.4101	377.2.10 <sup>6</sup>	22.1.10 <sup>6</sup>	952
Arboform	2.22.10 <sup>9</sup>	0.38	804.3.10 <sup>6</sup>	19.2.10 <sup>6</sup>	1350

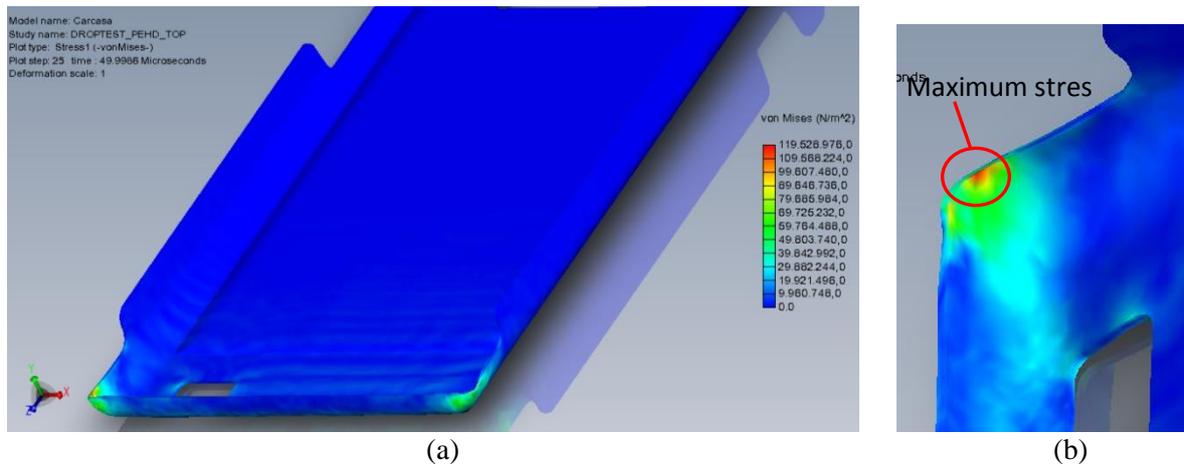
## 3. Results and discussion

### 3.1. “Head” impact of the half-carcass

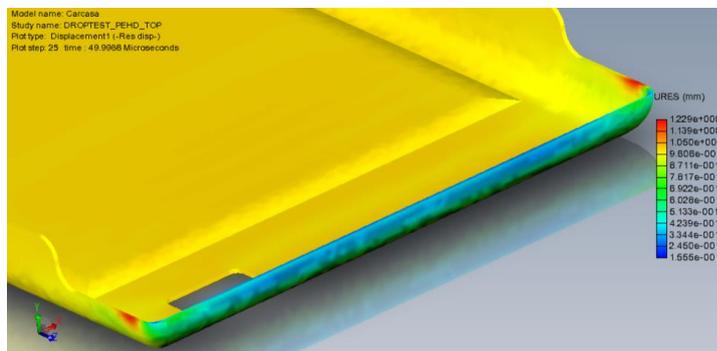
#### 3.1.1. For HDPE

In figure 3 is presented the equivalent stress state over von Mises criterion for HDPE half-carcass to “Drop test”.

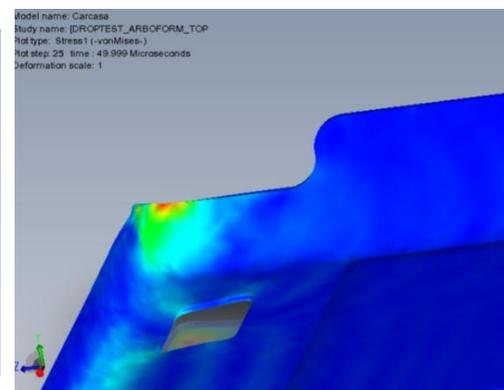
The maximum stress of 119.5 MPa was located as shown in figure 3(b) on the half-carcass inside part.



**Figure 3.** (a) Stress state for “Drop test” “in head” of HDPE half-carcass. (b) maximum stress detail.



**Figure 4.** Deflection state for “Drop test” “in head” of HDPE half-carcass.



**Figure 5.** Stress state for “Drop test” “in head” of Arboform half-carcass.

The state of deformation is shown in figure 4. The maximum impact deflection at “head” for HDPE half-carcass is 1.23 mm.

### 3.1.2. For Arboform

For “head” impact of the Arboform half-carcass, locations of maximum stresses and maximum strains are similar with those of the HDPE half-carcass. The values of these parameters are: maximum stress 231 MPa and maximum deformation 1.28 mm. It is noted that the stress distribution in the impact area is different from that of HDPE half-carcass (figure 5) by the fact that the impact edge stresses are reduced.

In case of “head” impact test for the Arboform half-carcass, maximum stress increased by 93% from that of HDPE, while the maximum displacement increased only by 4%.

## 3.2. “Corner” impact of the half-carcass

### 3.2.1. For HDPE

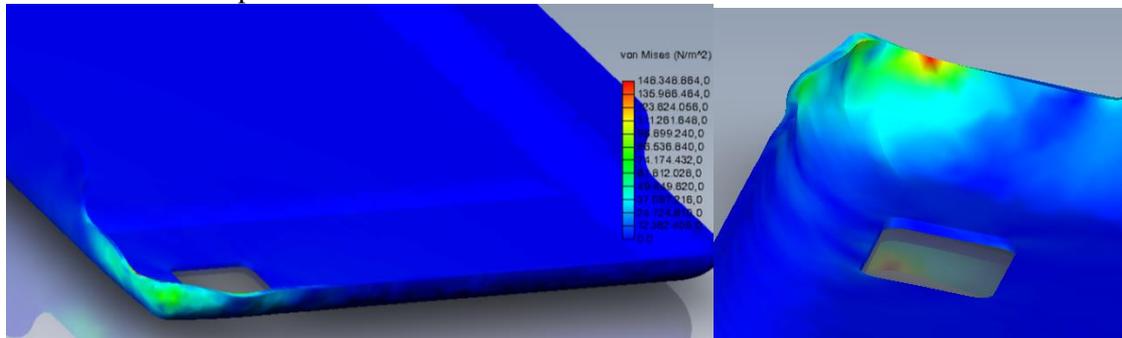
In Figure 6 is represented the equivalent stress state over von Mises criterion for HDPE half-carcass to “Drop test”.

The maximum stress of 148.3 Mpa was located as shown in figure 6(b) on the half-carcass inside part. Maximum stress is with 24.1% bigger than the “head” impact.

The state of deformation is shown in figure 7. The maximum impact deflection in “corner” for HDPE half-carcass is 1.42 mm. Maximum stress is with 1% bigger than the “head” impact.

3.2.2. For Arboform

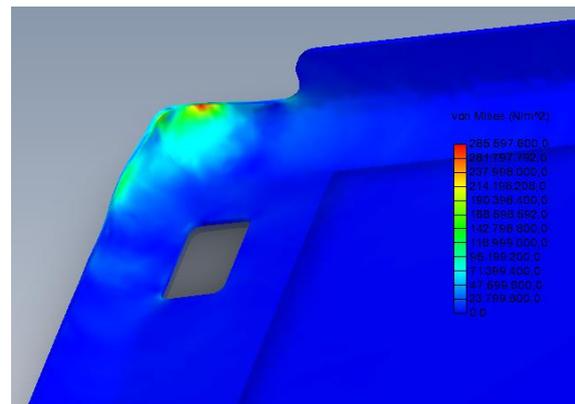
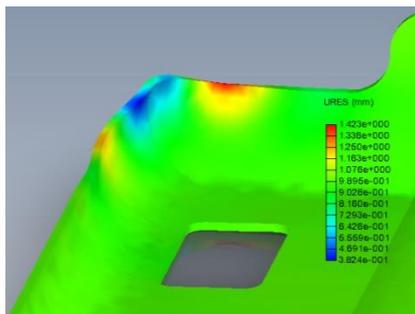
As in the case of a, For “corner” impact of the Arboform half-carcass, locations of maximum stresses (figure 8) and maximum strains (figure 9) are similar with those of the HDPE half-carcass. The values of these parameters are: maximum stress 286 MPa and maximum deformation 1.5 mm.



(a)

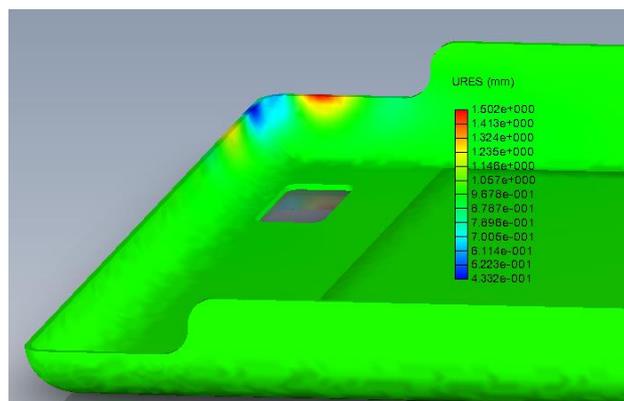
(b)

**Figure 6.** (a). Stress state for “Drop test” “in corner” of HDPE half-carcass. (b). maximum stress detail.



**Figure 7.** Deflection state for “Drop test” “in corner” of HDPE half-carcass.

**Figure 8.** Stress state for “Drop test” “in corner” of Arboform half-carcass.



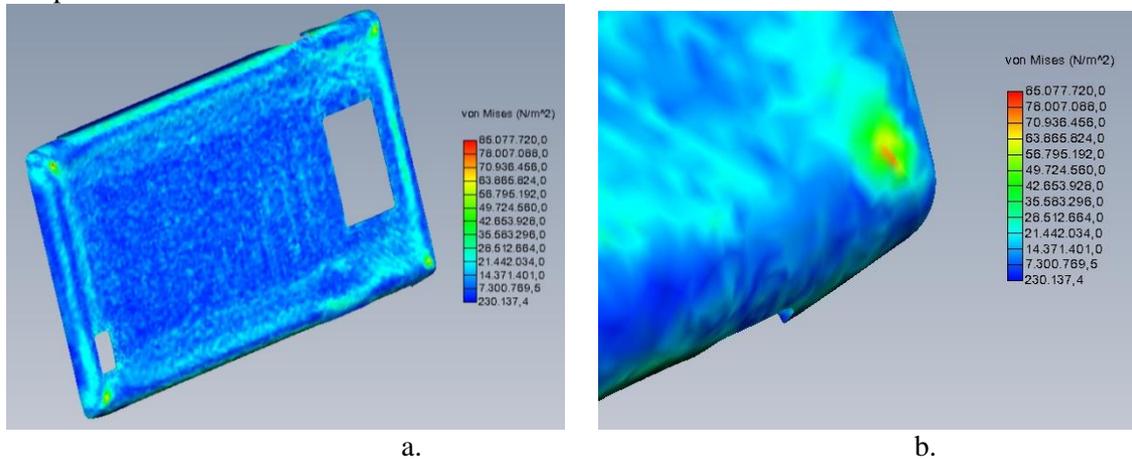
**Figure 9.** Deflection state for “Drop test” “in corner” of Arboform half-carcass.

Comparing the behavior of the two materials results that in case of “head” impact for Arboform half-carcass maximum stress increased by 93% from that of HDPE (similar increase in case a), while the maximum displacement increased by only 6% (higher than the growth of case a).

### 3.3. “Back side” impact of the half-carcass

#### 3.3.1. For HDPE

In figure 10 is presented the equivalent stress state over von Mises criterion for HDPE half-carcass to “Drop test”.



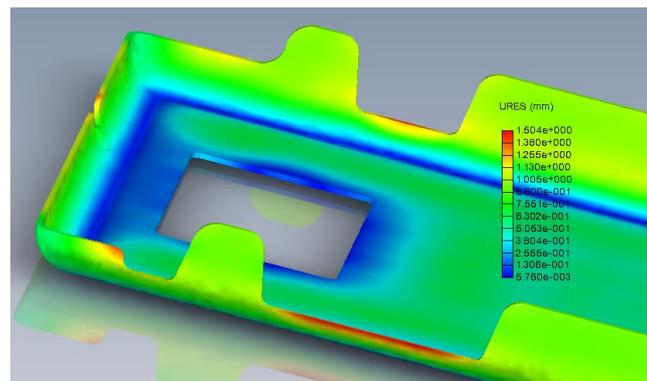
**Figure 10.** (a) Stress state for “Drop test” on the “back side “ of HDPE half-carcass. (b) maximum stress detail.

As indicated the figure 10(b), maximum stress of 85.1 MPa was located in the corners of the half-carcass with higher cropping. On the ribs from the back side of half-carcass high stresses are located. Maximum stress is with 28.8% smaller than the “head” impact.

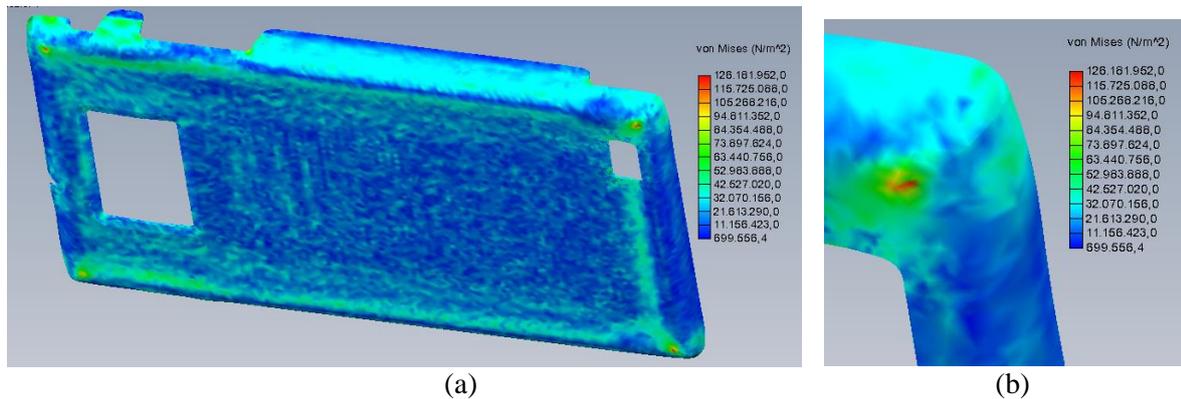
The state of deformation is shown in figure 11. The maximum impact deflections are located in the edges of the half-carcass recesses. The biggest release presents the maximum deformation of 1.5 mm. Increasing the maximum deformation in relation to that of the impact of “head” is with 21.95%.

#### 3.3.2. For Arboform

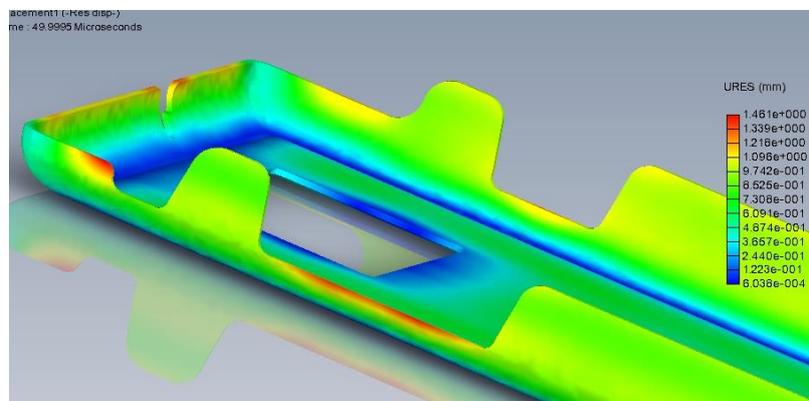
For the Arboform half-carcass case the state of deformation is shown in figure 12. The maximum stress (126.2 Mpa) is located in the half-carcass corner area (figure 12(b)). Compared to the HDPE case, maximum stress for Arboform is higher by 48.3%.



**Figure 11.** Deflection state for “Drop test” on the “back side” of HDPE half-carcass.



**Figure 12.** (a) Stress state for “Drop test” on the “back side” of Arboform half-carcass. (b) maximum stress detail.



**Figure 13.** Deflection state for “Drop test” on the “back side” of Arboform half-carcass.

Deflection state for “back side” impact of Arboform half-carcass is given in figure 13. The maximum displacement is 1.46 mm, which is lower by 2.6% compared to the HDPE case.

#### 4. Conclusions

To reduce the impact of plastic waste (based on petroleum products) on the environment, there is a tendency to replace them with biodegradable materials. Concerns in this area are manifested mainly on consumer products with a relatively low life cycle because, they generate a huge amount of waste. Among these are mobile phones parts. Most of these phones have carcasses made of plastics.

Arboform is a biodegradable material made from lignin, a component of wood and woody plants. The properties posed by this material recommend it as a potential substitute for plastics in the mobile phones carcasses manufacture. For this purpose are imposed research regarding the behavior of various Arboform tests faced by mobile phones.

A accidental test at which can be subjected a mobile phone is the impact with a plan. To verify this, the so-called Drop test is made. It can be performed under real conditions or numerical simulation by using specialized finite element packages.

In the study was performed a numerical simulation of the half-carcass mobile phone impact with a plan using SolidWorks software package. It was considered a half-carcass made from HDPE and, respectively Arboform. The “drop test” was performed in three circumstances depending on the side that hits the plan: “head”, “corner” and the “back side” of the half-carcass.

Compared for the two materials used were monitored/ followed maximum values of stress and deformations and also their localization on the half-carcass.

Simulations have shown for all three cases a maximum stress increase when Arboform was used, towards to use of HDPE when the “head” impact, respectively the “corner” impact is with 93% bigger and only 48.77% on the “back side” impact.

In case of maximum displacement, this one increase with 4% for Arboform half-carcass for “head” impact and 6% for “corner” impact, but decrease with 2.7% for the “back side” impact of the half-carcass.

The significant increase of stress can be attributed to the higher density of Arboform toward to HDPE, which led to different weights of the two half-carcasses. In case of assembled phones, the difference in weight between the two solutions, HDPE vs Arboform, is reduced and is expected an impact behavior better of the Arboform half-carcass.

Simulation models closer to the real part is a solution but that leads to important consumer of computer resources and time. Another solution that would save time and computer resources is the location on specific area on the body half-carcass of masses (weights) to replace the phone's electronic components/elements.

## References

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