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ABOUT FAILURE OF THE LPG TANK FASTENING WELDS ON THE CHASSIS OF TRUCKS

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Rezumat

Transportul rutier internaţional al mărfurilor periculoase se desfasoară sub incidenţa unor reglementări stricte. Realităţile din trafic şi experienţele acumulate ca urmare a inspecţiilor periodice asupra echipamentelor specifice (cisterne) conduc la permanenta actualizare şi imbunataţire ale acestora. Prezentul articol abordează un studiu referitor la apariţia în timp a unor fisuri ale imbinărilor sudate dintre cisternă şi suporţii de prindere pe şasiul camionului.

Cuvinte cheie:cisterna auto, îmbinări sudate, Metoda Elementului Finit

Abstract

The international road transport of dangerous goods is subject to strict regulations. Traffic realities and experiences accumulated as a result of periodic inspections of specific equipment (tanks) lead to their constant updating and improvement. This article is focused to a study related to the appearance over time of some cracks in the welded joints between the tank and the mounting supports on the truck chassis.

Keywords:truck tank, welded joints, Finite Element Analysis

1. INTRODUCTION

International carriage of dangerous goods by road is subject to an agreement (ADR) issued by the United Nations Organization (for Europe being issued by the United Nations Economic Commission for Europe – Committee for inland transport. This agreement includes both provisions relating to the packaging of dangerous goods, the use and operation of tankers, marking and signaling, transport documents, and the requirements for design, execution, etc., testing and periodic checking of tankers [ADR}.

As a result of the mandatory periodic inspections carried out by the competent authorities and bodies have been highlighted, and not infrequently, the occurrence of failed (cracks and even tears) of welded joints between the tanker body and the chassis mounts, which is totally unacceptable and dangerous in the safety of their operation (figure.1).

Figure 1 Examples of failures (cracks and breaks) in the tank supports

They require repair operations based on approved designs and by companies that have authorized personnel for such operations. These lead to results (Figure 2) that will require specific monitoring in the future.

a)

b)

Figure 2. Tank a) with broken and repaired support b) support repaired after breaking the joint

Starting from these facts and based on the experience gained by the team members during the expertise and communication of the results on similar installations (railway tanks for the transport of liquefied petroleum gases (LPG) [2], spherical storage tanks for LPG storage [3], we proposed an analysis using the finite element method on the resistance structure of such a tanker. We opted for such a theoretical analysis, as it was presented in the two mentioned works, the results of the numerical simulation were also confirmed by experimental measurements. Moreover, the method is also supported by the results reported in other works [4,5,6,7,8,9,10,11].

2. RESULTS AND DISCUSSIONS

The subject of the study is a LPG transport tank, manufactured in Italy in 2008. The main functional parameters of the tank are presented in Table 1.

Table 1 Tank parameters

1	volume	36000	l
2.	minmum working temperature	-20	^{0}C
3.	maxmum working temperature	40	^{0}C
4.	Working pressure	18	bar
5.	Test pressure	27	bar

The material from which the tank is made, according to the technical manufacturing documentation (as built), is ASA F60, and the mounting supports on the chassis are Fe 37 (structural steel).

When modeling, the smallest thickness determined by ultrasonic measurements, (9.5 mm), was taken into account.

The adopted simplifying assumptions regarding the macro construction of the tank are:

- The thickness of the tank mantle is uniform and equal to the lowest determined value, i.e. 9.5 mm

- the mantle has a unitary construction (without taking into account the welded joints cords.

For the modeling of the structure behavior, the SolidWorks 2014 work suite was used, through the specific capacities of developing the 3D model for the studied structure (two approaches), implicitly the simulation application, with the related simplified calculation scheme.

To establish some reference values of the output quantities taken into account, the first modeling option will opt for a treatment as a whole of the pressure vessel in question. Thus, it is not used for the moment the possibilities of simplification by particular calculation hypotheses of the calculation scheme. Figure 3 is represented

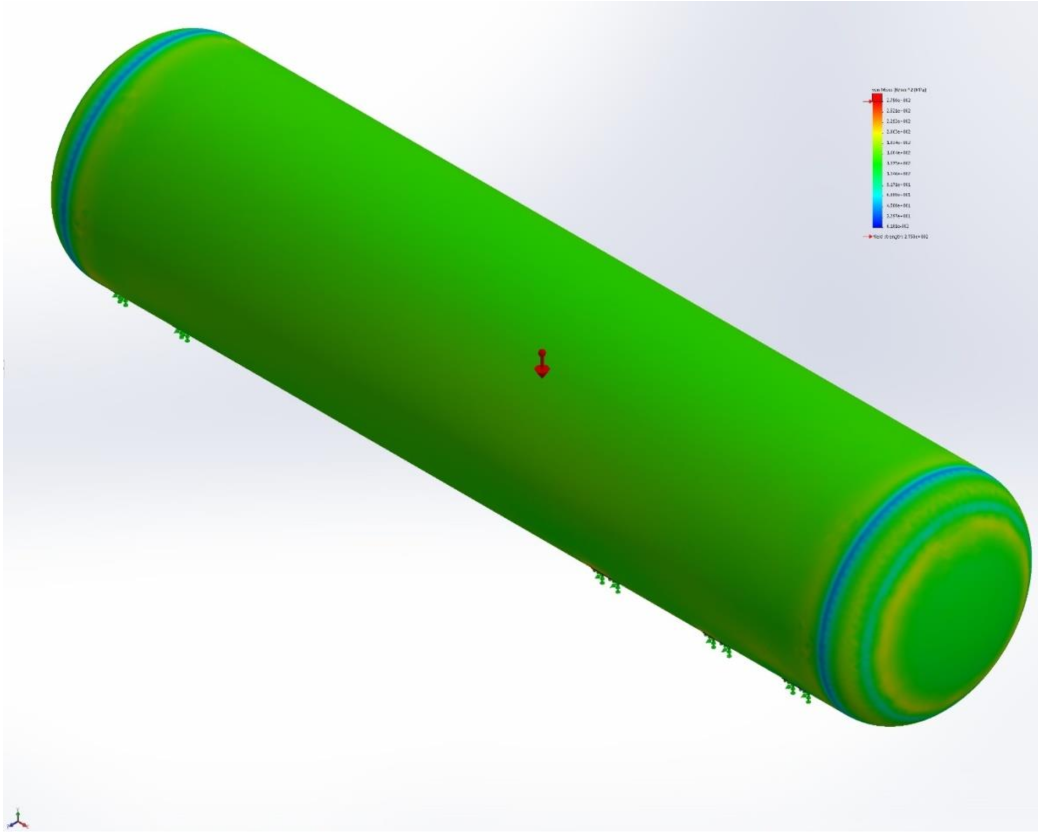
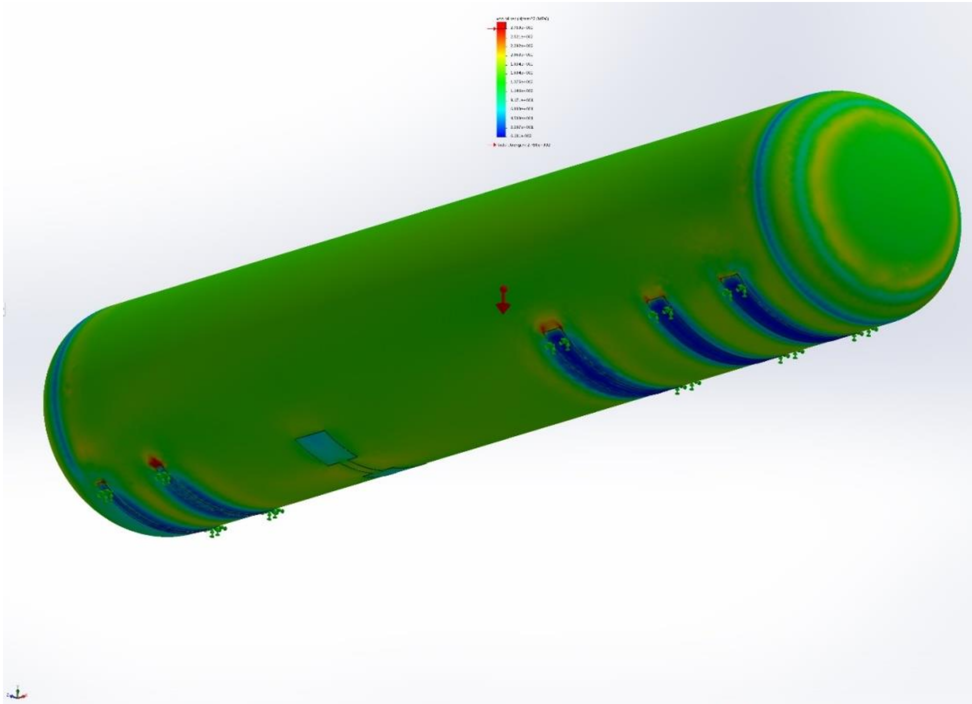
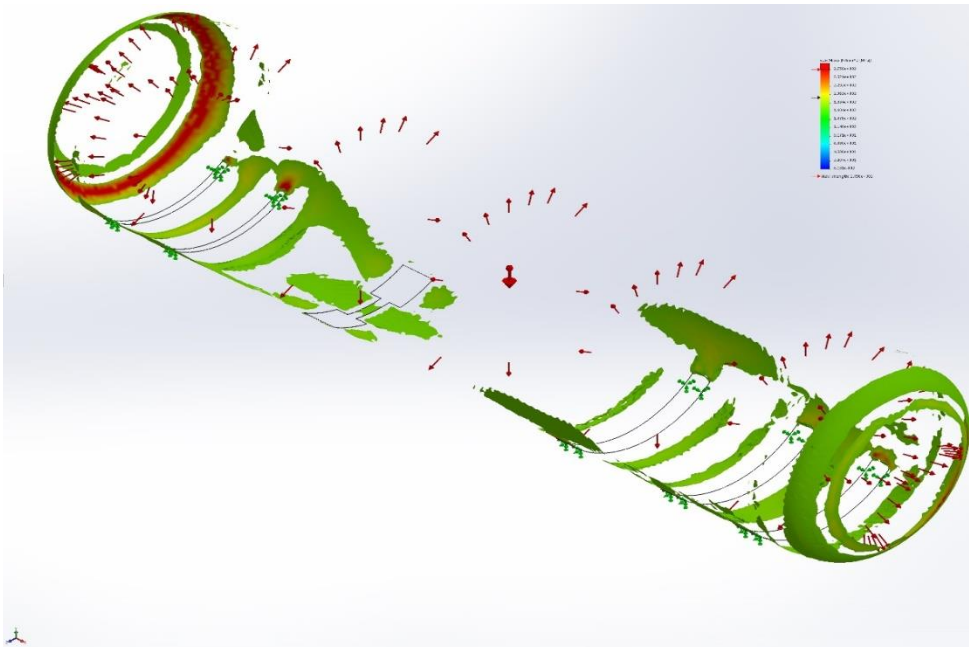


Figure 3. Full view

The overall view of this study variant includes the support scheme which is symbolized by the contact areas with the semi-trailer chassis. Areas are considered to have all degrees of freedom suppressed. The loading scheme includes the working pressure of the fluid contained in the container, the hydrostatic pressure generated by its volume (in percentage according to the regulations in force) and the own weight of the metal structure. Figure 4 shows the distribution field of the vonMises equivalent normal stresses, for the outside (fig.4a) and the inside (fig.4b) of the container.



a)



b)

Figure 4 The distribution field of the vonMises equivalent normal stresses a)outside b) inside of the tank.

For an overview of the working hypothesis addressed, figure 5 reproduces the field of the resulting displacements, as the output value of the completed simulation.

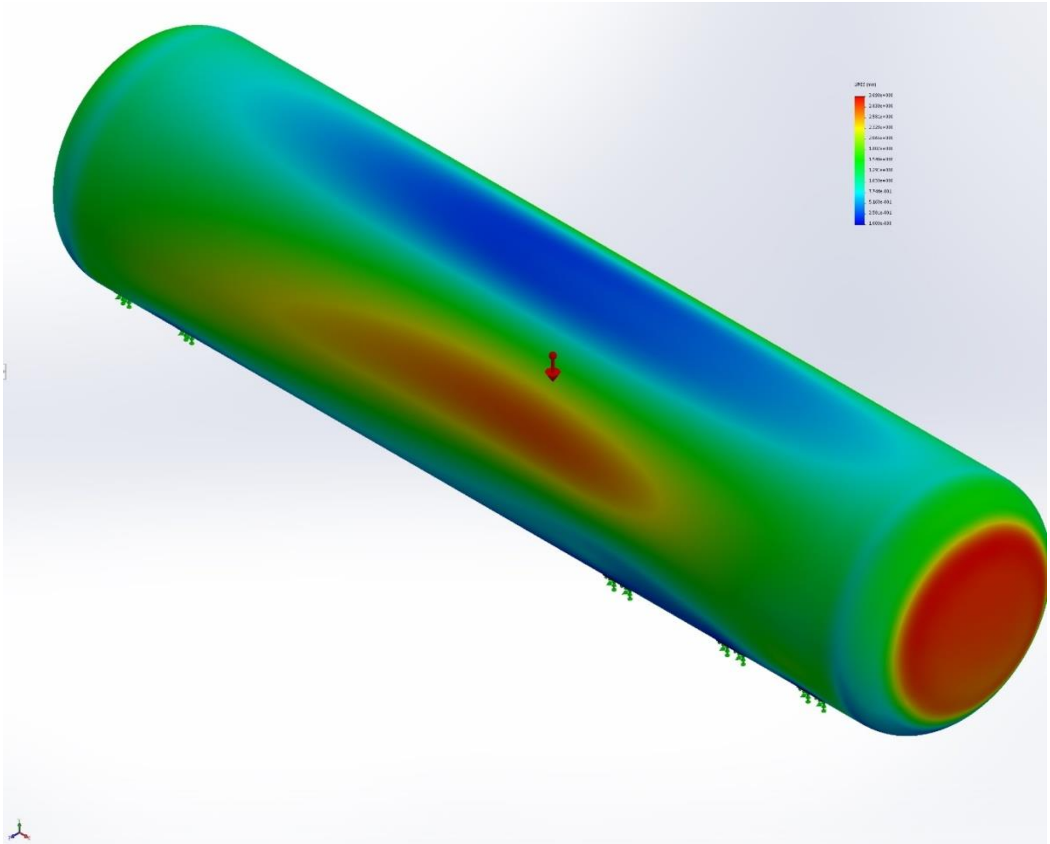
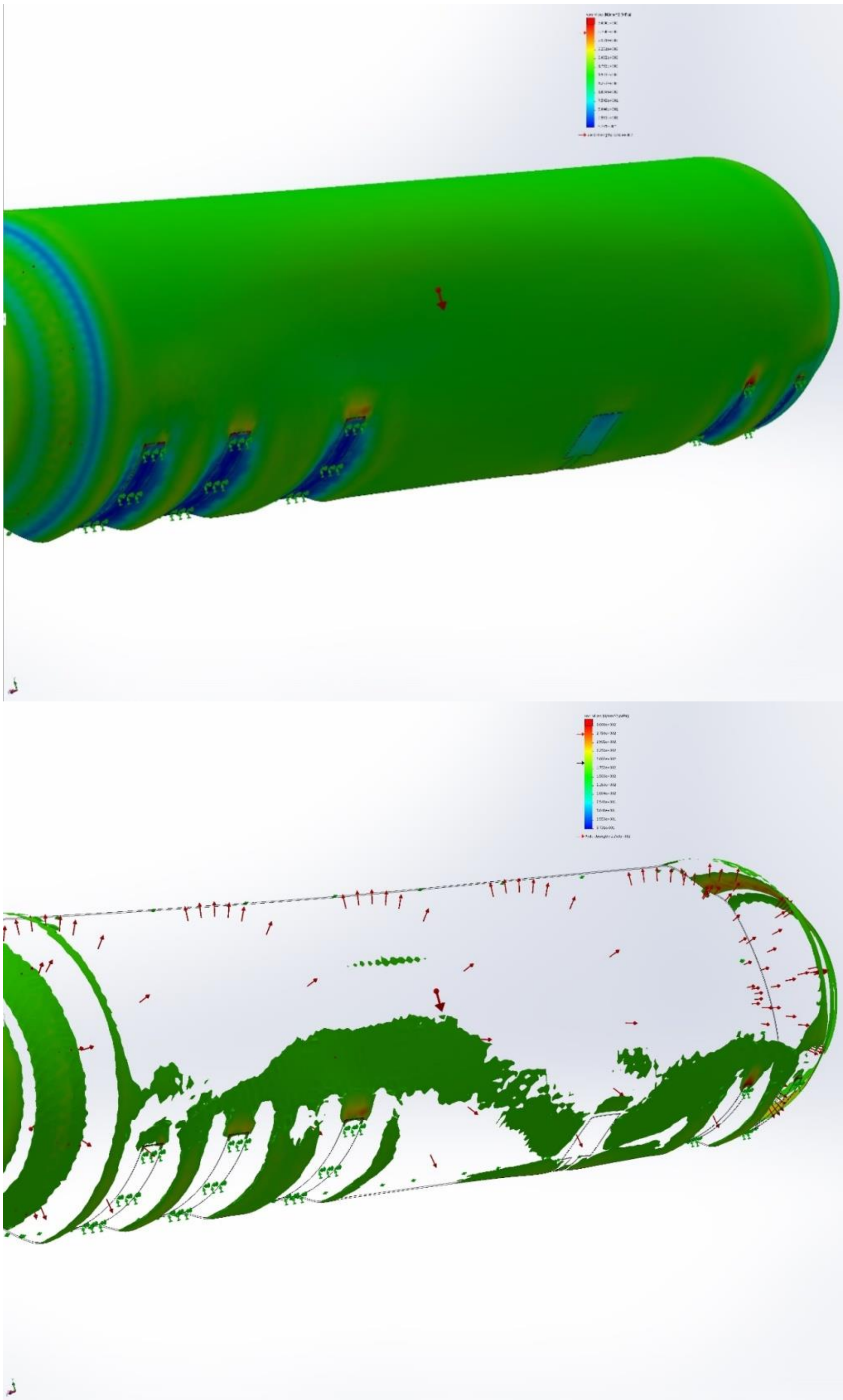
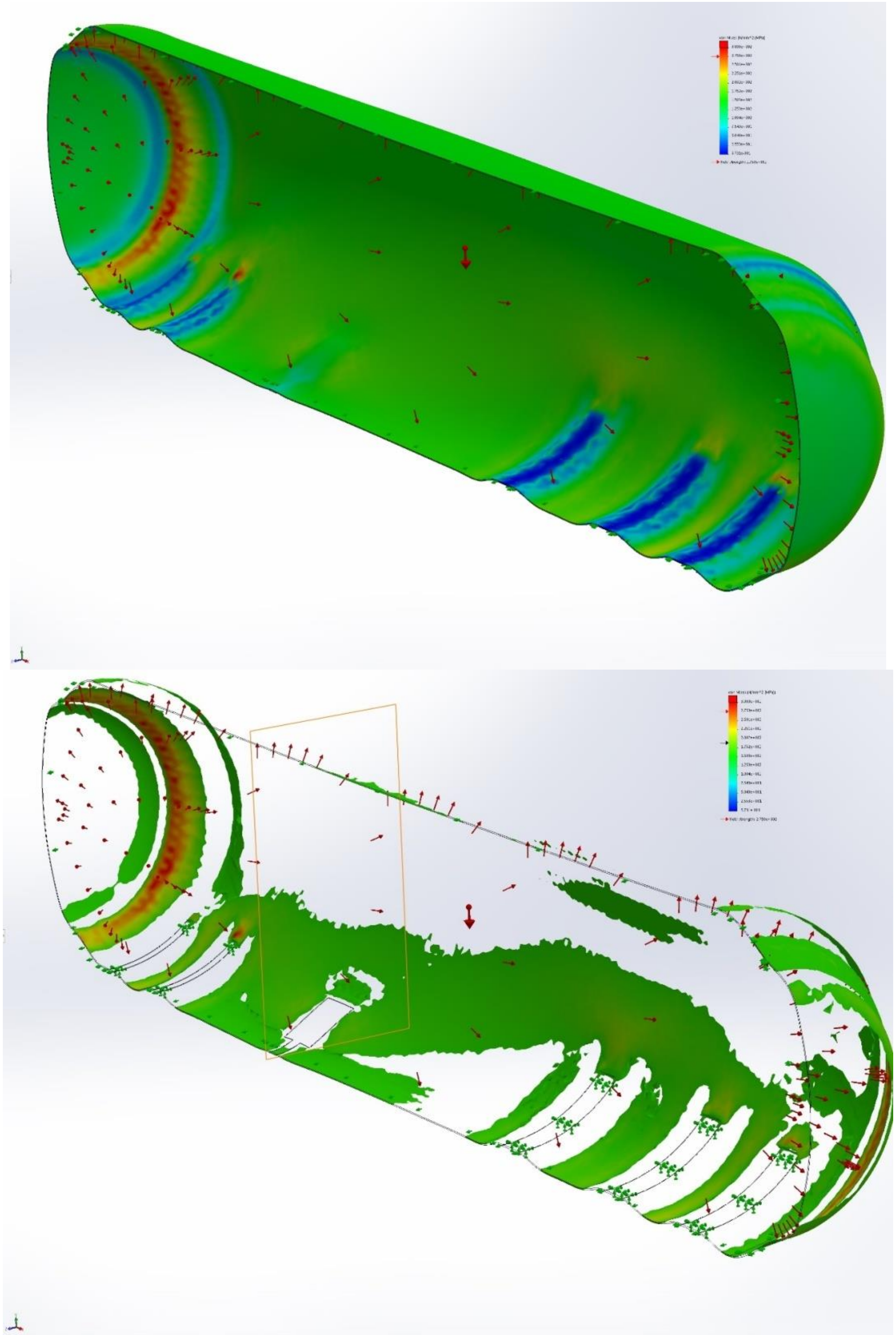


Figure 5 Displacement field distribution

Having as starting pointthe information accumulated through the use over time of the mentioned finite element calculation suite, due to the required calculation resources as well as the "resolution" of the computer hardware system available, it was necessary to investigate the accuracy of obtaining the values the output sizes of the simulation by using some computational facilities available within the suite [12]. Due to the particularities of the studied 3D model, one can only appeal to the use of symmetry towards a plane. In figure 6 the vonMises equivalent normal stresses were represented. In figure 6ª is showing vonMises equivalent normal stresses on the outside of the structure, and in figure 6b on the inside. The figures include information obtained for these two cases usingthe isolation and representation algorithm according to an established value - "iso clipping".



a)



b)

Figure 6 VonMises equivalent normal stresses distribution a)outside b) inside of the tank

Figures 7 and 8 show the output values for the field of the resultant displacement component for the simplified modeling with the help of symmetry facilities.

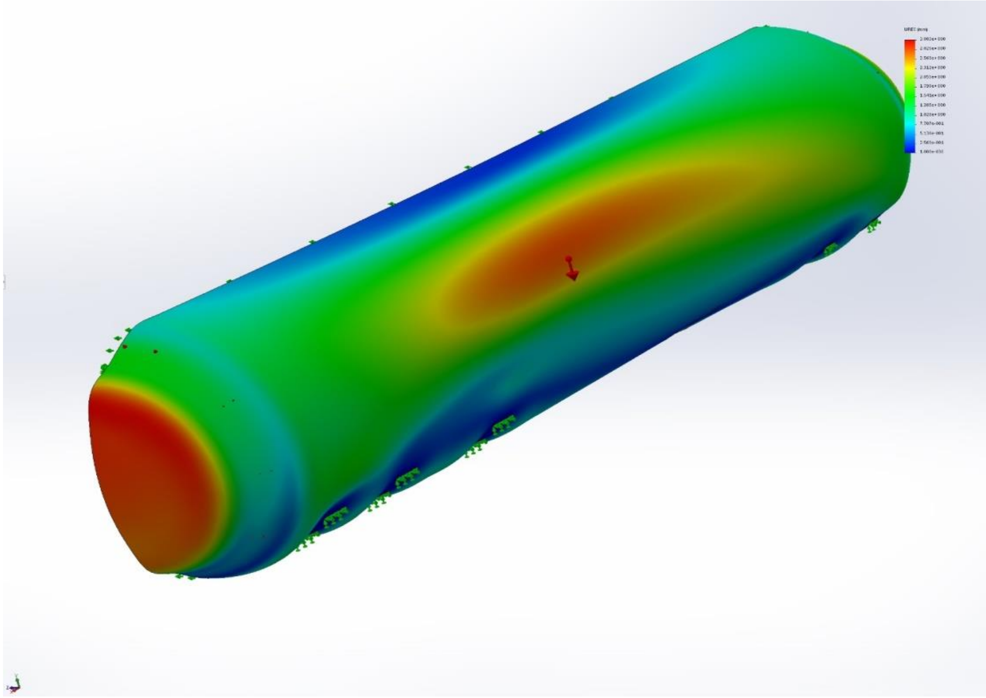


Figure 7. Displacement field distribution - outside of the tank

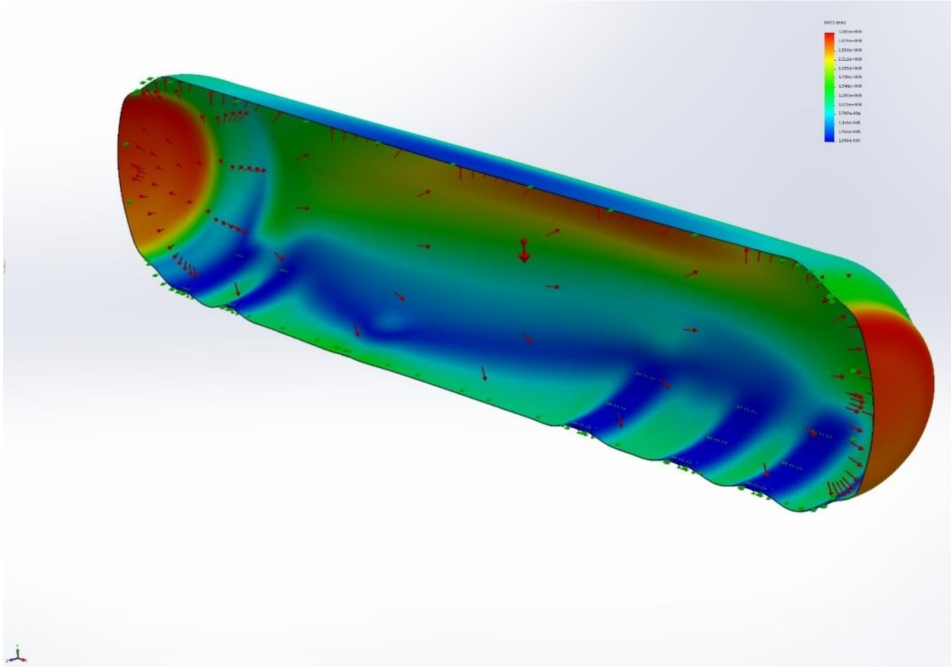


Figure 8. Displacement field distribution –inside of the tank

3. CONCLUSIONS

The analysis carried out shows that the welded joint area of the mantle with the mounting support on the truck chassis is an area with a high stress. Following the post-processing stages of the output sizes corresponding to the different work hypotheses proposed previously, the convergence of the results in terms of both the magnitude of the obtained values and the positioning of the so-called (dangerous) sections of interest is noted.

Unsurprisingly, these areas of maximum structure stress are determined by the value jumps of the geometric characteristics in the extremities of the flatbands of stiffening of the attachments at the level of the resistance structure of the trailer (figure 9), with comparable values regardless of the positioning of the reinforcements on the tank respectively.

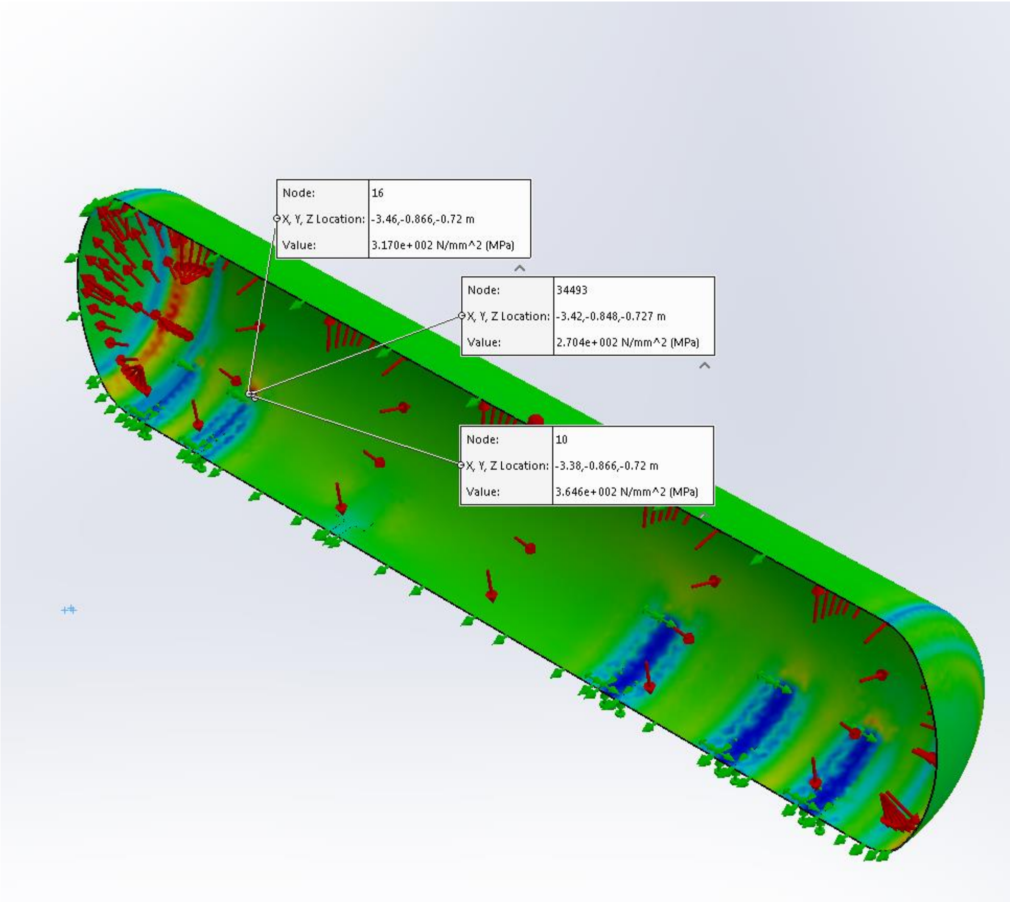


Figure 9. vonMises equivalent stress – overview

Values that exceed the maximum allowed working limit of the material are noted, with unfavorable implications both from the point of view of the static stress and of a possible study that would take into account the fatigue behavior of the material. Fatigue phenomena are caused by the variable stress cycles to which the structure is subjected.

One of the most unfavorable areas from the point of view of the output sizes obtained is shown in figure10

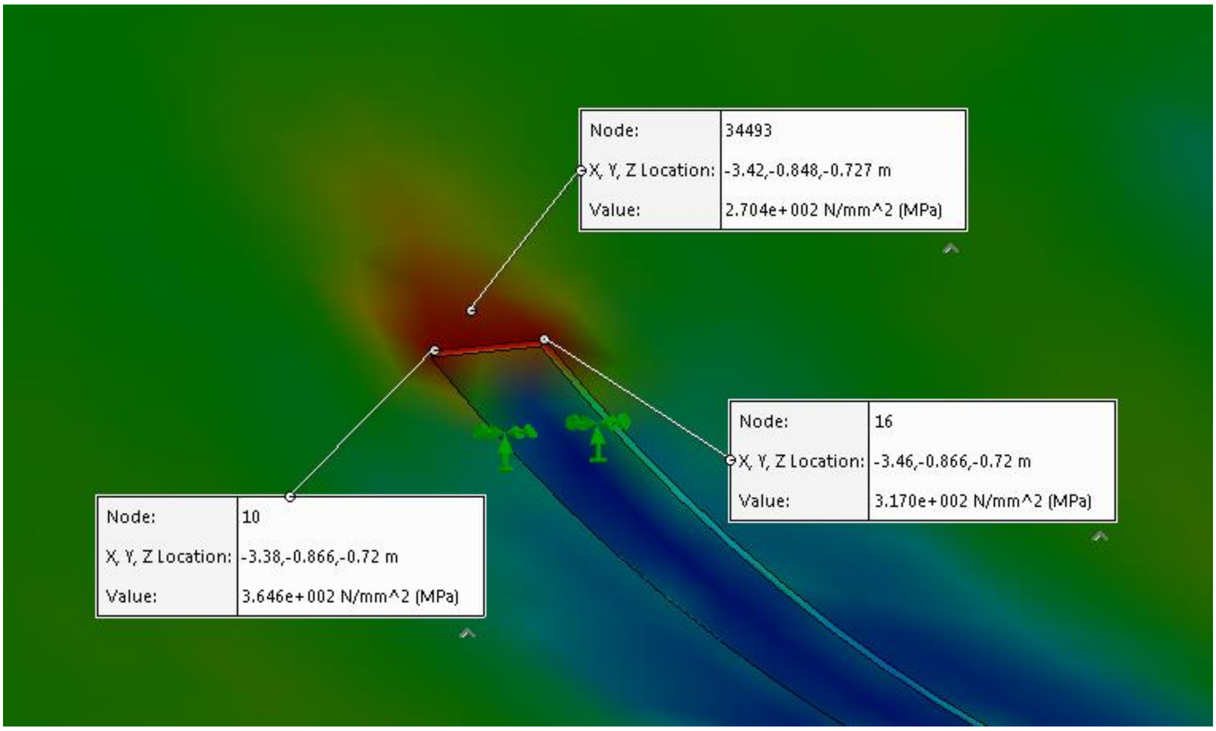


Figure 10. vonMises equivalent stress state – concentrator example

The simulation includes as a working hypothesis a simple request in static mode. The dynamic type phenomena that would lead to the drastic modification of the calculation scheme through the effective loading scheme was not taken into account. And in this case, the working hypothesis by using symmetry in relation to a plane does not remain valid (usable), with consequences on the computing resources necessary for the completion of the proposed simulation.

The appearance of stress concentrator type zones, even in the conditions of the substantial simplification of the calculation scheme, constitutes an alarm signal from the point of view of the behavior of the structure in real conditions. It is necessary to initiate some discussions on the topic of optimizing the technological and/or design flow of the assembly.

It is well known that the welded joint is accompanied by the thermal influence area, characterized by increased fragility.

Given this in addition with the mode of operation of the tank (vibrations, shocks), the authors consider that the periodic monitoring of these welded joints should become mandatory, at maximum 2 years. The volume of 100% by means of a non-destructive control method of penetrating liquid type or magnetic particle according to the method and acceptance level B standards is recommended.

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