Plunger Velocity Detection, Tracking, and Optimization

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Overview

• Fast plungers are the #1 issue in plunger lift
• Desire to detect fast plungers
• Use information to provide safety shut in
• Tracking plunger behavior
• Optimize off of plunger velocity
  – Enhanced safe operation
  – Maximize production
Issues with Fast Plungers

Safety Issues
- Possibly seriously injured
- Damaged equipment

Environmental Issues
- Potential for spills

Production
- Lost Production on Failure
- Non-Optimal Production (Safety Factor)
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 of 1000 ft/min
  – Dangerous Trip of 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
Use 2 Sensors?

- Too Much Error
  - Different Sensitivity per Sensor
  - Error in Clocks
  - Error in Position
  - Additional Hardware and Programming

- Have to space out 10s – 100s of Meters
  - Underground Installation
  - Long Cable Runs
  - Not Practical
Modern Plunger Detection

- New wave of digital plunger arrival sensors
- Magnetic sensor instead of a coil
- More accurate and reliable arrival detection
- Programmable software
Detecting Velocity – Single Point

Method

- Watch slope of the magnetic waveform
- Compensate for plunger material and length.

Benefits

- Inexpensive
- Simpler Hardware

Drawbacks

- Requires calibration
- Must input plunger information
- Plunger must pass sensor
Detecting Velocity – Multi Point

Method
- Multi sensor array on the same board
- High speed synchronous clock
- Multi Point Correlation

Benefits
- Plunger independent
- More accurate (+/- 8%)

Drawbacks
- Less compact
Increasing Velocity

- Slope increases
- Peak narrows
- Time difference between key waveform points reduces
- Waveform shape is maintained
- Each plunger has a unique waveform

![Graph showing two waveforms with a velocity of 253 ft/min]
Different Material and Geometry

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

- Dual padded plunger
- Multiple peaks
- More complex overall
- Acceleration skews the waveforms
Validation

- Motor with a pulley and a piece of tubing
- Motor speed is varied
- Velocity is independently recorded with photo sensors
- Velocity from sensor is compared to photo sensor velocity
Error Rates

- Compared photo sensor velocity to velocity from waveforms
- Found higher errors at the higher velocities
- Some error due to the fact that the motor is not at a stable speed yet
Further Testing Required

• Building a larger scale test setup
  – Longer run of tubing with higher velocities
  – Put the lubricator back in the equation
  – Add plunger acceleration back in

• Need more runs with different types of plungers

• Move towards field trial
  – Documentation is available
  – Several producers are integrating with their controls
  – Targeting a broad range of well types and plunger types
Safer Operation

• More plunger intelligence
  – Know velocity of each plunger run
  – Trend velocity over time
  – Monitor during afterflow (sales)

• Use velocity for safety features
  – Shut in multiple fast trips (>1000 ft/min)
  – Shut in on single dangerous trip (2000 ft/min)
  – Adjust system parameters to slow future runs
Optimization Algorithm

- Safety factor can be reduced to increase production
- Proportionally adjust afterflow and close times based on velocity
- ETC has patent pending based on our previous time based optimization
- Makes small corrections on each run instead of trying to stop a dangerously fast plunger

\[ \Delta \text{AfterflowTime} = \frac{\text{ActualVelocity} - \text{TargetVelocity}}{\text{TargetVelocity}} \times \text{ScalingFactor} \times \Delta \text{AfterflowTime} \]
What’s Next

• What else can velocity tell us?
• Can we use the difference between average velocity and actual velocity?
• Can we catch other situations where a fast plunger is ignored?
• Do lubricator and spring designs change now that we know the velocity?
• There is certainly a lot more possibilities now that we know actual plunger velocity.
Questions?
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