Procedure for Arranging Centralizers in Casing String Run into Directional Wells

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Postup pre rozmiestnenie centrátorov na pažnicovej kolóne určenej pre zapaženie v horizontálných vrtoch

Centrátory patria medzi najdôležitejšie elementárne častí technického vybavenia pažnicových kolón. Centrické umiestenie pažnicovej kolóny, obzvlášť v horizontálnom vrte, je jednou z podmienok kvalitnej cementácie vrtu. Centrátory sú prostriedkami pre centráciu pažnicovej kolóny a umožňujú rovnomerné zaplnenie medzikružia vrtu cementovou suspenziou. Tento článok pojednáva o postupe metódy pre rozmiestenie minimálneho potrebného počtu centrátorov na pažnicovej kolóne, ktorá je určená pre zapaženie horizontálneho vrtu.

Key words: Centralizer, Casing String, Directional Well, Three - Dimensional Space, Borehole Well.

Introduction

Centralizers (Weatherford, 1994) are one of the most important elementary parts of technical equipment of a casing string. Currently throughout the world more and more directional holes are being drilled, which are often located in three-dimensional space. Generally it can be said the more complicated the hole axis, the more difficult it is to maintain coaxial placement of a casing string run into such a hole. Centralizers play a significant role in limiting a number of columns of a casing string run to a hole and in minimizing the clearances in the hole (Lubinski, 1987; Wisniowski et.al., 1995). Maintaining the right clearance between the wall of the hole and the casing columns has critical impact on the quality of its sealing.

Placing too many centralizers on the casing string seriously impedes running pipes into the hole and unnecessarily increases the overall cost of the hole. On the other hand too few centralizers on the casing string will not ensure proper sealing of the hole. For this reason the aim is to develop a kind of method for placing centralizers on a casing string which would take into account the spatial position of the hole as well as the load of the casing string with a minimum number of centralizers. An attempt at viewing this problem in such a light is presented in this article.

At the present time when sealing of casing strings is carried out, their construction as well as recipes for sealing slurries are very carefully selected, taking into consideration such factors as the influence of temperature, pressure and time on technological parameters. The field equipment used to prepare and pump sealing slurries into the hole is continually being improved.

The Casing String Load

The casing string run into the hole is subject to various loads, the most important of which are axial tension, compressing, bending and torison (Gonet, 1997). Centralizers located on the casing torsion-string mediate in the above-mentioned loads and are places of contact with the holewall. The system of Kirchhoff equations was chosen for this discussion on the casing string load with centralizers run into holes.

Given the assumptions presumed in this study (Gonet, 1997), the unit stresses acting on a centralizer along tangent, normal and binormal axes of the hole (Fig. 1) amount to:

$$N_1 = -ks^2EI - q\cos\alpha \qquad \text{[N/m]} \qquad (1)$$

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$$N_2 = ks^2EI - ksM_1 - kT_1 - q\sin\alpha \qquad [\text{ N/m}] \qquad (2)$$

$$N_3 = s^3EI \qquad [\text{ N/m}] \qquad (3)$$

where:

N1, N2, N3 - unit stress of casing along axes x_1, x_2, x_3 respectively [N/m],
T1 - tangent tensile force of the casing [N],
E - Young's modulus of the casing material [N/m^2],
I - axial moment of inertia [m^4] ,
q - unit weight of the casing immersed in fluid [N/m] ,
M_1 - momentum acting along axis x_1 [N .m] ,
α - deviation angle of the hole's axis [^{o}],
k - curvature of the casing's axis in the hole [1/m],
s - torsion of the casing's axis in the hole [1/m].

The origin of the coordinate system (Fig. 1) is always located at the casing string's axis in a place where the next lower centralizer is situated. This means that the first centralizer is located by counting from the bottom of the casing string. The next ones are counted in succession and together with an increase in the number of centralizers, the coordinate's system is shifted upward in such a way that its beginning is always at the lower centralizer whose placement was last designated. The elementary length of the casing string is always matched to the distance between neighboring centralizers. The curvature and torsion of the elementary arc for the axis of the casing string run into the hole are approximated on the basis of geophysical measurements made earlier in a given hole. Depending on the measuring equipment used, the spatial placement of the hole's axis may be determined for example by the tangent, trapezoidal or Mercury methods (Walstrom, 1972).

When the type and location of the centralizers on the casing string are properly chosen, the axes of the hole and casing string are close to each other. Therefore it can be assumed, with very little error, that the curvature and torsion on the elementary arc are constant. The momenta acting on the casing string are dependent upon the casing string's curvature and torsion as well as upon the way it is run into the hole.

Unit resultant force acting on a centralizer is equal to the the diagonal of a cuboid constructed on three sides suited to the unit stresses *N1, N2, N3* respectively. However the total resultant force N_d acting on a centralizer is a product of the unit stress and length L_c of a casing between neighboring centralizers, that is:

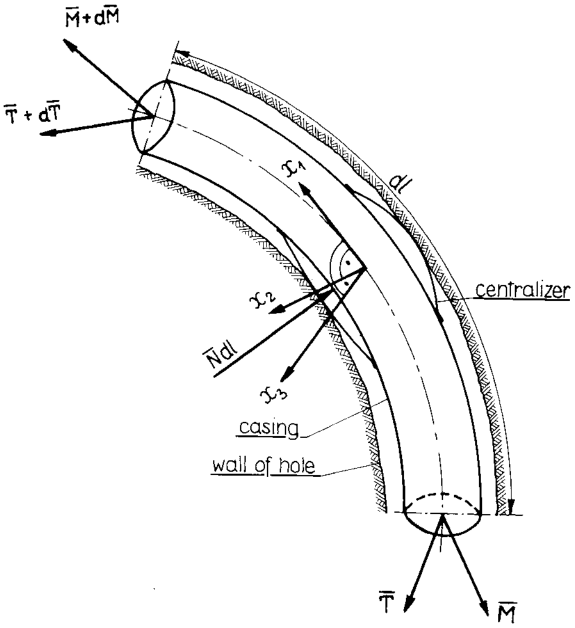

Fig. 1. The unit stresses acting on a centralizer located on a casing string in the hole.

$$N_d = L_c[N_1{}^2 + N_2{}^2 + N_3{}^2]^{0.5} \qquad [N] \qquad (4)$$

Each type of centralizer has its own characteristics (API Specification, 1990; Weatherford 1994), from which an permissible load, which will be called N_c [N], is chosen earlier. Given the assumption that the stress on a centralizer, whose distance is defined, does not exceed the permissible stress, the maximum distance for placing the successive centralizer is calculated as follows:

$$L_c = \frac{N_c}{[(-ks^2EI - q\cos\alpha)^2 + (ks^2EI - ksM_1 - kT_1 - q\sin\alpha)^2 + (s^2EI)^2]^{0.5}} \qquad [m] \quad (5)$$

Limitations

A casing string run into a hole undergoes fluctuation of stress. Centralizers which are improperly located can become damaged during the run and become the cause of complications. For this reason, the entire methodology of locating centralizers on a casing string consists of the part suited to the goal of ultimately placing of the casing in a hole as well as the part with limitations resulting from their translation in a hole. This is particularly significant in these intervals of a hole in which the largest curvatures and torsions of the casing occur. Verification of the centralizers' placement is based on calculating the quotient of the maximum translation of the casing axis and the radial clearance given by the following formula:

$$S = \frac{R_i - R_z - C_i - D_i}{R_i - R_z} \qquad [\text{dimensionless}] (6)$$

where:

R_i - radius of the hole at the i-th intersection [mm],

R_z - outer radius of the casing string [mm],

C_i - bending of a centralizer due to a side-load at i-th intersection [mm],

D_i - maximum bending of the casing at i-th intersection [mm].

If the quotient defined by the equation (6) is not less than 0,67 in the tested intervals of casing run into the hole, then the distances between centralizers calculated using equation (5) are not subject to change (Fig. 2). Otherwise the distance between these centralizers should be decreased enough so that the stand-off attains a value of 0,67.

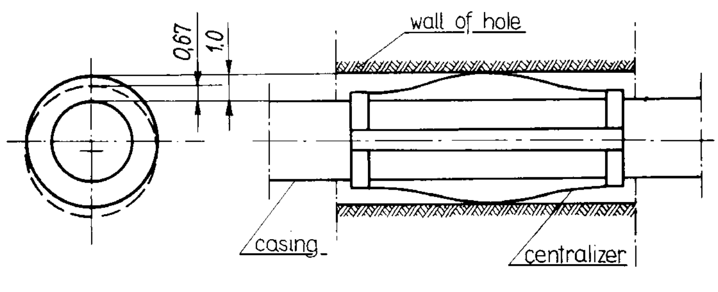

Fig. 2. Centralization of centralizers casing string in directional well.

The above procedure is repeated for all centralizers starting with the one situated lowest on the casing string run into a hole.

Conclusions

1. The casing string run into a hole is subject to various loads depending on:
   - the unit weight of the casing string,
   - the stiffness of the casing string,
   - the technology of running the casing string run into a hole,
   - the spatial placement of the hole's axis.

2. For a hole calculated in three-dimensional space, the distance between successive centralizers is calculated according to the equation (5). This distance depends on the permissible stress resulting from the technical characteristics of a given type of a centralizer, the placement of the hole's axis, the local load of the casing and their parameters.

3. The ultimate placement of centralizers in the casing string should be determined by verifying along the trajectory of the hole's axis the condition (6) stating that the quotient of the greatest clearance of the casing's axis and of the radial clearance does not exceed the permissible value if 0,67. As the rheology parameters of sealing slurries and sealing technologies improve, this value should decrease.

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