Initial conditions calculations

Oliasoft

Abstract

In this document we describe the calculation machinery behind initial conditions calculations in the Oliasoft application. Essentially, we offer three types of calculations, i.e. running of tubing, setting cement, and setting a packer. The methods are related, although there are some important differences, e.g. allowable movement of packers versus static conditions in cement. Running of tubing is pre anything, i.e. the only effect to take into account is the weight of the tubing and buoyancy. Setting a packer or cement can be done on an arbitrary string configuration of both packers, cement, plugs and expansion devices, without any practical considerations, e.g. setting cement between two packers or setting a packer in a cemented area.

Run in hole

Running of a tubing[1] is pre anything else, and this implies that the only effects that need to be taken into account are the weight of the tubing and buoyancy, i.e. piston forces. The following inputs are necessary for run in hole calculations:

1) The dimensions of the tubing, i.e. inner- and outer- diameter and weight per meter.
2) The (hydrostatic) pressure in the wellbore, usually given based on mud weight in the wellbore.
3) If the pressure is based on mud weight, also the true vertical depth along the wellbore as a function of curve length/measured depth is required.

From this, an initial axial load from running tubing can be calculated as follows [1]

a) Calculate the (underhanging) weight along the tubing.
b) Calculate piston forces on the tubing, i.e. piston forces at the base of the tubing, and at any crossovers.
c) Calculate the initial axial load from running tubing by adding the buoyancy and the weight.
d) (Add bending from dogleg and buckling if desired, although this is usually not considered part of *running tubing*.)

Set cement

Setting cement is usually done after run in hole, and is defined by the density of the cement(s) and TOC and BOC. In most cases, the cemented part of the tubing starts at the bottom and goes up a certain distance, to the TOC. However, the set cement procedure in Oliasoft is not restricted to this situation, and one can put cement at any location of the tubing. Practical considerations are not taken into account. Also note that many of the calculations are the same as in axial loads calculations, and details can be found there.

Calculating the axial load from setting cement involves the following input:

1) Initial conditions, i.e. pre-cement, including axial loads, internal- and external initial pressures, and an initial temperature profile along the tubing. These are usually the *run in hole* conditions.

[1] We denote any tubulars by tubing. All the calculations encompass both tubings and casings.

2) A complete description of the tubing string, including internal- and external diameters, any cemented areas and any existing packers, plugs, or expansion devices.

3) A complete description of the fluid densities, pre cement (?), in the wellbore, including top- and bottom- of cement (TOC and BOC), and position of any floats.

4) The fluid densities are further used in calculating the load case internal- and external- pressure, hence also the true vertical depth along the wellbore as a function of curve length/measured depth is required.

5) A load case temperature profile. This is usually the same as the initial temperature profile.

From this, post-cement axial load is calculated as follows [1]

a) Calculate the hydrostatic load case pressures from the fluid densities.

b) Identify the position of the nearest packer/TOC, I_L, below the cement, and the position of the nearest packer/BOC, I_U, above the cement. If I_L is empty, i.e. the cement starts at base of tubing, then set this point equal to the base of tubing and treat it as a free-to-move packer with seal bore area equal to the outside area of the base of tubing. If I_U is empty, i.e. no packer or already set cement between the current TOC and hanger, then set this point equal to the hanger and treat it as a fixed packer with seal bore area equal to zero.

c) Calculate length changes due to ballooning, thermal- and piston- effects (ref. axial loads calculations), between I_L and I_U.

d) Calculate the axial load due to piston effects between I_L and I_U.

e) Calculate the post-cement axial load along the string, from the initial conditions, the axial load due to piston effects, and correction force due to movement. Above I_U and below I_L, the axial load is unchanged, i.e. is equal to the initial conditions axial load. We also remark that if I_L is the base of the tubing, no correction force is present.

f) Finally, add bending stress from buckling and dogleg.

Set packer

Setting a packer is very similar to setting cement, with one important difference, the packer may have allowable movement up and down, in contrast with cement which is completely static. The set packer procedure is completely general, and one can install a packer anywhere along the tubing. Again, practical considerations are not taken into account, and many of the calculations are the same as in axial loads calculations.

Calculating the axial load from setting a packer requires the following input

1) Initial conditions, i.e. pre-packer, including axial loads, internal- and external initial pressures, and an initial temperature profile along the tubing. These can be the *run in hole* conditions, or conditions after e.g. a deeper packer has been set.

2) A complete description of the tubing string, including internal- and external diameters, any cemented areas and any existing packers, plugs, or expansion devices.

3) A load case temperature profile. This is usually the same as the initial temperature profile.

4) A complete description of the packer and setting conditions, including the packer depth, I_P, internal- and external- set pressures, allowable movement up and down, and seal bore diameter.

The post-packer axial load is then calculated as follows [1]

a) Identify the position of the nearest packer/TOC, I_L, below the packer to be set, and the position of the nearest packer/BOC, I_U, above the the packer to be set. If I_L is empty, i.e. there is no packer/TOC below the packer to be set, then set this point equal to the base of the tubing, and treat it as a free-to-move packer with seal bore area equal to the outside area of the base of tubing. If I_U is empty, i.e. no packer/BOC above the packer to be set, then set this point equal to the hanger and treat it as a fixed packer with seal bore area equal to zero.

b) Calculate length changes due to ballooning, thermal- and piston- effects (ref axial loads calculations), between I_L and I_U.

c) Calculate correction force on the deeper packer, if any and if fixed or limited movement, and convert this force to movement between I_U and I_L.

d) Calculate the correction force due to the overall movement, between I_U and I_P and between I_P and I_L, if the packer being set is fixed, and calculate the resulting axial load.

e) Calculate the axial load if the packer being set is free to move.

f) Calculate the movement of the tubing between fully fixed and free to move.

g) Calculate the correction force to limit this movement.

h) Calculate the post-packer axial load along the string, from the initial conditions, the axial load if free to move, and the final correction force.

i) Finally, add bending stress from buckling and dogleg.

References

[1] Jonathan Bellarby. *Well Completion Design*. Elsevier Science, 1 edition, February 2009.