Sucker Rod Lift Downhole Gas Separators
Proposed Industry Testing

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Background

- API Spec 12J covers design of separators for produced fluids including horizontal and vertical separators.
- These design principles were used by F. W. Gipson and applied to design of downhole sucker rod lift separators back in the 60s based on gravity separation and bubble rise velocity (0.5 ft/sec).
- Developed 4 main criteria for both main types of separator based on area relationship of internal pipe versus external pipe, openings in the mud anchor pipes and required volume of 1.5 to 2 pump displacements.
- Showed importance of pressure and mainly annulus area on separation capacity, typical example follows.
Separator Types

• 2 main types
  – Intake set below perfs (Natural gas separator)
  – Intake set above perfs (many different types)
• When ever possible, should run natural gas separator
• But, many cases where there is no or insufficient rat hole need to consider which is the other best separator to use
• Testing has been conducted verifying Gipson’s recommendations and separator design principles, especially bubble rise for vertical separator
• Echometer developed separator simulator
• But, how do these work, what is the capacity, what is the efficiency when not placed vertical in the well?
Natural Gas Anchor

- Gas entering the wellbore through the perforations rises; liquids fall and pool.
- During the pump upstroke, gas and liquids are drawn downward toward the end of the tail pipe.
- During the pump downstroke:
  - Pooled liquids remain stationary
  - Gas bubbles rise at 6 inches/sec.
- During the next upstroke:
  - Pooled liquids are drawn into the tail pipe and into the pump.
Natural Gas Anchor Capacity

• Methane gas rise velocity in \( \cong 6 \) inches/sec

• The rise velocity of fluid through the annulus of the tubing in casing is given by:

\[
V_{\text{Liquid}} = 0.012 \left( \frac{\text{Pump Capacity in BFPD}}{\text{Separator ID}^2 - \text{Dip Tube OD}^2} \right) \text{ feet/sec}
\]

• For gravity separation:

\[
V_{\text{Liquid}} < 0.5 \text{ feet/sec}
\]

• The maximum pump capacity for gravity separation:

\[
\text{Pump Capacity (BPD)} < 42 \times (\text{Separator ID}^2 - \text{Dip Tube OD}^2)
\]

NOTE: A liquid column with a cross sectional area of 1 inch traveling at 6 inches per second is a flow rate \( \cong 50 \) BPD.
Vertical (Natural Gas) Separator Capacity

Gipson & Swaim Beam Pump Design Chain, 1985
Some Gas Anchors/Separators

**Poor-Boy Gas Anchor**
- Standard tubing used for separator.
- Pump landed above perforations.
- Open bottom can let some gas in.
- Most gas passes along the high side of the wellbore.

**Mud Anchor**
- Larger diameter improves separation.
- Closed bottom blocks direct entry.
- Protects the anchor during run-in.
- Tubing can be run to the bottom of the well without damage.

**Collar Size Separator**
- Outer barrel OD same as collar OD.
- Closed bottom blocks direct entry and protects anchor.
- Thin wall tube and short dip tube.
- Large inlet ports
- Set min 3 jnts below TAC
More Gas Anchors/Separators

Modified Poor-Boy Gas Anchor
- Pump landed above perforations.
- Closed bottom forces fluids downward.
- Oversized tubing for more volume.
- Gas can exit the intake during downstroke.

Packer-Type Anchor
- Pump landed above perforations.
- Very effective gas separation.
- Larger casing required for spillover tube.
- Production limited by size of spillover tube.
- Particulate can accumulate on packer.

Gilbert Cup, Shell Type
- Cups deflect fluid away from inlets.
- Liquids fall back to inlets.
- Gas continues to rise.
- Effective in heavy oil with slug flow.
Static helix separator

- Fluids are pulled by the pump through a helical flow passage.
- Gas is displaced by heavier fluids to the inside and then expelled.
- Creates pressure drop which can lead to early gas breakout when FBHP approaches fluid bubble point.
- In a Venezuelan PCP application*:
  - 8% increase in PCP efficiency
  - 11% increase in production

*Experiences and Best Practices in the use of PCP’s in Orinoco Belt Carabobo Area, Venezuela. Ramos et al., World Heavy Oil Congress, 2008

Source: http://blog.kudupump.com/blog/bid/325064/PC-PUMP-GAS-SEPARATOR
Hybrid-X Type
gas, sands, solids separator

A. Well fluids enter through ports at top and travel down inner annulus.
B. Baffles create turbulence to break up emulsions.
C. Gas separates and flows up annulus and out upper-most ports.
D. Liquids follow spiral path downward; particulate is slung outward to fall downward into mud joint.
E. Cleaned liquids flow up center tube.

Figure courtesy of Dover Artificial Lift
Gravity Orienting Horizontal Separator

- Fluid enters through slots in the outer shell.
- Heavier fluids (liquids) are drawn through a gravity oriented slot within the separator, and into the pump intake.
- Gas and lighter gassy fluids exit through the slots in the shell.

Figure courtesy of Weatherford
The problem…

Which gas separator is appropriate for my well?
## ALRDC R&D Project

### Description
Organizing a joint industry project (JIP) for standardized testing and evaluation of gas separators.

### Purpose
To simplify selection of gas separators

### Project Tasks
1. ALRDC team to Develop standardized evaluation and testing guidelines (test protocols).
2. ALRDC team to prepare an RFP for a centralized testing facility/location to establish and manage the testing JIP.
What can you do?

Be part of the ALRDC team to get this going:

• Join the ALRDC if you are not already a member!  
  (www.alrdc.org)

• Contact Norm Hein with ideas or to join the team:
  nwhein@prodigy.net  
  Office: (412) 833-3620  or Cell: (432) 631-2026

• Help develop evaluation criteria and testing standards.

• Help define test equipment and systems.

• Help write an RFP for the centralized testing JIP.
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