IMPROVED DOWNHOLE GAS SEPARATORS IN SRP SYSTEMS

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OUTLINE

• PROBLEM DESCRIPTION
• GRAVITY DRIVEN SEPARATORS
• EXPERIMENTAL PROCEDURE
• RESULTS
• CONCLUSIONS
100% liquid pump barrel fillage is desired. Otherwise:

- Decreased volumetric efficiency
- Fluid pound
PROBLEM DESCRIPTION

Incomplete liquid barrel fillage using a “poorboy” gas separator

Delayed opening of traveling valve
GRAVITY DRIVEN SEPARATORS

Gas bubble’s position in separator annulus:

\[ V_{\text{gas}} = V_{\text{liquid}} - V_{\text{slip}} \]

(downward velocity)

\[ V_{\text{slip}} = 6 \text{ in/s for low viscosity fluids} \]

- Bubble size
- Fluid viscosity
- Density difference
Varying liquid velocity during the upstroke in separator annulus

Conventional, $D_{\text{plunger}}=1\text{in}$, $L_s=86\text{in}$, $8.45\text{spm}$, 200BPD
Gas bubble flow path over several strokes

Conventional Pump. $D_{\text{dip tube}} = 1.5$ in,
$D_{\text{plunger}} = 1$ in, $L_s = 86$ in, 8.45 SPM
Gas bubble’s net velocity, $V_{\text{net}}$

\[ V_{\text{net}} = V_{\text{avg. upstroke (downward)}} - V_{\text{avg. downstroke (upward)}} \]

- $V_{\text{net}} \leq 0$: No gas enters dip tube
- $V_{\text{net}} > 0$: Gas will enter dip tube
(If upstroke duration = downstroke duration)

Is a long downhole gas separator needed?

6 ft is enough (Lisigurski)
EXPERIMENTAL PROCEDURE

LABORATORY FLOWLOOP SCHEMATIC

Allows intermittent flow
Intermittent flow conditions

Automated butterfly valve

Program motor to set pumping speed
i.e. Open for 3 s. and close for 3 s. → 10 SPM

Max. torque: 24 oz-in
Inertia: 0.32 oz-in²
RESULTS

POORBOY 1 AND 6
OD DIP TUBE = 1”  \( P_c = 10 \) psi
LOWEST ENTRY PORT DISTANCE ABOVE PERFORATIONS = 20”
STROKES PER MINUTE = 10

\[ V_{sl\,avg} = \frac{\text{Average liquid production rate}}{\text{Mud anchor-dip tube annular area}} \]

Extra foot with 12 more 3/8” holes
<table>
<thead>
<tr>
<th>Poorboy 1</th>
<th>Poorboy 6</th>
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<tbody>
<tr>
<td>(12 holes along 1 ft)</td>
<td>(24 holes along 2 ft)</td>
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Poorboy 1

231 BPD
106 MSCFD

Poorboy 6

241 BPD
111 MSCFD
Changing entry port geometry
Can we go beyond 6 in/s?

PATTERSON, ECHOMETER AND POORBOY
OD DIP TUBE = 1”  Pc = 10 psi
LOWEST ENTRY PORTS DISTANCE ABOVE THE PERFORATION: 20”
STROKES PER MINUTE: 10

\[ V_{sl\, \text{avg}} = \frac{\text{Average liquid production rate}}{\text{Mud anchor-dip tube annular area}} \]
Separator annular area effect

Mud Anchor – Dip tube annular area
Using 1 in. OD DT:
  5.154 in²
Using 1.5 in. OD DT:
  4.172 in²
19% less space than with 1 in. DT

Bubble size inside separator

3 mm.
4 mm.
6 mm.
The ‘pump’ stroke

A. Bubble phase moving down
B. Bubble phase continuing to move down after 4 inches
C. Bubbles begin to enter the dip tube

UPSTROKE

D. Bubbles no longer enter the dip tube
E. Bubble phase moving up
F. Bubble phase continuing to move up after 4 inches
G. Bubble phase moving down (back to position A)

DOWNSTROKE

UPSTROKE
Smaller annular space allows more gas bubbles coalescence.

Hence, higher gas bubble rise velocity.

LOWEST ENTRY PORT DISTANCE ABOVE THE PERFORATION: 20"

Pc = 10 psi  DIMENSION OF THE SLOTS = 4” x 1”

10 STROKES PER MINUTE
As well as increased liquid velocity

At similar superficial liquid velocities, the liquid holdup is smaller for smaller annular spaces.
Entry port position relative to perforations

- Entry ports above the perforations
- Entry ports in front the perforations

32”
Placing entry ports in front the perforations is better than above.

**Separator Type:** Echometer 6

- OD Dip Tube = 1.5”
- Number of Slots = 4
- Dimension of the Slots = 4” x 1”

**Entry Port Position:**
- Blue: 3.2” above perforations
- Red: In front perforations
- Green: 0 psi

**Graph:**
- Gas rate entering the well (MSCF/day) vs. Liquid production rate (BPD)
- Gas Rate through Separator (MSCF/day)

*(223 BPD)*
CONCLUSIONS

• What we learnt before (Lisigurski and Guzman):
  – If we have enough rathole to set the pump intake below the perforations (at least 6 ft), we do not need a downhole gas separator.
  – Multiple rows of slots are not necessary.
  – The width of the slot is not important, but the total area is.
  – Maximize diameter of the dip tube (avoid high pressure drops).
  – It is not necessary to have a long dip tube (6 ft is enough).
CONCLUSIONS

• Developments:

  – Increasing the number of holes in a “poorboy” separator improves the operational range.
  – Having an entry port area half the size of the mud anchor-dip tube annular area is sufficient (as seen with the “poorboy” with 24 holes).
  – Changing the entry port geometry has no significant impact on downhole gas separator efficiency.
  – Placing the separator entry ports in front of the perforations is better than placing them above the perforations (Guzman).
  – Decreasing the separator annular area
    • Increases bubbles coalescence.
    • Increases liquid effective velocity.
CONCLUSIONS

- All gravity driven separators tested are limited by the 6 in/s threshold; and,
- changing the entry ports configuration does not have a significant impact.
- So, changing the inside of the separator should be tried.

• Future work:
  – Centrifugal downhole gas separators (early testing already in progress)
  – Study effect of pumping speed
  – Study effect of changing liquid’s viscosity
THANK YOU FOR YOUR ATTENTION

ANY QUESTIONS?

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