Plunger Velocity: Average vs Surface

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AVERAGE PLUNGER VELOCITY

The way it has always been done
Plunger Sensor Background

• Inductive coil sensing has been the standard
  – Ferrous metal induces current in a coil which closes a switch
  – Susceptible to noise or slow plungers which leads to incorrect detections

• Side Effects
  – One of the least expensive, but one of the most critical components
  – Leads to poor system performance
  – Many times operators compensate for poor sensors further eroding production
Calculating Average Plunger Velocity

• Most systems still rely on average plunger velocity

• Simply use the well depth and arrival time
  – \( v = \frac{d}{t} \)

• System Parameters Depend on Plunger Type and Lubricator
  – Target of 750 ft/min
  – Fast Trip > 1000 ft/min
  – Dangerous Trip > 2000 ft/min
Average Velocity Issues

- The plunger is not entering the lubricator at the velocity you think it is
- Assumes that the plunger was at bottom
- Ignores acceleration and deceleration
- Non-Optimal Operation
- Potential damage to plunger, lubricator, and spring without knowing it
MAGNETIC SENSING TECHNOLOGY

How it works and why it is better
Magnetic Sensing

• Wanted to measure surface velocity, but needed a more reliable technology first

• Magnetic field sensor with microprocessor
  – Digitally filter out noise
  – Build more complex detection algorithms
  – Adjust sensitivity
  – Upgradable software
  – Real time debugging
Magnetic Sensing

- Digital Noise Filter
  - Convert analog voltage to digital
  - Remove high frequency changes

- Detection Algorithms
  - See how signal changes with plunger arrival
  - Arrival sensor simply looks for an amplitude change
Magnetic Sensing

• Magnetic Data Capture
  – Communications interface on Cyclops streams data in real time to ETC Vision
  – Data is graphed or logged to file
  – 10s of thousands of runs captured

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Variance in Plunger Waveforms

- Unique signature per plunger type
- Magnetic field pushed or pulled by ferrous objects
- Some can be very simple
- Other can have multiple peaks
- Difficult for a set of rules that apply to all plunger types
DETECTING SURFACE VELOCITY

Using an instantaneous velocity sensor
• Implements ETC’s magnetic sensing technology to determine instantaneous velocity

• Interfaces
  – Dry contact switch
  – RS-485 Modbus slave

• Operation
  – Velocity measured as plunger passes
  – Switch closed once velocity is available
  – Logs all arrivals even when control system has moved on
  – Modbus port used to retrieve velocity and access settings and logs
Detecting Surface Velocity

• Method
  – Multi sensor array in the same device
  – High speed synchronous clock
  – Multi Point Correlation
  – Accurate (+/- 8%)

• Increasing Velocity
  – Slope increases
  – Peak narrows
  – Time difference between key waveform points reduces
Detecting Different Plunger Types

- Alloy brush plunger
  - Different waveform shape
  - Same principles apply
  - Each plunger type has a signature

- Dual Padded Plunger
  - Multiple Peaks
  - More complex
  - Waveforms may differ
PLUNGER VELOCITY AT SURFACE

Field trial analysis
Surface Velocity Misconceptions

• Issues
  – Historically little to no visibility of instantaneous velocity at surface
  – Assumptions made about surface velocity

• Reality
  – The plunger does not consistently travel at the average calculated velocity
  – Plunger rapidly accelerates at surface due to gas expansion, low line pressure, or loss of fluid.
  – Can also decelerate based on dampening from large slug size
  – Varies per well and each plunger run
Surface Velocity when Venting

- Average velocity relatively stable (750 ft/min).
- Surface velocity lower (475 ft/min)
- Rising surface pressure, slows plunger.
- Well is vented to rise plunger
- Average velocity reported lower on vent cycle because time increased
- Surface velocity spikes over 2000 ft/min.
Optimizing on Average Velocity

- Well optimized on plunger arrival time (average velocity)
- Surface velocity slightly lower, but still erratic per trip
- Average lowered further with no impact on surface velocity
Optimal Average Velocity?

- Operator believed system was optimal based on consistent average velocity (750 ft/min)
- Surface velocity was consistently more than 50% higher (1200 ft/min)
- Decrease in surface pressure brought more fluid into well bore
- Large slugs brought to surface reduced plunger surface velocity
Broken Plunger Investigation

- Operator reported numerous broken plungers and springs
- Average velocity was approximately 300 m/min (1000 ft/min)
- Plunger did not make it to surface in time
- Well closed and build up time added
- Next arrival was over 900 m/min (3000 ft/min)
- Some arrivals over 1700 m/min (5500 ft/min)
Conclusions

- Using times or average velocity is limiting
- Surface velocity is a key parameter that is currently missing in plunger lift operations
- Helps identify issues that are currently getting missed
- Potential to dramatically increase safety and production while reducing maintenance costs
- Gateway to new optimization methods
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