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SIMULATION WITH CATIA A FIBRE REINFORCED, COMPOSITE MATERIALS

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Abstract : *The paper aims at presenting the critical analysis of some fiber reinforced composite materials used in the construction of different equipments, using finite element method, in order to prove their benefits by comparison to classical materials . For properties such as elastic modulus, this is appropriate. Even though there may be variations from point to point at very small scales, these will average out over the volume at which typical engineering tests are carried out.*
Keywords : *glass fiber**,** fiber reinforced, composite material, tank*

1. INTRODUCTION

Most of the composite materials consist of at least two components: a compact material called “matrix” and a reinforcing component, usually fibers. The matrix includes the fibers, which are acting in order to raise the material stiffness.
The possible combinations that lead to the obtaining of various types of composite materials.

The mechanical properties of these materials are mainly depending on the fibers orientation and also on the lamina positioning. Some of the types of fibers used in most of our applications are presented in figure. 2 – 5.

Figure.1

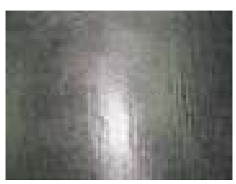


Figure.2

Figure.3

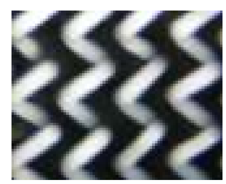


Figure.4

Figure.1 – short glass fibers not included in matrix, Figure.2 – carbon fiber in matrix, Figure.3 – rowing weaving, Figure.4 – multiple fibers weaving

2. PROPERTIES OF FIBER REINFORCED MATERIALS

It is a well-known fact that the composite materials have outstanding mechanical properties but the choice of the material for a certain purpose should match the designing requirements.
The components are combined in such way that the new material acquires some properties, necessary for a certain type of application.
When a composite structure is subjected to traction and compression loads, it usually changes its shape along two directions: longitudinal (along the load line of action) and transversal (perpendicular to the load line of action).The Poisson coefficient represents the ratio of the lateral and longitudinal extension.

$$\upsilon = \frac{\varepsilon_y}{\varepsilon_x} = \frac{\text{Lateral extension}}{\text{Longitudinal extension}} = \frac{\frac{\Delta d}{d}}{\frac{\Delta l}{l}}$$

The values of the Poisson coefficient for different types of materials.

The resistance of a fiber reinforced composite material is usually studied by help of some breaking criteria empirically determined or experimentally determined. The most used criteria are:

- Criterion of maximum tension – according to this criterion, a body subjected to tensions is giving in if one of the components $\sigma_{\|}$, $\sigma_{\perp}$ or σ_z reaches the critical value, in case of traction – compression loads.

$$\sigma_{II} = \sigma_{II\ traction/compression_{\lim}} \quad (2.2)$$

$$\sigma_{\perp} = \sigma_{\perp\ traction/compression \lim it},$$

$$\tau_{\#} = \tau_{\ shearing \lim it}$$

- Criterion of maximum extension, whose equations are given by

$$\varepsilon_{II} = \varepsilon_{II\ Traction/compression \lim it}, \quad (2.3)$$

$$\varepsilon_{\perp} = \varepsilon_{\perp\ traction/compression \lim it},$$

$$\gamma_{\#} = \gamma_{\ shearing \lim it},$$

The bending resistance of a fiber reinforced polymeric composite material depends on the environmental conditions like temperature and humidity, and on the resistance of each lamina.
There are two important properties that characterize the bending of a material:
- the bending resistance – representing the maximum bending tension in the external fibers of a proof sample during the breaking
- the bending elasticity modulus – representing the ratio between the tension and bending, within the elasticity limit, ratio determined by bending

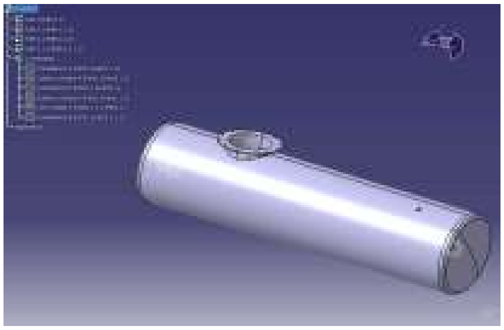
As the theoretical relations are either empirically determined or experimentally assessed, the most accurate way of testing the resistance of the composite material is to simulate its properties using suitable software. Of course, this should be followed by experimental tests on proof samples.
In order to test the resistance of the composite material used in a practical application (a storage tank for additives), we used a finite element program (ANSYS) to simulate the constraints, the loads and the material properties.
Finite element analysis using ANSYS provides a very useful tool in simulating the properties of various materials, starting from metal to rubber, but also for combined materials such as composite materials. This way the cost of the products will be less and the design more reliable.

3. PRACTICAL APPLICATION ON AN ADDITIVE STORAGE TANK

The companies manufacturing composite materials need to store important amounts of additives, which usually are dangerous for the environment, so the storage facilities should be safe and resistant both to mechanical stress and all kind of environmental conditions.
The research team designed using CATIA a storage tank for the additives used in a local manufacturing company.(figure.5)

Figure.5

The material we used consists of non-woven glass fibers impregnated with non-saturated ortophtalic resin.
It consists of a cylinder, two lids at the ends of the cylinder, a ventilation hole and a supply pipe. (figure.6)



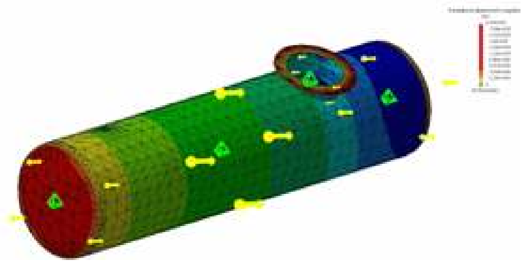


Figure.7

Figure.6

The blue areas mean that the efforts in the composite material are not very significant, the green ones mean moderate efforts, while the yellow and red ones indicate strong solicitations in the respective areas.
A very good indication is given also by the triangular finite elements that change their shape in the areas where the deformations are more significant.
Observations of a size effect on tensile strength go back a long time. Another issue is whether the properties are affected by differences in the cure process.As the thickness increases, differences in heat transfer and the effect of exotherms produce nonuniformities of temperature and degree of cure. Residual stresses are also set up due to different rates of curing through the thickness.

4. CONCLUSION

Analyzing the results obtained in the previous paragraph, by help of the simulation using the finite element method, we may conclude the following:

- The efforts are higher in the areas of connection between the components of the tank (the lids, the ventilation hole)
- The deformations are also higher in the same areas and also around the supply pipe where the screw coupling between it and the cylinder produces high deformations of the material.

These lead us to the conclusion that the weak parts of such an assembly are the connections with the cylinder of the components, which makes us think for the future to the possibility of manufacturing the tank in one piece. The possibility may be also studied from the point of view of deformations and efforts.Also the composite material behaves very well in different conditions of humidity and temperature, without affecting its resistance and structure.
There are large size effects for matrix-dominated failures. Strength is controlled by defects, especially voids and machining damage during specimen preparation.

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