

Title: -

Horizontal High GOR Tight Oil Wells - Novel Unconventional Dyna Card Signatures And Non-Acoustic Gas Rate Measurement Way To Estimate Gas-Free Liquid-Level

Objective

Longer-laterals, more-stages and larger frac-jobs in tight-oil horizontal-wells have enabled enhanced production capabilities. However, production-optimization practices, correlations & charts, which were developed decades ago, are still in use today. The published-charts for fluid level calculations does not meet the challenges caused by high-GOR wells and assumptions on which they were derived. High gas-rate (0.4-1.5 MMscfd) distorts acoustic reflection-signal and cause heavy-noise. The saturation-curve ("S"-curve) which is used conventionally in industry, published by Echometer-company in 1985, is still used everywhere, even though it is applicable for 32-45 deg API-crude and maximum 0.15MMscfd gas-rate wells with no relevance of well gas-composition. Application of gas-rate measurement at surface has potential to estimate the gas-free fluid-level without echoshot gun/acoustic signal data for gas-column length. It is an excellent method of great accuracy which is verified with gauge-pressure data. This work gives thorough analysis/interpretation of new dyna-card signatures in sucker rod pumping. The new dyna-card signatures are observed mainly due to high-deviation, azimuth, DLS and rod guides in horizontal wells. It is observed that there are three dyna-card signatures that are entirely unconventional. They are not stated in literature, or any publication of sucker-rod based artificial lift.

Method/Process

There are total of 45 horizontal wells of which 19 wells run on gas separators. 12 wells, out of these 19 wells, have 100% gas separation efficiency. The same is observed via well dyna-card. The well-pad MPFM measures total gas rate (both tubing and annulus). In these 12 wells, all the gas-measured by the MPFM exits from well-annulus. The gas-free fluid-level can be easily calculated in real-time from the established correlation derived when annulus is shut-in for pressure build-up (upto max. 5-10 psi) for few minutes under constant gas & foam column volume assumption. Equation - $Q_g = 0.68 \times \text{Area}_{\text{annulus}} \times \text{Fluid_level} \times dp/dt$

$$Q = \frac{0.00068 \times \Delta p A D_a}{\Delta t}$$

Below are the three new types of dynacard signatures (REFER TO ATTACHED IMAGES FOR 3 DYNACARDS PICTURES: -

- 1) "J" or "L" type-shape appearing during the start of upstroke. This extends in the range of 5 inches to even 30 inches in rod position before load comes on travelling valve
- 2) Hook-type shapes are observed during start of downstroke. Sometimes multiple hooks shaped patterns are observed in decreasing order of width and size.

3) In downstroke, polished rod load once decreased to zero in downhole card is later increased in the range of 1000-4000 lbs for 30% to 90% of downstroke rod position. It then comes down to zero again.

For analyzing these new dynacard signatures, detailed mechanics-based theories were formulated. One of the theories matched with multiple pulled out rod string and pumps observations.

Results/Conclusion

The Gas-free fluid-level was calculated for 12 wells over a period of last 1.5 years using gas-rate input method.

- 1) The data was plot with same date conventional echoshot gun fluid-level (which has good acoustic-signal reflection). The accuracy is observed in the range of 5%.
- 2) From this calculated gas-free fluid-level data, pump-intake pressure calculations were done and plotted with gauge-pressure (gauge was installed to verify this method). The data is observed in the range of 3-6% from gauge-pressure trend.

It was concluded that this method is better suited & can be applied very effectively in these 12 wells. The gas-free fluid-level calculation doesn't require any echoshot gun especially where acoustic challenges are observed.

This method of gas free liquid level calculation saves echoshot cost (the gun and manpower), reduce HSE risks related to CSE (Confined space entry) and enabled better production optimization of wells

Detailed understanding of the new dynacard signatures in addition to other rare signatures assisted in better understanding of pump and rod behavior in vertical & deviated sections of all the wells. It resulted in adaptation of modified rod string design different from what is proposed by various industry software. The analysis led to premature rod change out interventions prior to failure, detection of standing valve or/and travelling valve chokings, indication of rod string buckling cases, and many more.

Novel Information

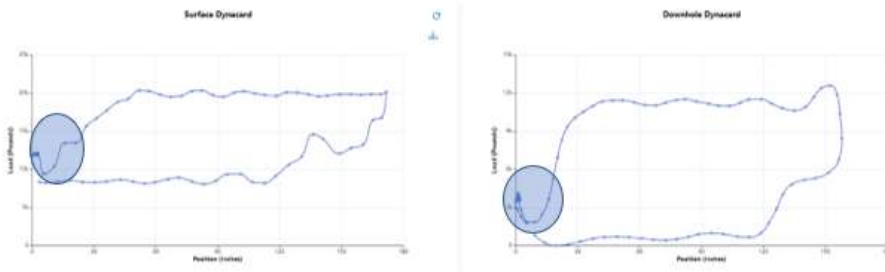
The method of gas-free liquid-level calculation is great for operators running field on gas-separators, or those who have separate access to measure annulus gas-rate. This method has further application of deriving field's own "S-curve", determine the gas-column length, monitor pump-intake pressure and pump-fillage, etc

Additionally this paper provides novel information regarding dynacard analysis in artificial lift industry. These theories are not mentioned in any literature books, publications, or journals. It will add great value to the industry.

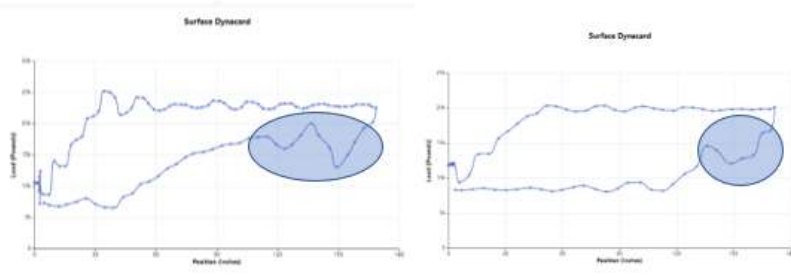
NEW DYNA CARD SIGNATURES ILLUSTRATION

(OBSERVATION NUMBER -1, 2 and 3)

1) Observation number 1: -



2) Observation number 2: -



3) Observation number 3: -

