Smart Automation of Plunger Lift Systems

Exploring the Benefits of Plunger Automation and Advanced Optimization Technologies

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Smart Automation of Plunger Lift Systems: Topics

- ★ Introduction
- ★ Liquid Loading and Plunger Lift
- ★ Conventional Controls and Methane Losses
- ★ Plunger Lift Optimization
- ★ Field Experience
- ★ Discussion

Liquid Loading

- ★ Build-up of hydrocarbons (condensate) and water in well bore which reduces and may halt production.
- ★ Multi-phase flow has three distinct forms:
  - ★ Bubble
  - ★ Slug
  - ★ Annular Mist
- ★ Deliquification methods can vary based on well characteristics and preferences.

Plunger Lift

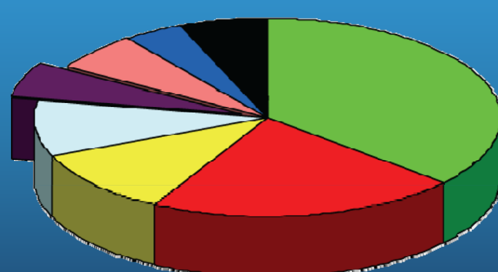
- ★ Intermittent artificial lift method that uses the energy of the reservoir to bring the liquids to the surface.
- ★ Cyclic process with the well alternately flowing and shut-in. Each cycle removes built-up liquids from the formation.
- ★ Due to a wide variety of formation characteristics and well bore irregularities, each well will have distinct behaviors and “personality”.

Conventional Plunger Control

- Manual adjustments to cycle parameters (shut-in time, flow time, etc.) are problematic:
  - Adjustments are not performed regularly
  - Do not account for changing down-hole (liquid production, pressure) or collection conditions (line pressure, separation equipment)
- Fixed cycle times may not match well performance:
  - Cycle too frequently
    - High plunger velocity
    - Excessive plunger wear
  - Not frequently enough
    - Liquid loading becomes excessive
    - Plunger unable to reach surface

Methane Losses

- Liquid loaded plunger wells that will no longer produce gas must be blown down to the atmosphere.
- Onshore well venting and flaring releases 9 Bcf/year of methane.



Plunger Lift Optimization

- Using well-known algorithms and real-time monitoring of well conditions, cycle performance can be evaluated each cycle:
  - Plunger velocity
  - Liquid loading (casing/tubing pressure)
- Adjustments to cycle parameters can be made based on evaluated performance:
  - After flow duration
  - Shut-in time duration

Evaluating Performance

- Plunger velocity:
  - Each plunger type will have specific operating velocity for which it was designed to perform best.
  - The optimization routine will calculate velocity based on arrival time and tubing length.
  - An arrival will be designated as Fast, Normal, Slow etc. based on configurable time "windows".
- Liquid loading and load ratio:
  - Liquid loading of the well is determined by the difference of the casing pressure and the tubing pressure.
  - Well energy is estimated by taking the difference of the casing pressure and the line pressure.
  - The ratio of the well's liquid load and the energy is the load ratio.

Parameter Adjustment

- Shut-in duration:
  - The load ratio (LR) is calculated from well conditions.
  - After enough time is elapsed for the plunger to reach the bottom, the cycle compares the load ratio to a setpoint.
  - When the LR has dropped below the setpoint, the well is brought online.
- After flow duration:
  - The well's critical rate (rate at which liquid can remain entrained) is calculated from well conditions.
  - The "drop rate" is calculated as a percentage of the critical rate.
  - The percentage is adjusted each cycle based on whether the previous arrival was Fast or Slow.

Optimization Advantages

- Plunger cycles adapt to changing conditions:
  - Line pressure swings
  - Liquid surges from within the formation
  - Plunger mechanical wear
- Greatly reduced venting
- Increased uplift volumes:
  - Cycles adapt toward optimum frequency
  - Well life is extended from consistent deliquification
- Plunger wear reduced
- Manpower requirements reduced

Economics of Advantages

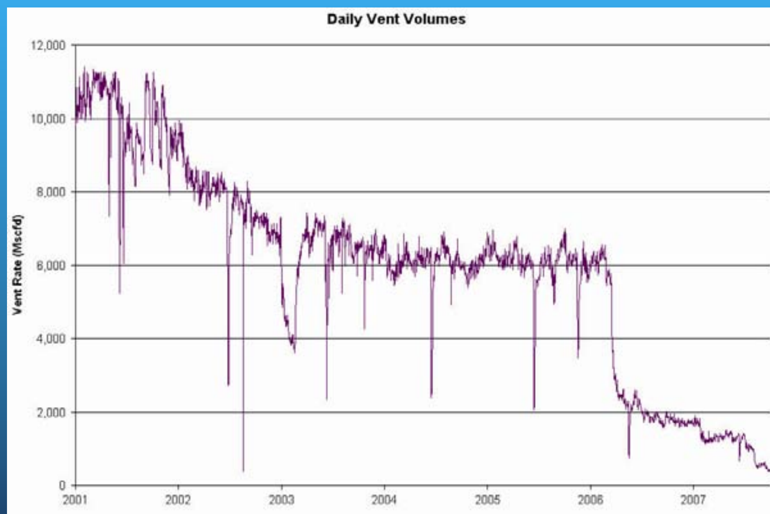
- Well production will generally increase
  - Optimized plunger cycles can increase well production by 10 to 20%
  - The decrease in needed venting can provide an additional production increase of 1 to 2%
  - Manpower requirements reduced by half
- Simple payback calculation:

	(50,000 Mcf/yr) x (10% increased production) x ($4/Mcf)
+	(50,000 Mcf/yr) x (1% vent savings) x ($4/Mcf)
+	(500 personnel hrs/yr) x (0.5) x ($30/hr)
	($12,000 installed cost)
	$17,500 savings in first year (5 month simple payback)

Field Experience at BP

- Installation of optimization in 2000
  - Plunger optimization installed on ~2,200 wells
  - Most sites required installation of logic controllers or RTU's (Remote Terminal Unit)
  - Central hosting system also installed to collect and monitor field data from RTU
- Venting was reduced by 50% from 2000 - 2004

Field Experience at BP



Discussion

- Limitations of optimization
- Other applications
  - Different plunger types
  - Intermitters
- Expertise requirements and learning curve