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Analysis of Stress Distribution in Casing-Grapple Contact Areas

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Abstract

The paper focuses on the analysis of the stress distribution developed in the contact zone between the casing and the grapples within a new grapple clamping system developed by an important petroleum equipment company. The analysis of stress distribution was made by using the Finite Element Method (FEM).

Key words: *casing, grapple, FEM*

Introduction

The paper focuses on the analysis of the stress distribution developed in the contact zone between the casing and the grapples within a new grapple clamping system made by an important petroleum equipment company.

The analysis of stress distribution was made by using the Finite Element Method (FEM), based on the following initial data provided by the petroleum equipment company:

- The geometry, the size and the assembling mode of the new grapple clamping system;
- The forces of grapple clamping system calculated by petroleum equipment company for a casing of 9 5/8 43.5 lbs/ft (64.73 kg/m) / 5000 m;
- The relative position of the grapple in relation to the casing for various loads.

Developing the Model

Because the new grapple clamping system has an axial, symmetric structure (fig. 1) only a quarter of the model was used in order to determine the tension fields in the walls of the casings (fig. 2) by using the Finite Element Analysis.

The model was created only for the grapple clamping zone (fig. 2) based on the new grapple clamping system (fig. 3) and the data provided by petroleum equipment company.

To mesh the model a SOLID45 element type, from the ANSYS library elements, was used. We used for the contact areas a TARGE170 element for the surface of the grapples and a CONTA174 one for the surface of the casing (fig. 4).

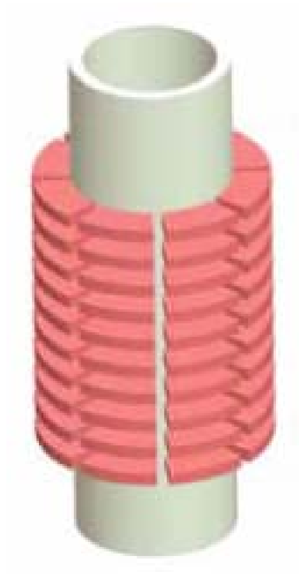

Fig. 1. The distribution of grapples around the casing surface

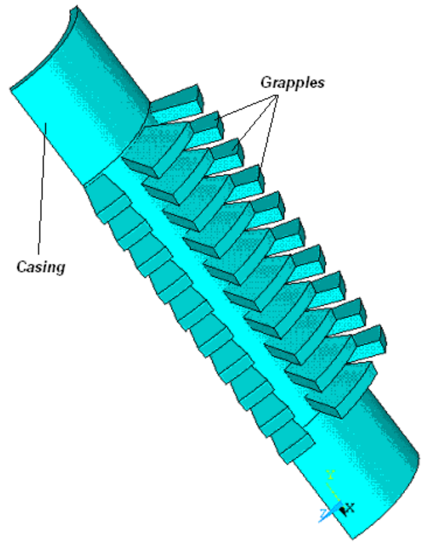

Fig. 2. The model for FEA

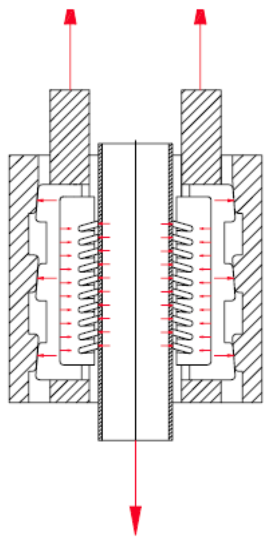

Fig. 3. The grapple clamping system

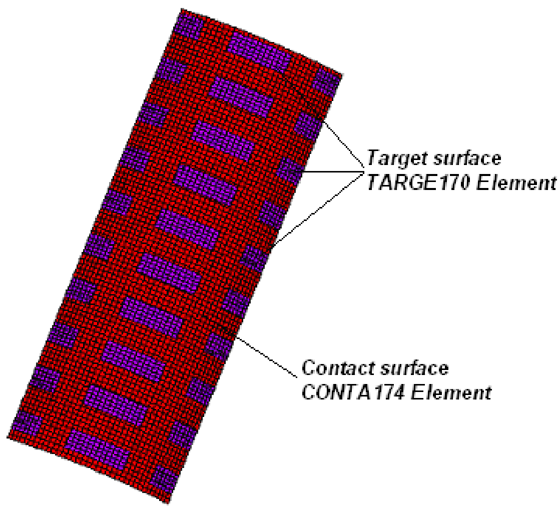

Fig. 4. Contact and Target area of the model

Modelling Loads and Links

The adopted solution was that the load of the model would be given by the displacements imposed to the grapple on the exterior surface of the casing and not by the *Fv* and *Fr* forces calculated by petroleum equipment company. The stress distribution was calculated with FEM for the same 9 5/8 43.5 lbs/ft (64.73 kg/m) / 5000 m casing for which petroleum equipment company did the numerical application.

The value of this displacement is 0.3 mm/radius and it is given by the relative position of the grapple for two load cases (fig. 5 and 6): $j = 61.7 - 61.4 = 0.3$ mm.

The value of the angle $\gamma = 14^{o}$ fits the case in which the system is loaded with 270 tf (fig. 6).

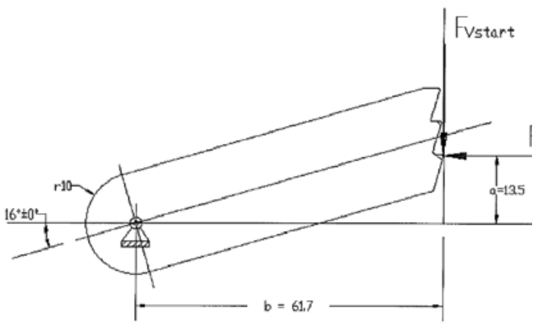

Fig. 5. The position of the grapples to the pipe under starting load.

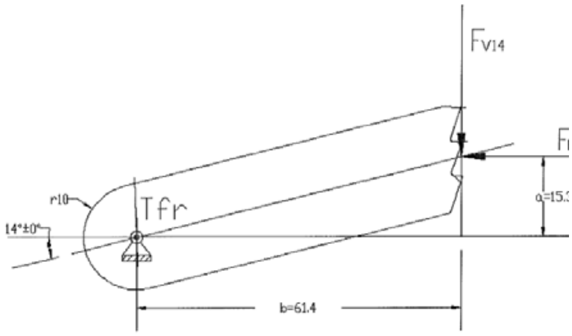

Fig. 6. The position of the grapples to the pipe under load of 270 tf

For the friction between the sides of the grapple and the external surface of the casing we considered a friction coefficient of $\mu = 0.3$ also used by petroleum equipment company when calculating the forces Fv and Fr .

The surface of the grapples, which are not in contact with the casing, was fixed (fig. 8).

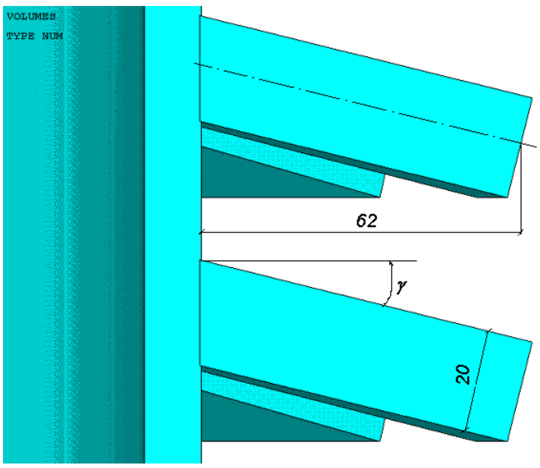

Fig. 7. The dimensions and the position of grapples to the pipe of the FEA model.

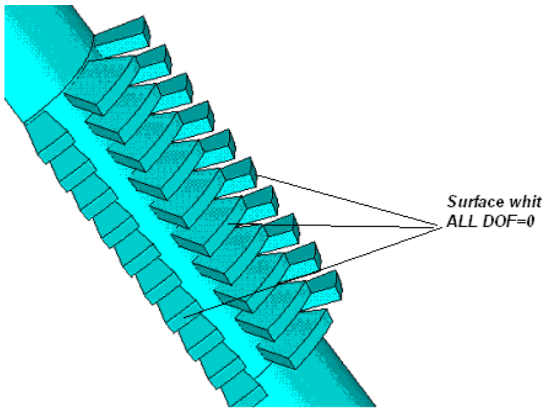

Fig. 8. The surfaces with the degree of freedom (DOF) blocked.

Results

The model which was obtained was solved for different values of the inclination angle of the grapple towards the perpendicular axis on the axis of the casing $\gamma = 6^o$; 12^o; 14^o. In Figure 9 the stress maps are reproduced.

In table 1 below, one can find the maximum values for the equivalent stress σ_{ech}^{max} (Tesca) and the maximum positive values for the main maximum stress σ_1^{max} .

Table.1. The maximum values of stresses.

The stress	$\gamma = 14^0$	$\gamma = 12^0$	$\gamma = 6^0$
σ_{ech}^{max} , MPa	419	438	440

Critical pressure of loss of stability at long tubes subjected to outside pressure is calculated with the formula of Carman:

$$p_{cr} = \frac{2E}{1-\nu}\left(\frac{t}{d_m}\right)^3 \qquad (1)$$

whit the E – modulus of elasticity of the material of the casing; ν – Poisson's ratio; t – thickness of casing; d_m- average diameter of casing.

For casing 9 5/8 43.5 lbs/ft, p_{cr} = 48.9 MPa results. This pressure produces a σ_{cr} = 517 MPa.

Conclusions

For great hole drill, the problem consists in support the column of casings. This is ensuring by grapple system. The grapple system must provide supporting of casings without producing buckling of casings. Because of this is necessary to analysis stress distribution in casing-grapple contact areas.

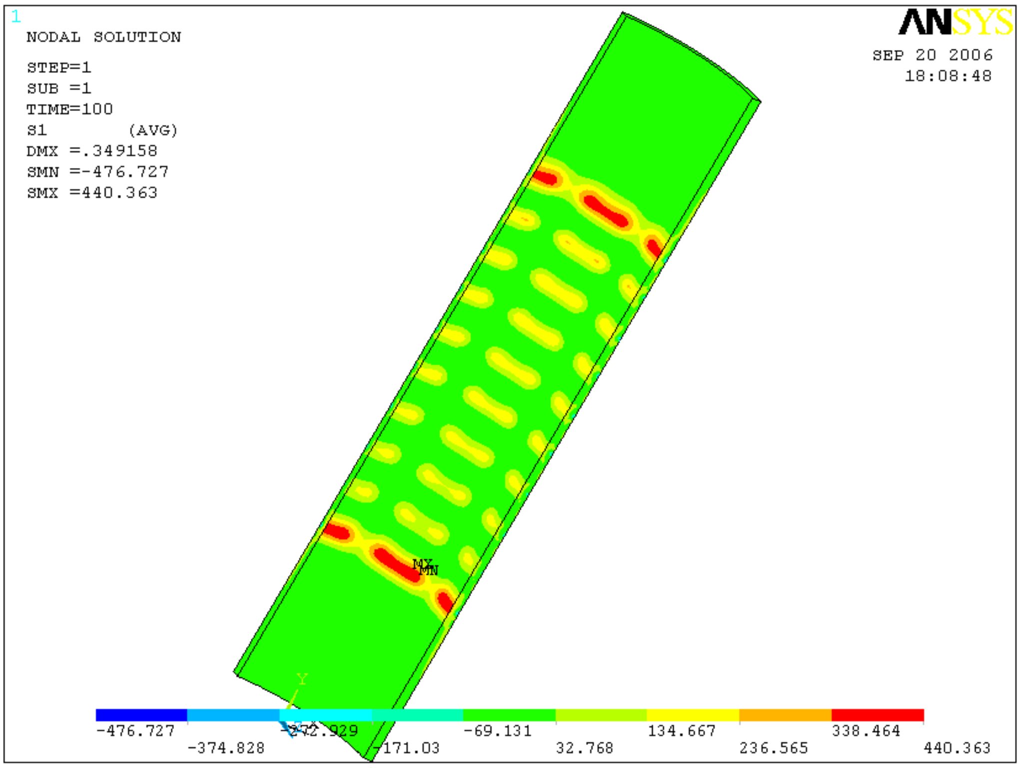

Fig. 9. The equivalent stress σ_{ech} (Tresca) distribution for the casing for j = 0,3 mm şi $\gamma = 6^0$.

From the analysis of the stress distribution maps the following elements result:

- The most critical areas of the casings are those corresponding to the first (top) and last (bottom) row of grapples, areas where the equivalent stress reaches the values of 419 MPa ($\gamma = 14^0$) … 440MPa ($\gamma = 6^0$); (API Specification 5CT / ISO 11960 specifies the technical delivery conditions for steel pipes (casing, tubing, plain-end casing liners and pup joints), coupling stock and accessories and establishes requirements for three Product Specification Levels (PSL-1, PSL-2, PSL-3). The mechanical properties of casing steel are: $R_{p,0,2}$ = 350 ... 1050 MPa and R_m = 420 ... 1120 MPa).

- Between these two areas the stresses within the wall of the casing are uniformly distributed with the higher values being found in the space between the rows of grapple;
- The maximum equivalent stresses correspond to the lowest values of the γ angle;
- Maximum stress is less than critical stress, so do not loss of stability of casing.

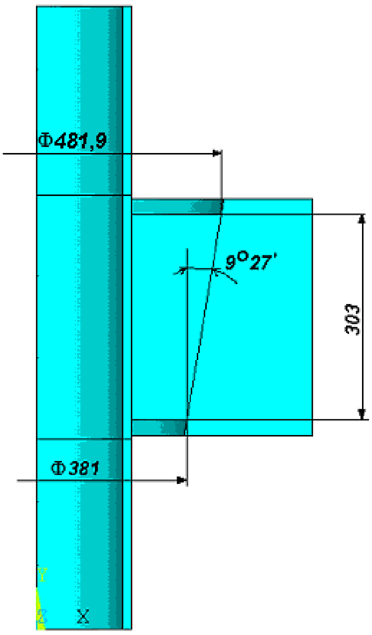

Fig. 10. The model for FEA of the wedge type clamping system.

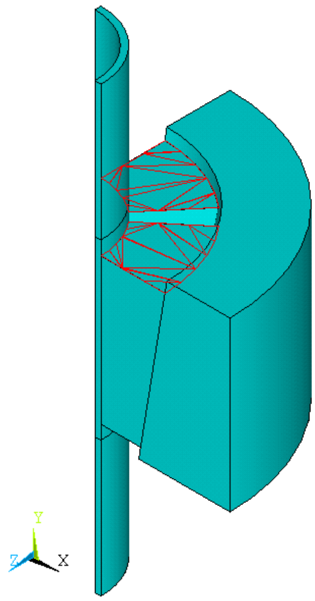

Fig.11. The load of the wedge type clamping system.

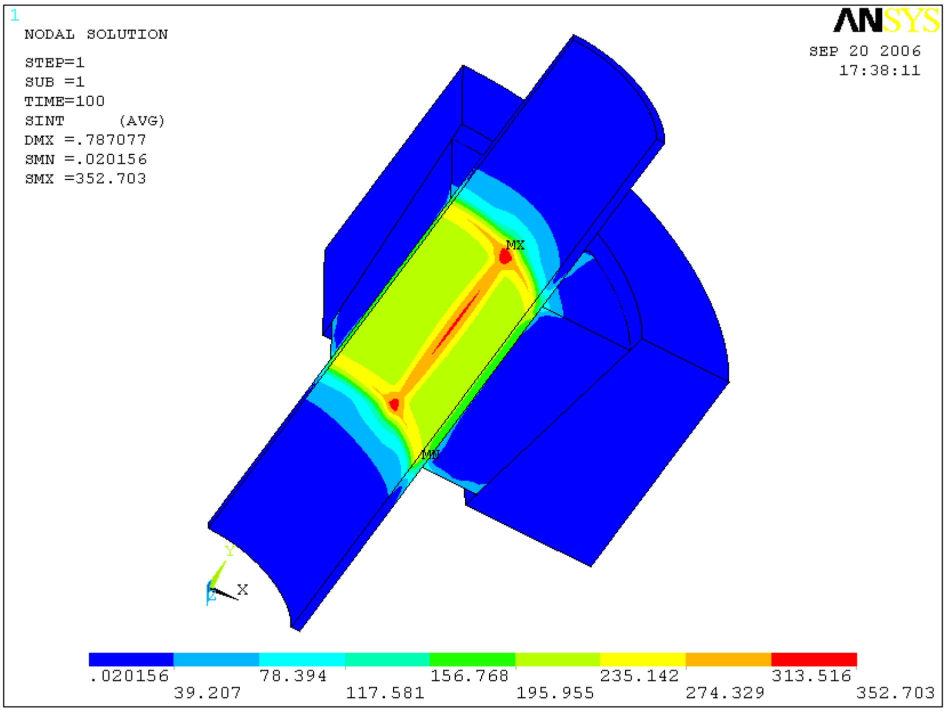

Fig. 12. The equivalent stress σ_{ech} (Tresca) distribution for the model of the wedge type clamping system.

In order to compare the stress distribution developed within the casing in the new grapple clamping system with that developed in the case of the wedge type clamping system, we have focused also on the stress distribution in this case based on the model which can be found in Figure 10. This model was loaded like in Figure 11 and the value of the applied pressure on the exterior surface of the slips was equivalent to that of an axial load of 270 tf. In Figure 12 the stress for maps the wedge type clamping system are reproduced. In this case too, the mesh of the model was similar to the mesh of the first model.

The results indicate the fact that in the classic wedge type clamping system the stress is lower than in the case of the new system. One should mention, however, that the mesh of the old system was idealized, the contact between the slips and the casing being made on the whole common surface, fact which in reality does not happen because of the dimensional deviation due to the use and deterioration of the clamping elements.

References

1. * * * – API Specification 5 CT- 2005, *Specification for Casing and Tubing.*
2. * * * – ISO 11960: 2004, *Petroleum and natural gas industries—Steel pipes for use as casing or tubing for wells*.
3. P a n t a z i , D . – *Construcţia şi tubarea sondelor,* Editura Tehnică, Bucureşti, 1972.
4. M a c o v e i , N . – *Tubarea şi cimentarea sondelor*", Editura Universităţii din Ploieşti, 1998.
5. * * * – *Mechanical cementing aids,* Weatherford, 2001.

Analiza stării de tensiuni în burlanele de tubaj în zona de prindere în pene

Rezumat

Prezenta lucrare analizează starea de tensiuni dezvoltate în zona de contact dintre burlanul de tubaj şi elementele de susţinere din cadrul unui nou sistem constructiv de susţinere a burlanelor, elaborat de o firma importantă de echipament petrolier. Au fost determinate hărţile de tensiuni în zona de prindere atât pentru noul sistem de pene cât şi pentru un sistem clasic. S-au evidenţiat avantajele şi dezavantajele noului sistem de susţinere în pene a burlanelor de tubaj.