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CONSTRUCTIVE SOLUTION, USING FINITE ELEMENT METHOD, FOR OPTIMIZATION STRUCTURE OF COMPOSITE MATERIALS

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Abstract: *The paper presents a theoretical approach regarding the mechanical behavior of glass fabric reinforced composite for liquid storage tank. The internal stress and deformation field is locally influenced by the relative difference between the constituents' properties, their size, shape and relative orientation as well as by the geometry of the repeating structures that form the composite material*
Keywords: *finite element method, layers, stress.*

1. INTRODUCTION

Finite element method (FEM) becomes more and more a general method used for solving different types of complex problems concerning both stationary and non-stationary phenomena from all engineering fields but also in other activity and research areas.
As far as the stress and deformation are concerned we may observe that the internal mechanical work is linked to three components of the stress in 2D coordinates, the normal plane component of the stress does not involve the canceling of other strains or stresses.
From mathematical point of view, the problem is very similar to that of plane stress and deformation analysis, this is why the situation may be regarded as two dimensional.
In order to control the complexity of the problem and "filter" the irrelevant aspects we need to accomplish a suitable mathematical model. This model should consider the fact that we are dealing with an anisotropic material, consisting of several layers and also that the loads and deformations along the contours are difficult to be obtained.

2. MATHEMATICAL MODELLING WITH FEM

The main part of the process is, as shown in the diagram, the mathematical model. This is mostly an ordinary equation or a differential one, developed in space and time. A discrete model with finite elements is generated by help of the variation form of the mathematical model. This stage is called meshing. The FEM equations are solved using an equation solver that will provide a discrete solution.
More relevant are the meshing errors, representing the extent to which the discrete solution does not check the mathematical model. The replacement in the ideal physical system might identify the modeling errors.
Then the model will be analyzed by help of MSC Nastran processor but before running the file we need to do some previous checking in order to validate the finite elements model, as follows:

- determination of the distance between two locations or nodes;
- determination of the angle between two directions determined by three point, one of them being considered as origin;
- identification of common points;
- identification of common lines;
- identification of common nodes and joining them;
- identification of nodes belonging to a selected plane, with the possibility of moving to this plane of the nodes from the adjacent area;

- identification of the common finite elements;
- determination of a finite element distortions;
- identification of the normal in a plane finite elements group and comparing them to a given direction;
- determination of mass properties for the finite elements;
- checking the geometric boundary conditions;
- determination of the loading forces sum in a node.

3. FEM ANALYSIS FOR LIQUID STORAGE TANK

The paper presents a theoretical approach regarding the mechanical behavior of glass fabric reinforced composite for liquid storage tank.
The model was achieved using MSC Patran preprocessor/postprocessor and MSC Nastran processor. In the preprocessing stage, the finite elements geometric modeling requires the finite element model, which will be finally solvable by help of the programs kit meant for this purpose.
A finite element modeling requires the material behavior modeling, selection and personalization of finite elements, finite elements structure generation, introduction of boundary conditions and loads.
The analysis and solution of the finite element model, elaborated during preprocessing requires the preliminary setting of the solving parameters and the execution of the specific program modules.
The geometric modeling previous the meshing requires the generation of closed contours consisting of lines for plane areas or surfaces. In figure 1 we presented the detailed model geometry.

Figure 1: Geometric model of the liquid storage tank

According to standards the water density is of 1000 kg/ m^3. Considering a safety factor of 1,25 the water density used in calculus is of 1250 kg/ m^3. The pressure was determined upon the 5 sectors obtained after model meshing, taking into account the length of each sector and the water volume.
The output data corresponding to the nodes, usually include the problem unknowns, like displacements, temperatures, pressures, velocities.
The output data corresponding to the finite elements are different from one element to another, for example the internal forces, strains, deformation energy.
The structure is made of 8 different layers as shown in Table 1, the arrow representing the succession of the layers starting from the interior towards the exterior of the structure.

Table 1: Succession of material layers

Layers direction	*Layer(Ply)*	*Material type*
Inferior side	1	MAT600
	2	MAT600
	3	RT800
	4	RT800
	5	RT800
	6	RT800
Superior side	7	MAT450
	8	MAT450

The structure is made of 5 different layers as shown in Table 2, the arrow representing the succession of the layers starting from the interior towards the exterior of the better structure.

Table 2: Succession of material layers

Layers direction	*Layer(Ply)*	*Material type*
Inferior side	1	MAT600
	2	RT800
	3	RT800
	4	RT800
Superior side	5	MAT450

In figure 7 and 8 is presented the maximum Von Misses stress distribution for all layers

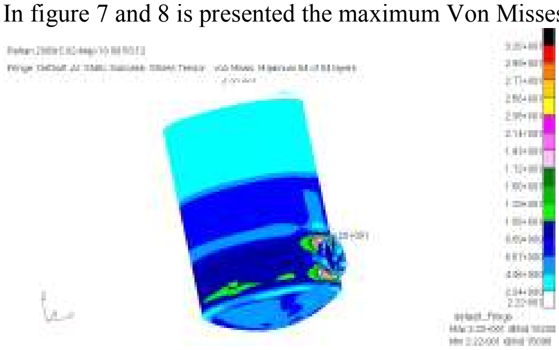

Figure 2: The maximum Von Misses stress distribution for 8 layers, MAT-Roving material

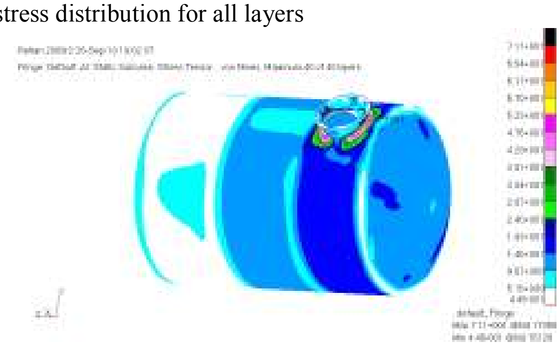

Figure 3: The maximum Von Misses stress distribution for 5 layers, MAT-Roving material

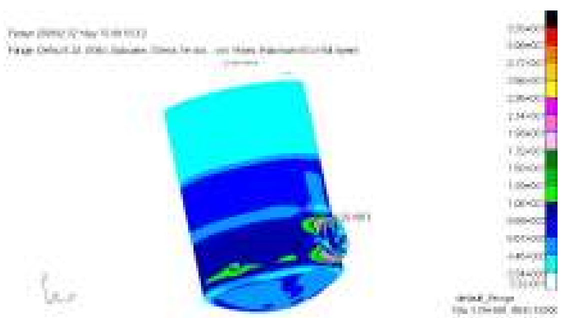

Figure 4: The maximum Von Misses stress distribution for 8 layers, Roving material

In figure 9 and 10 is presented the maximum stress distribution on all layers for X axis

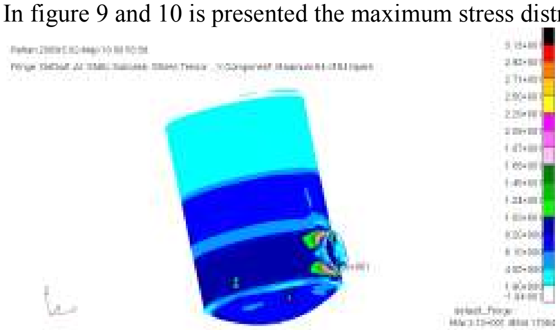

Figure 5: The maximum stress distribution on 8 layers for X axis, MAT-Roving material

Figure 6: The maximum stress distribution on 5 layers for X axis, MAT-Roving material

In figure 11 and 12 is presented the maximum stress distribution on all layers for Y axis

Figure 7: The maximum stress distribution on 8 layers for Y axis, MAT-Roving material

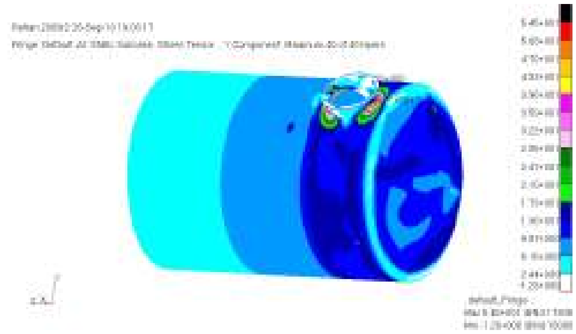

Figure 8 : The maximum stress distribution on 5 layers for Y axis, MAT-Roving material

There was obtained a MAT-Roving optimized material with 5-layers, canceling from each type of material one layer from first model realized, where the maximum stress is 40% higher.

Table 3: The maximum stress for all composite materials used

Nr. Crt.	Composite materials	The maximum stress for X axis (σ_x), *MPa*	The maximum stress for Y axis (σ_x), *MPa*	The maximum stress von Mises ($\sigma_{ech\ V}$), *MPa*
1	MAT-Roving 8 layers	42.8	29.4	46.9
2	Roving 8 layers	31.3	21.1	32
3	MAT-Roving 5 layers	**69**	**54.5**	**71.1**

Following the experimental researches and also the studies based on FEM we conclude that the material thickness is oversized.
In this respect we decided that we may reduce the number of layers from 8 to 5, namely we may give up to one of each type of material.

4. CONCLUSION

MAT type material resists much better to the applied loads (considering all directions), the values are smaller in comparison to the efforts occurred in the roving.
This leads to costs diminishing, weight loss and not last to less exposure of the working personnel to toxic wastes.

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