Animation of Dynamometer Analysis Plots Improve Ability to Troubleshoot and Analyze Problems

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Introduction

• Analysis of the performance of a rod pumped well is achieved by visually displaying real time operation along with fluid distribution inside the down-hole pump chamber.

• Simultaneous display of input KW, surface and pump dynamometer loads versus time or position in conjunction with motion of the pump plunger and polished rod leads to better understanding of the sucker rod lift system.

• Provide an advanced troubleshooting tool so that the complete performance of the well and lift system can be seen without directly interpreting the conventional dynamometer card.
Available Parameters for Analysis

- Polished rod load, acceleration, velocity, position
- Motor power & current
- Plunger load, position, velocity
- Gearbox torque from power and from load
- Polished rod torque
- Counterbalance torque
- Torque factors
- Instantaneous SPM
- Motor RPM
- Crank position

Up to 4 Parameters can be plotted/animated as a function of: time, polished rod position, plunger position or crank angle
Discussion

• Solving “difficult problems” of pumping systems is helped by studying the behavior of other measured and computed data and seeing their corresponding relationship.

• Many combinations of analysis plots for pumping system analysis are possible and only a few are shown in this Presentation.

• Need to use our imagination to develop additional diagnostics and start thinking “out of the dynamometer box” to fully understand pumping system performance.
Dynamometer Analysis Plots Permits Display of Various Parameters Both Acquired and Calculated
Anchored Tubing Velocity and Position Relationship
Tubing Unstretches When Fluid Load is Transfer from Tubing to Rods

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- **Peak Load**
  - Polished Rod Pump: 17.01 Klb
  - Min Load: -0.17 Klb
  - Power: 3.1 HP

- **Stoke Length**: 100 in

- **PDP**: 2651 psi (g)
- **Wrf + Fo FL**: 15.12 Klb
- **Wrf**: 11.13 Klb

- **SV Open**
- **SV Close**
- **Fo Max**: 4.69 Klb

- **EPT**: 56.65 in
- **MPT**: 89.37 in

- **Unanchored Kf**: 464 lb/in
- **Kf**: 176 lb/in

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Animation of Surface and Pump Card for RotaFlex Unit

- PDP = 3736 psi (g)
- 178 psi (g)

Graph showing:

- Wft + Fo Fl = 28.50 Klb
- Wft = 17.02 Klb
- SV Open
- SV Close = 11.74 Klb

Additional data:

- Stroke Length = 306.00 in
- Stroke: 6 00:01:42
- Unanchored K1: 552 lb/in, 224 lb/in
- Power:
  - Polished Rod Pump: Peak Load 32.07 Klb, Min Load 12.22 Klb, Power 29.4 HP
  - Pump: Peak Load 14.17 Klb, Min Load 0.04 Klb, Power 26.0 HP
RotaFlex Load and KW Relationship

Polished Rod Load (Klb) vs. Power (KW) graph showing:
- Polished Rod Load peak at 20.71 Klb with Power peak of 0.8 KW at an elapsed time of 0.000 sec.

Polished Rod Load (Klb) vs. Polished Rod Velocity (in/s) graph showing:
- Polished Rod Load peak at 20.71 Klb with Polished Rod Velocity peak of 2.320 in/s at the polished rod position of 0.11 in.

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Velocity from Integrated Acceleration
Plunger Slows when Fluid Pounds
Blocked Strainer NO Flow at Surface

Plunger Velocity (in/s)

-20.075 in/s

Plunger Position (in)

5.16 in

Elapsed Time (sec)

0.000 sec

PDP = 3523 psi (g)

0 psi (g)

Plunger Stops After Hitting Liquid
Frequently Standard Surface and Pump Dynamometer Card NOT Sufficient to Troubleshoot the Problem

Dynamometer Cards Appear to be OK
Normal 7 SPM Slows to 3 SPM Due to Rod Heavy Imbalance
Standard Surface and Pump Card NOT Sufficient to Troubleshoot Problem.

Normal 7 SPM Slows to 3 SPM Due to Rod Heavy Imbalance
Chamber Pressure ~ Gas Interference

Pump Animation, Plunger Load and Chamber Pressure

Discharge = 1833 psi (g)

Test Duration: 00:59
Gross Plunger Stroke: 157.86 in
Eff. Plunger Stroke: 67.93 in
SPM: 8.57
Fillage: 43%
Pump Displacement: 344 BBL/D

Fo Max = 7287 lb
Equivalent Gas Free Pump Fillage Line
Traveling Valve Opens with Pressure

Peak Load: 17.83 Klb, Min Load: 7.97 Klb, Power: 16.4 HP

Polished Rod Pump
- Peak Load: 5.49 Klb, Min Load: -0.15 Klb, Power: 9.1 HP

Adjustable Pump Displacement: 263 BBLD
Calculated Fluid Load Max: 7.29 Klb
Surface Efficiency: ---- %
Pumping Speed @ 20Hz: 8.571 spm
Motor to Pump Efficiency: ---- %
Pump Intake Pressure: 562 psi (g)
Damp Up: 0.080
Damp Down: 0.121
Adjust Fillage: 32.98 %
Adjust EPT: 52.1 in
Tubing Pressure: 138.0 psi (g)

Adjustments:
- Stroke Length: 188.50 in
- Equivalent Gas Free Fillage: 54.32 in
- Fo Max: 7.29 Klb
- Wrf + Fo FL = 15.23 Klb
- Wrf = 10.70 Klb

804 psi (g)
PDP = 1833 psi (g)

Unanchored ft: 884 lbf
Anchored lb: 299 lbf

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Delay Closing of TV Shock Loads Rods.
TV Delays Seating ~ Repeat Stops Pump
Summary

- User-specified time frequency, the polished rod load, polished acceleration, electrical motor power, and current data are acquired during a dynamometer survey.
- Using the descriptive well information and pumping unit geometry many other parameters are calculated, such as: pump load, polished rod position, polished rod velocity, pump plunger position, pump plunger velocity, existing mechanical and electrical net gearbox torque, instantaneous SPM, and motor RPM.
- Values can be plotted, in pairs in one or two separate plot windows in any combination versus any of four horizontal axis parameters; polished rod position, plunger position, elapsed time, or crank angle.
- Graphic capabilities to easily select, compare, and animate the different acquired and calculated parameters for any individual stroke provides a unique troubleshooting tool.
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