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NUMERICAL STRESS AND STRAIN ANALYSIS OF VERTICAL CYLINDRICAL TANK

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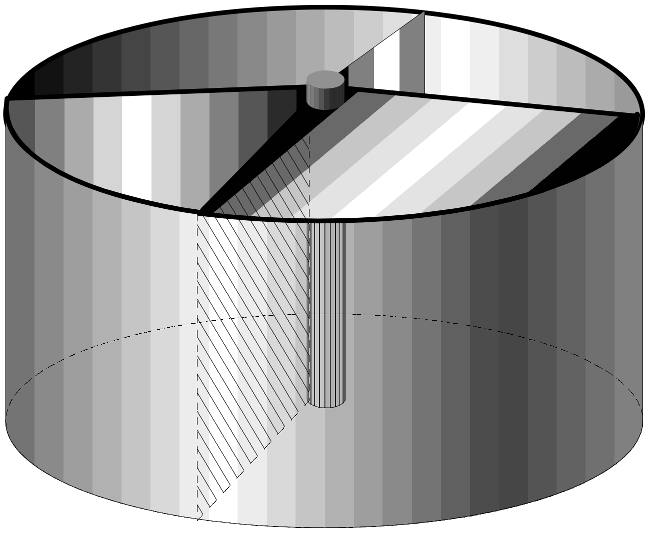
ABSTRACT:
The calculation of cylindrical tank rebuilt by four separated vertical chambers, as well as stress-strain analysis, were performed by using finite element method through software package NASTRAN. In paper are especially defined combined T details and welded joint angle for critical nodel points of floor, jacket and blocks welded joint, thus giving numerical stress and strain analysis results for all applied welding technologies.
Keywords: tank, strain, stress, welding, numerical model, numerical analysis.

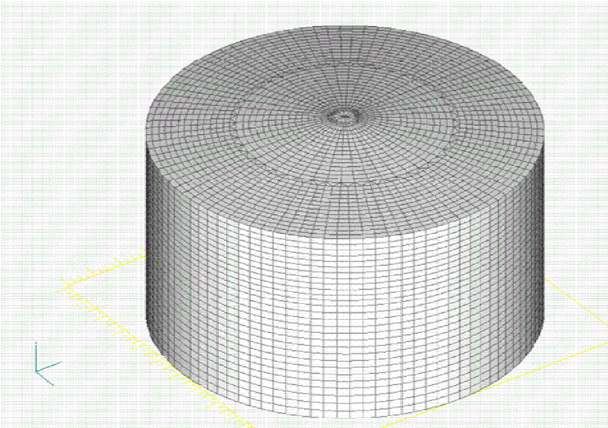
1. INTRODUCTION
5000 m^3 capacity cylindrical tank made of S.0361 steel is designed for storing petroleum products and specific weight petroleum up to 1000 kg/m^3. Internal diameter of tank is 24384 mm. Height, measured from bottom of tank to internal surface of boundary angle arm, is 11010 mm. These dimensions enable tank to accept 5000 tons of useful load [1]. Schematic illustration of multi-chambered cylindrical tank is given in Picture 1.



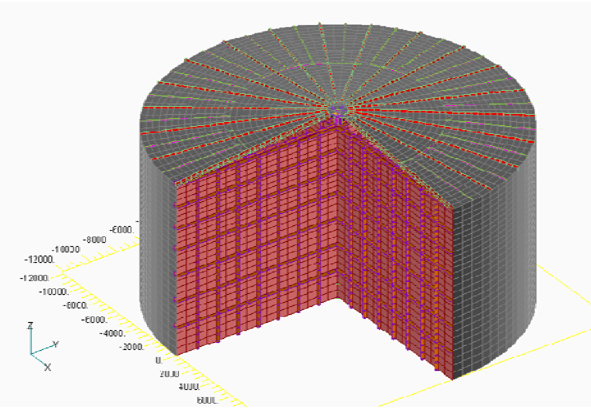
Picture 1. Multi-chambered cylindrical tank

2. NUMERIC STRESS AND STRAIN ANALYSIS OF JACKET AND PARTITION

The starting numeric model of petroleum multi-chambered tank is defined by choice of shape and dimensions of 5000 m^3 capacity cylindrical tank [2]. Picture 2 shows overall image of 5000 m^3 capacity tank.



Picture 2. Global view of 5000 m^3 capacity tank

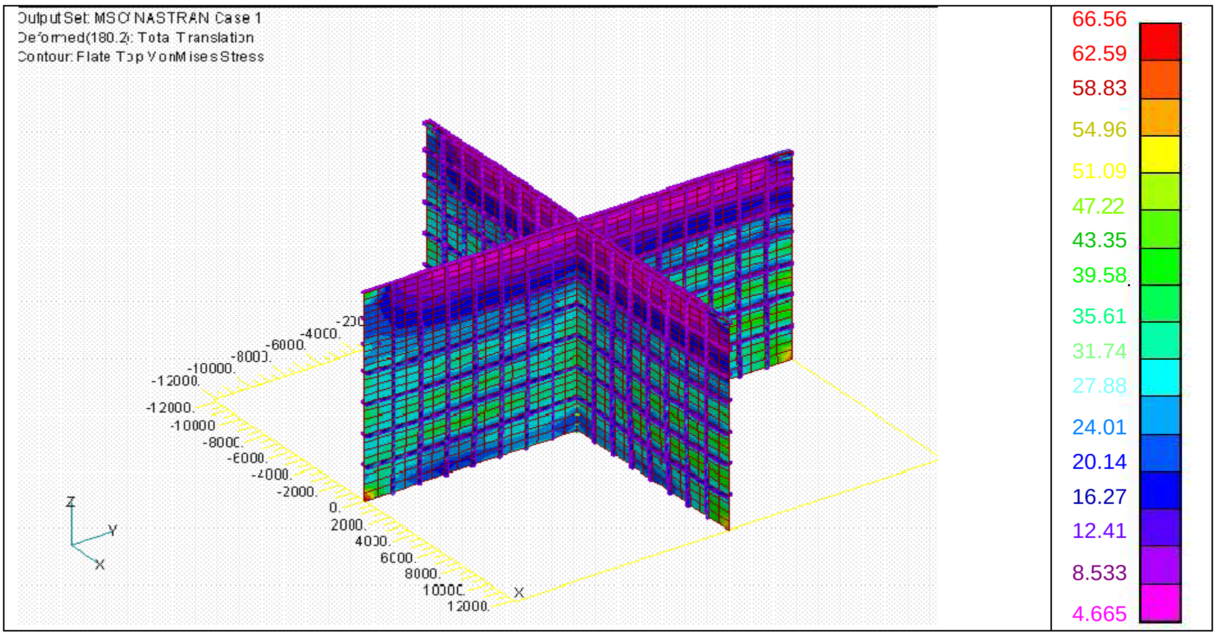


Picture 3. Model with horizontal and vertical partitions

Detailed calculations of tank converted into four different chambers, as well as analysis of stress-strain condition, were performed by using finite elements method through software package NASTRAN [3]. Having in mind the results of model testing, linear static analysis was used during work with tank jacket and vertical partitions that, according to previous researches and testing [4], together with welded nodel zones present the highest overload points.

Therefore, overhead 5000m^3 capacity cylindrical tank presented by finite element model in Picture 3 is idealized by means of two types of finite elements:

1. Structure of outer wall shell, rooftop, and barrier walls (sheets) are idealized by shell elements (accepts membrane and bending load).
2. Central pillar, reinforced roof construction (I-profiles), as well as reinforced partition walls (I-profiles) are idealized by beam type finite elements. This type of finite elements accepts all types of loads (all forces and moments).



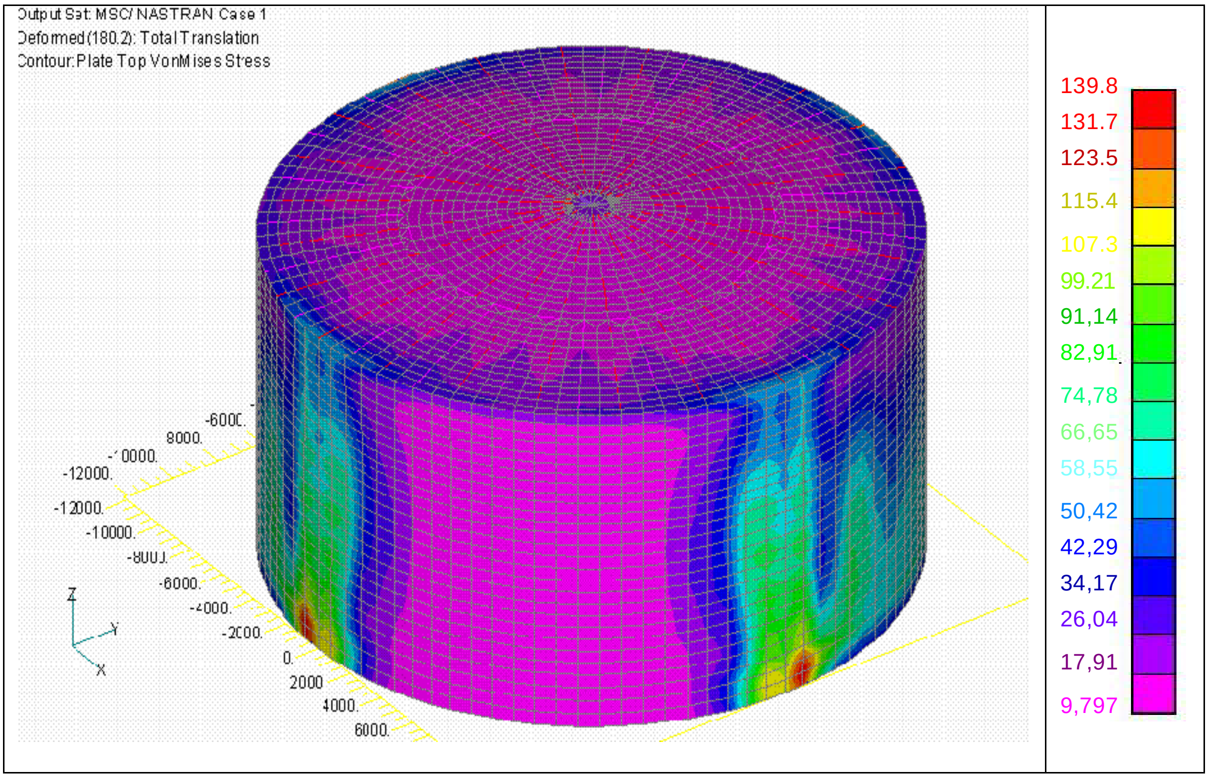
Picture 4. Stress distribution on partitions after bearer reinforcement

By introducing hydrostatic pressure we analyzed the case of loading when two opposite chambers are filled with liquid (ρ = 1000 kg/m^3), while two other chambers are empty. Compared to research carried out in my master's thesis, where I did not know whether stress levels and displacements in partitions without reinforcement would be so high, this research started with postulation that, for stiffening of partition sheets, profiles were positioned for reinforced structures.

In order to overcome the problem and move tank partitions into permissible stress zone, general overhead cylindrical tank model was horizontally and vertically reinforced with 8 x 7 bearers. As bearers we used standard I profiles type I 32, Picture 4 (Stress distribution across partitions after bearer reinforcement). The same bearers were idealized with beam type of finite elements.

According to Picture 5, stress condition on vertical tank jacket is satisfying, since maximum stress levels range in between 120 and 140 MPa.

By analyzing results of previous research [4], it is notable that in nodal point zone of floor, jacket, and partition welded joint stress values reached enormously high level that range up to 255 MPa. These levels are a consequence of liquid absence in neighbouring chambers and relatively low jacket bending rigidity in partition connection zone, where jacket is exposed to high bending strain. Additionally, these stress levels are a consequence of welding technology that was not properly chosen for specific conditions.

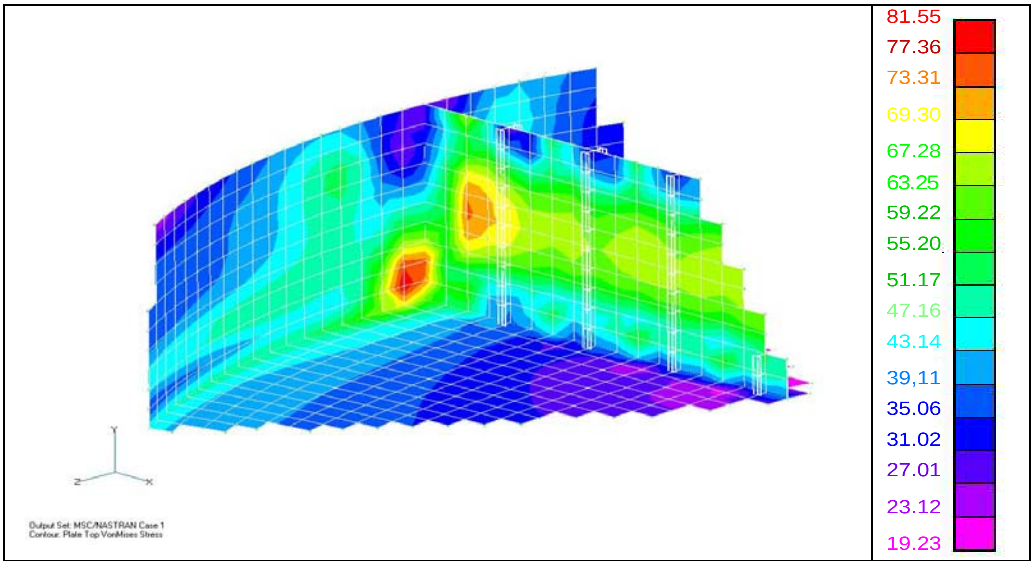


Picture 5. Stress distribution across tank jacket after bearer reinforcement

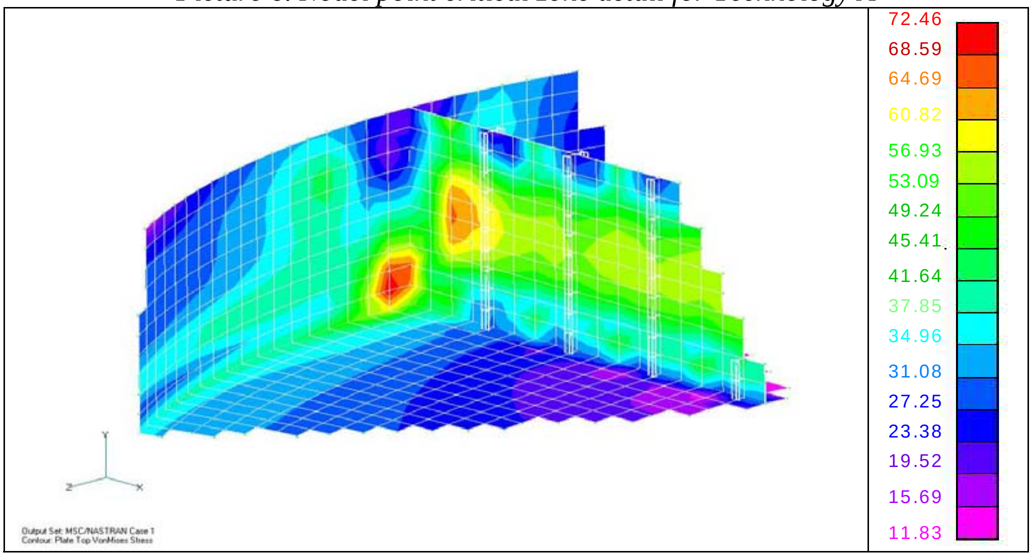
Jacket and partition connection zone needs to be additionally reinforced on partition and jacket part in order to reduce bending strain, and perform testing of all cases with numeric model.

3. NUMERIC STRESS AND STRAIN ANALYSIS OF NODEL POINTS

Having in mind aforesaid, critical nodel point detail has been defined, i.e. T combination and welded joint angle detail for all four applied welding technologies. Picture 6 shows reinforced partitions and details with stress condition distribution in nodel zone for Technology A, Picture 7 for Technology B, while Pictures for Technologies C and D were omitted due to limited space in this paper.



Picture 6. Nodel point critical zone detail for Technology A



Picture 7. Nodel point critical zone detail for Technology B

4. CONCLUSION

Correction of numeric model, by introducing additional reinforcement for the purpose of lowering bending strain, resulted in fact that, according to defined model, maximum stress levels in average do not go above 85 MPa. The optimum condition, i.e. the lowest stress values were registered in applied welding technology B (72, 46 MPa), what was expected, having in mind all previous research results [4]. It should be noted that complete analysis and calculation are treating one or two opposite tank parts, which is the most critical point. Solution, that was in basic technical sense performed by ''NASTRAN'' program (reinforcement of partitions was performed with standard I profiles type I32 with 8 x 7 fields), is no doubt one of possible high-quality tank solutions.

5. REFERENCES

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