

Sucker Rod Pump Fluid Friction Evaluation

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Sucker Rod Pump

Sucker rod pumps are one kind of artificial lift system to produce crude oil from non-naturally flowing reservoirs. This system consists of the pump jack, situated at the surface, the subsurface pump, position in the wellbore and the connecting link, called sucker rod string.

The sucker rod string is assembled out of coupled individual rods and rod guides stabilise its up- and downward motion in the production tubing string.

As a result of the pump's working principle, during the upstroke the rod string and the fluid are travelling at almost the same speed, during the downstroke the rod string is pushed through the static fluid column.

Field Application

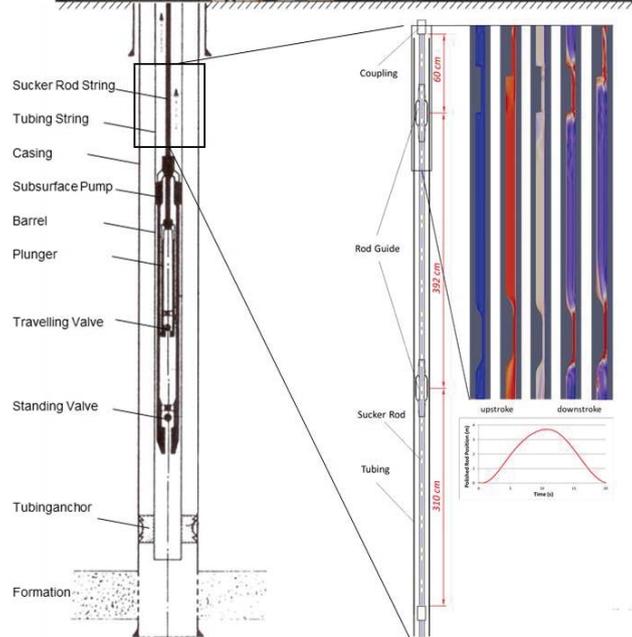


Figure 1: Sucker Rod Pump Rod String Fluid Interaction

For increasing the lifetime of the pumping system and performing predictive maintenance an accurate knowledge about the downhole condition is required. Downhole measurements can hardly be performed because of the harsh environment in the well. As a result the presented simulation is used to give precise information about the fluid interaction with the sucker rod string and the production tubing.

Simulation Technique

The Computational Fluid Dynamics (CFD) simulation is based on an axial-symmetric mesh, where the rod guides are modelled by an equivalent full cross-section body instead of the actual geometry with grooves. The relevant mixture fluid properties, density and viscosity, which are required for the simulation, are based on the pumped fluid mixture (90% water, 10% oil). The transient and incompressible solver OpenFoam® pisoFoam is used to calculate the friction pressure drop of the fluid and the frictional forces on the tubing and the sucker rod string. Figure 1 presents an overview of the pumping system and the velocity distribution of the lifted fluid in the rod string – tubing annulus.

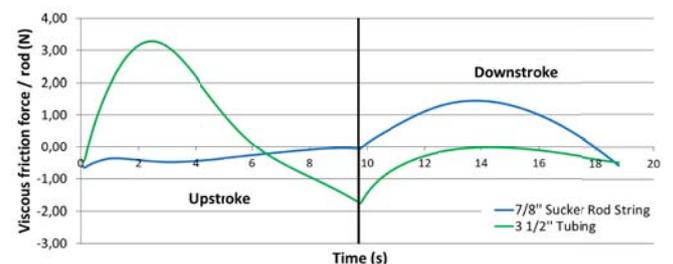


Figure 2: Fluid Frictional Behaviour

Results

Figure 2 presents the frictional behaviour for a full pumping cycle. As a result of the working principle of the pumping system the peak frictional forces on the tubing occur during the upstroke, whereas the maximum frictional loading on the sucker rod string is during the downstroke.

Beside a sensitivity analysis of mixture viscosity, tubing diameter, rod diameter, stroke length and strokes per minute (SPM) is performed. The results indicate that the influence of the viscosity is the highest, followed by the SPM and the clearance between tubing and sucker rod string.