MECHANICAL STRESS SIMULATION OF THE EXPLOSION-PROOF ENCAPSULATION WITH CYLINDRICAL FRAME

DANIELA PEAGU (FURDUI)[1], FLORIN DUMITRU POPESCU[2], ANDREI ANDRAŞ [3]

Abstract: The maximum internal pressure developed during the ignition of the explosive mixture with air within the encapsulation is directly dependent on the volume released through clearances or other discharge devices, if present. Consequently, the increase in explosion pressure must be correlated with the study of explosion-proof joints to prevent the transmission of the explosion through clearances to the ambient atmosphere. Through a comparison of defects observed during dynamic explosion tests and checks with static overpressure, a safety factor simulating the explosion demands has been identified. By checking the static overpressure at a certain pressure increase factor, the encapsulations are no less stressed than during an explosion. It has been determined that an overpressure increase factor of 1.5 times above the maximum reference explosion pressure value, during hydrostatic testing, ensures the mechanical stress of the encapsulation equivalent to the stresses resulting from overpressure through explosion. This paper presents the mechanical stress simulation of the explosion-proof encapsulation with a cylindrical frame using the SOLIDWORKS application.

Keywords: explosion-proof encapsulation, pressure, assembly, von Mises stress, deformation

1. THE MECHANICAL CALCULATION OF EXPLOSION-PROOF ENCAPSULATION

Experimental findings have established that the internal explosion pressure is dependent on the volume of the encapsulation and the components of the explosive mixture. As the encapsulation volume decreases, the explosion pressure decreases due to the increased cooling surface per unit volume of the encapsulation. When ignited by

[1] *Ph.D. student, University of Petroşani, danafurdui2012@yahoo.com*
[2] *Professor, Ph.D. Eng., University of Petroşani, fpopescu@gmail.com*
[3] *Professor, Ph.D. Eng., University of Petroşani, andrei.andras@gmail.com*

a spark of limited power, the explosion pressure is found to be within the range of 0.3 - 1.0 MN/m^2 according to Table 1.

Table 1. **Design pressures and test pressures for explosion-proof encapsulations**

The explosive mixture category	The design pressure and test pressure magnitude (MN/m^2) at the free volume of the encapsulation		
	Up to 0,5 l	over 0,51 – up to 2 l	over 2 I
1 (Gr.l)	0,3	0,8	0,8
2(Gr.llA)	0,4	0,8	1,0
3(Gr.llB)	0,4	0,8	1,0
4(Gr.llC)	0,6	0,8	1,0

The main components of explosion-proof encapsulations are the cylindrical frame and the circular or planar bottom. The dimensions of the frame (volume and diameter) typically depend on the dimensions of the electrical elements or subassemblies of the machine or apparatus subject to encapsulation assembly (Figure 1).

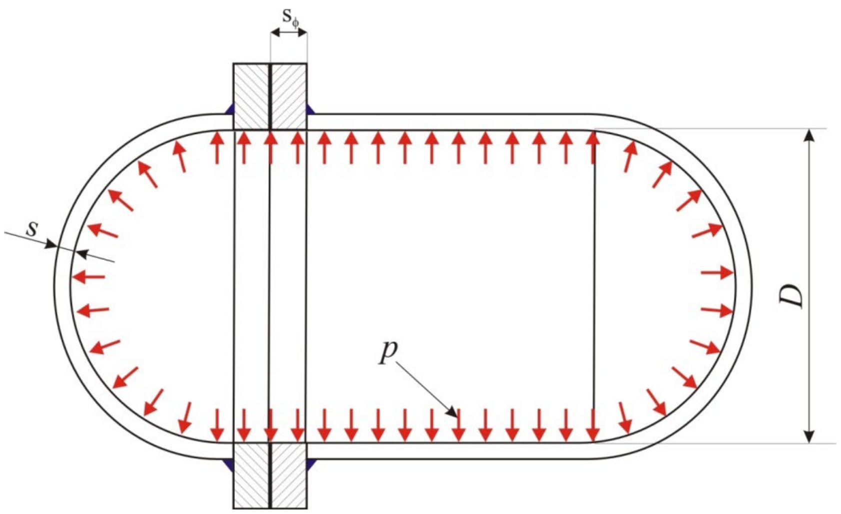


Fig.1 Example of explosion-proof encapsulation (cylindrical frame)

2. CONSTRUCTING THE MODEL OF THE EXPLOSION-PROOF ENCAPSULATION WITH CYLINDRICAL FRAME

The simulation of the mechanical stress on the encapsulations was carried out using the SOLIDWORKS application through the `Simulation` menu. Initially, an assembly was constructed based on Fig. 1, the dimension of which are presented in Figure 2.

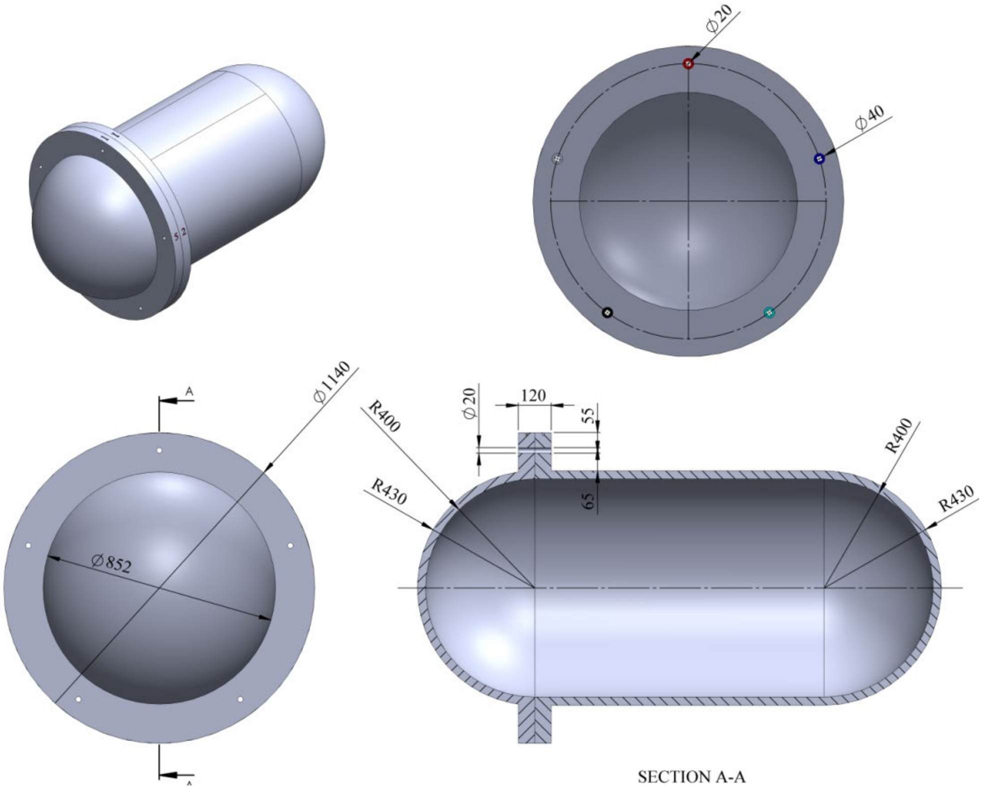


Fig.2 The dimensional specifications of the model subjected to simulation

Using concentricity and coincidence constraints, we created the model shown in Figure 3. It's important to note that coincidence constraints were established between the areas with a diameter of 40 mm from Figure 2. These constraints simulate the fastening of the two parts of the explosion proof encapsulation with screws.

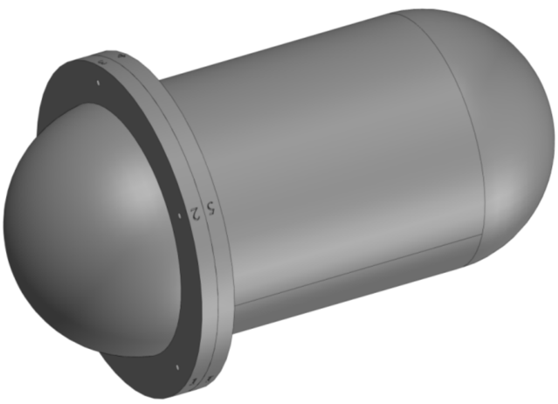


Fig.3 The model subjected to simulation

3. THE SIMULATION UNDER MECHANICAL (PRESSURE) LOADING OF THE MODEL

In accordance with Figure 4, we assigned the alloy steel material to the two parts of the assembly (`Alloy Steel`).

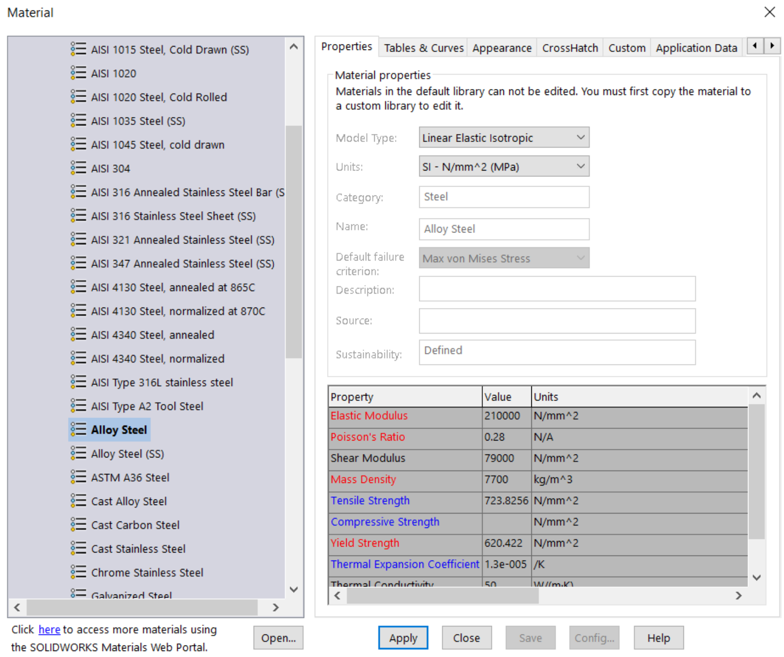


Fig.4 The assignment and properties of the assembly

In Fig. 5, we displayed the fixed elements of the assembly, while in Figure 6, the applied load (pressure) acts uniformly on the interior walls of the assembly. The pressure value is $p=1\times10^6$ [N/m^2].

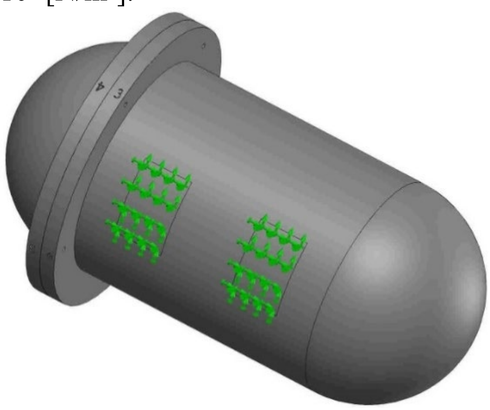


Fig.5 The fixed element of the model

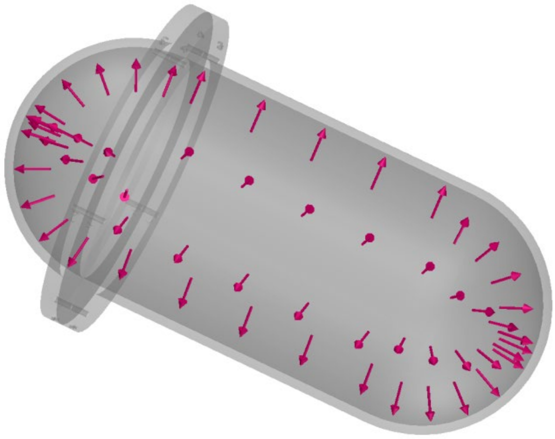
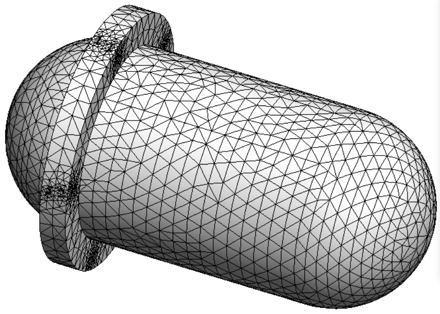


Fig.6 The loading on the interior walls of the model

Figure 7 depicts the finite element mesh and its characteristics.



Mesh Details

Study name	Static 1 (-Default-)
Mesh type	Solid Mesh
Mesher Used	Curvature-based mesh
Jacobian points	4 points
Max Element Size	69.1034 mm
Min Element Size	13.8207 mm
Mesh quality	High
Total nodes	38773
Total elements	23133
Maximum Aspect Ratio	21.861
Percentage of elements with Aspect Ratio < 3	94.6
Percentage of elements with Aspect Ratio > 10	0.225
% of distorted elements (Jacobian)	0
Remesh failed parts with incompatible mesh	Off
Time to complete mesh(hh:mm:ss)	00:00:02
Computer name	LAPTOPDIMIT

Fig.7 The finite element mesh and its characteristics

Figure 8 depicts the variation of von Mises stress following the calculations.

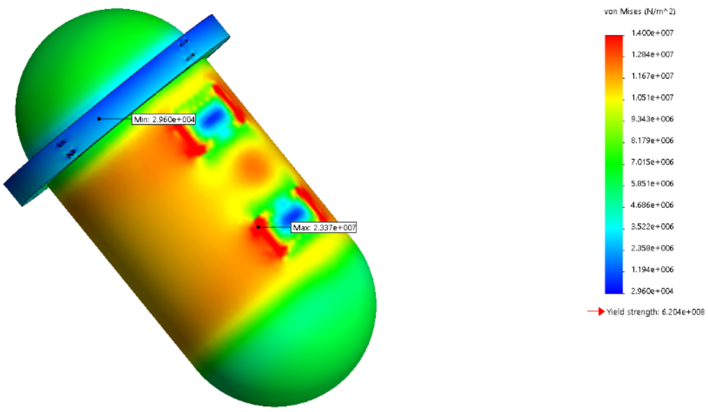


Fig.8 The spatial representation of von Misses stress variation

It can be observed that for the simulated model, the von Mises stress does not exceed the yield stress of the material from which the assembly is constructed, and the maximum value is localized near the attachment point of the explosion-proof encapsulation.

To obtain a clearer view of the von Misses stress distribution, we represented the variation of this quantity using the `Plot Tools` → `Section Clipping` as seen in Fig. 9, where the clipping plane is frontal.

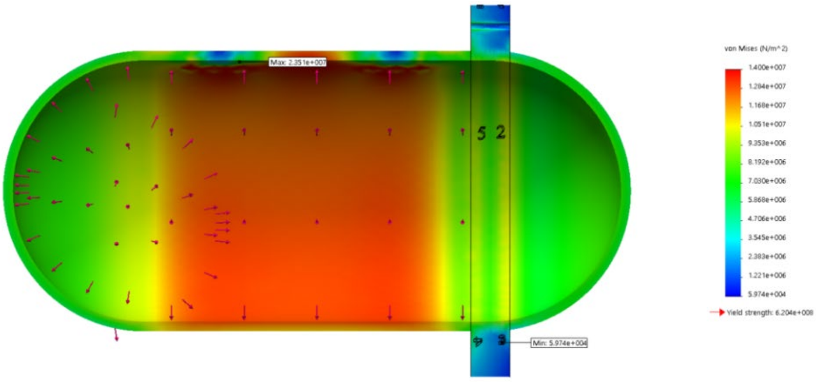


Fig.9 The variation of von Misses stress – representation in section according to the frontal plane

The deformation of the explosion-proof casing with the `Deformed Shape` is represented in Fig.10. It can be observed that the minimum deformation is in the area of the casing attachment, while the maximum deformation is in the diametrically opposite zone. The maximum deformation value is 0,032 mm.

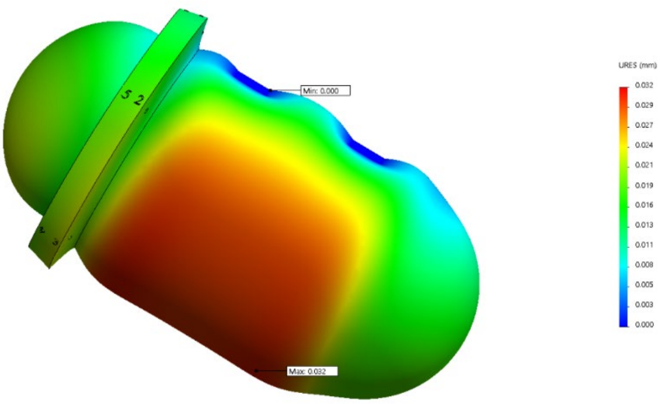


Fig.10 The spatial representation of the deformation of the model subjected to simulation

Similar to the von Misses stress, the variation of deformation has been represented in a section according to the frontal plane, as shown in Fig. 11.

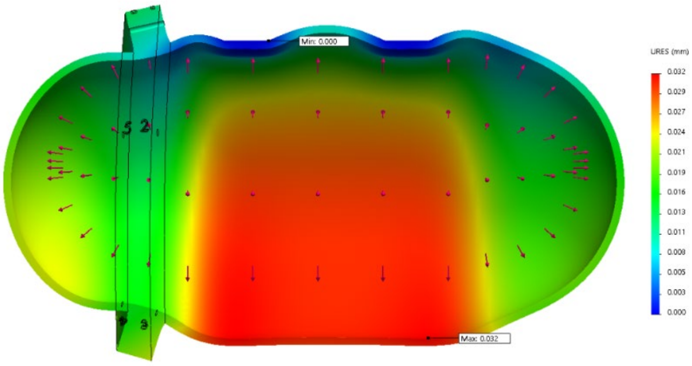


Fig.11 The deformation of the model subjected to simulation – representation

In Fig.12 and 13, the variation of the safety factor is presented.

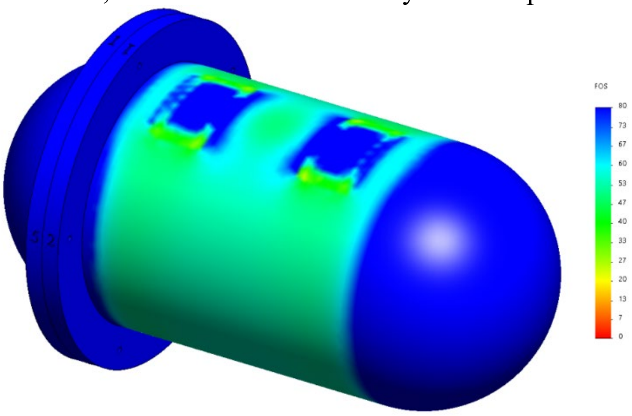


Fig.12 Safety Factor- Spatial representation

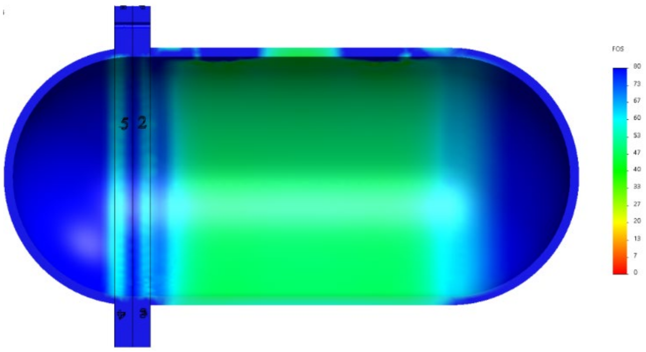


Fig.13 Safety Factor – Representation in section according to the frontal plane

It can be observed that the safety factor is above unity for the entire surface of the explosion-proof encapsulation.

CONCLUSIONS

Results obtained from simulating the model of an explosion-proof encapsulation with a cylindrical frame under the pressure generated by an explosion inside, indicate maximum values of von Mises stress and deformation on the diametrically opposite side of the attachment zone. The simulation highlighted that the von Mises stress has low values in the contact surface zone of the two component parts of the assembly, leading to the conclusion that the explosion inside the analyzed model does not propagate towards the potentially explosive environment surrounding the casing.

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