Dynamic Modeling of Hydraulically Operated Gas Well Dewatering Pumps

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Presentation Summary

- Single conduit dewatering pumps
- Through Tubing Pumps
- Through Casing Pumps
- Dynamic Modeling of Pump Systems
- Pump Installation Process
- Comparison of Model to Field Measurements
- Conclusions
Single Hydraulic Conduit Pumps
(Only requires 1 CT string with hydraulic fluid)

- Pressure applied to the hydraulic conduit causes pump to stroke upward
- Pressure released allows pump to stroke downward
- Density difference between pumped water and hydraulic fluid enables the down stroke
- Less expensive dewatering system due to single conduit
Through Tubing Pump

2 3/8” or 2 7/8” Tubing
- Uses existing tubing
- Single CT string filled with Hydraulic Fluid
- Water up the CT/Tubing Annulus
- Seats in tubing seating nipple
- 1 3/4” or 2 1/4” pump
- Inexpensive solution for low water rates
Through Casing Pump

2 3/8” through 3.5” OD

- Run on dual 1 ¼” FLATpak™ (consisting of two 1 ¼” CT strings)
- Hydraulic fluid in one CT string, water up the other
- Deeper or Higher Flowrate Applications
Dynamic Numerical Model

- Dynamic Simulation
- Finite Element in Space
- Finite Difference in time
- Considers:
  - Compressibility of fluids
  - Pressure losses in CT
  - Surface HPU
  - Pump response
- Inputs
  - Downhole pump piston sizes, stroke length, restrictions, friction
  - CT / FLATpak sizes
  - Fluid properties, viscosity, bulk modulus, density, n’, k’
  - Surface hydraulic power unit
    - max pressure, pump flowrate, accumulator volume, charge pressure, restrictions
Sample Model Output

- Hydraulic Fluid Pressure at Surface (psi)
- Water Pressure at Downhole Pump (psi)
- Water Flow Volume at Surface (gal)
- Hydraulic Fluid Flow Volume at Surface (gal)
- Volume of Hydraulic Fluid in Accumulator (gal)
- Hydraulic Fluid Pressure at Downhole Pump (psi)
- Piston Displacement (in/10)
Sample Model Output
Without Accumulator

- Hydraulic Fluid Pressure at Surface (psi)
- Water Pressure at Downhole Pump (psi)
- Water Flow Volume at Surface (gal)
- Hydraulic Fluid Flow Volume at Surface (gal)
- Piston Displacement (in/10)

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Sample Model Output
With 10 gal Accumulator

[Graph showing various pressure and volume measurements over time]
Engineering Test Facility
Used to Develop/Test Pump Systems and Validate Model
Pump and Hydraulic Power Unit
Attaching Pump to FLATpak
Run in Hole
Hang in Well
Water - Full Stroke!
2 3/8” Through Casing Pump
2800 ft, 86 deg, OK CBM Horz. Well

- Hydraulic Fluid Pressure at Surface (psi)
- Water Pressure at Downhole Pump (psi)
- Hydraulic Fluid Flow Volume at Surface (gal)
- Piston Displacement (in/10)
- Hydraulic Fluid Pressure at Downhole Pump (psi)
- Hydraulic Pressure from Field
- Water Flow Volume at Surface (gal)
- Volume of Hydraulic Fluid in Accumulator (gal)
Pressure Oscillations Correspond to Speed of Sound in Water Column
Gas in Water Column Reduces Bulk Modulus to 250 Kpsi
3 ½” Pump Through Casing 7,000 ft Near Vertical, Conventional

- Hydraulic Fluid Pressure at Surface (psi)
- Water Pressure at Downhole Pump (psi)
- Hydraulic Fluid Flow Volume at Surface (gal)
- Piston Displacement (in/10)
- Hydraulic Fluid Pressure at Downhole Pump (psi)
- Field Data
- Water Flow Volume at Surface (gal)
- Volume of Hydraulic Fluid in Accumulator (gal)
Conclusions

• A dynamic numerical model has been developed to model the performance of hydraulically operated dewatering pumps.

• Four pump systems have been built, tested and installed. Results from these systems have been used to modify and validate the model.

• Natural gas driven HPU currently being built.
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