FEA AND WEAR PREDICTION IN ROD PUMPING SYSTEMS

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ABSTRACT

One of the most common methods of artificial lift used in the oilfield is sucker rod pumping where a rod string is used to connect the surface driver to a pump near the bottom of the well. These are the classic "nodding donkey" beam pumps seen in oilfields throughout the world. Historically, these pump systems have typically been used in conventional vertical or near-vertical wellbores. The shale revolution has led to a significant increase in the amount of horizontal and directional drilling in the US. Rod strings can rub, buckle, and impact tubing walls in highly deviated wells, causing premature rod and/or tubing failures which can cost operators millions of dollars over the life of a field. Strategies to minimize this damage include adding centralizers/guides in the rod string, applying coatings to the internal surfaces of tubing, and using continuous rod strings (co-rod) rather than jointed rods.

There are commercial codes and software packages which can be used to design and analyze rod/tubing systems; however, these codes have limitations in their modelling capabilities and in their results output. The underlying modelling approach for these packages can significantly lose accuracy in highly deviated and horizontal wells. Additionally, the results output is limited to simplified tubing contact forces which only provide the total force per rod segment without detailing the distribution of the contact stresses.

Using FEA methods allows for a more comprehensive diagnostics tool for identifying the cause and effect of problems with the rod and tubing system.

Modelling the rod pumping system for an entire wellbore using traditional FEA methods presents many challenges due to the high aspect ratios and length scales of the system. A typical wellbore may be over 10,000ft in length while the rod and tubing string may only be 1 in. and 3 in. in diameter, respectively. A beam element analysis can be useful in identifying potential trouble spots in the system. Further submodelling can provide a more detailed look at regions with high-contact pressures to determine potential wear patterns and material loss rates. Accurately modelling the actual rate of material loss requires physical testing to determine wear coefficients for the material pairing.

The Abaqus FEA model presented here can be used in a wide range of well paths, including highly deviated and horizontal wells. It can also be used to explore and isolate various parameters of the artificial lift system, including: rod material and geometry, guide spacing and shape, prime mover characteristics (speed and stroke length), and effects of the downhole pump in both normal operations and off-normal conditions.

A comprehensive FEA model paired with physical testing of material wear characteristics can be a powerful tool in the design of the artificial lift system as well as in the diagnostics of existing wells experiencing premature rod and tubing damage.