Comparing Annular Flows Through Tubing Anchors

Walter Phillips
Black Gold Pump & Supply
http://blackgoldpump.com/
Two Basic Types of Anchors

Mechanical & Hydraulic
What is a Hydraulic Tubing Anchor?

Similar to a TAC in function (not form)

• Rod-pump application
• Uses tubing pressure to engage teeth
  – No rotation/screw/wedge action
• Not a “Catcher” (when does tubing typically fall?)
• Resolved/fixed design flaws and failures
• Successfully deployed in over 1500 wells
Numerical Flow Area Comparison

<table>
<thead>
<tr>
<th>Casing</th>
<th>Hydraulic Area</th>
<th>Mechanical Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>7” 26#</td>
<td>7.215 in²</td>
<td>4.475 in²</td>
</tr>
<tr>
<td>7” 29#</td>
<td>6.813 in²</td>
<td>3.875 in²</td>
</tr>
<tr>
<td>5½” 17#</td>
<td>3.306 in²</td>
<td>1.262 in²</td>
</tr>
<tr>
<td>4½” 11.6#</td>
<td>2.020 in²</td>
<td>0.606 in²</td>
</tr>
</tbody>
</table>
Motivation

Different flow characteristics

• The hydraulic anchor has a larger bypass area
  – How significant is this?
• Offset/eccentric tubing
  – See offset gas anchors
• Restricted Casing Annulus
  – See Echometer paper
    – SWPSC #2014015 - Tubing Anchors Can Restrict Production Rates And Pump Fillage

The Beam Lift Handbook, by Paul M. Bommer and A.L. Podio. Published by PETEX™ (Petroleum Extension Service) of The University of Texas at Austin, 2012.
Un-Restricted Tubing

- No anchor restriction
- Fluid level drops easily & consistently

Inflow increases as bottom-hole pressure is reduced
(reservoir pushes fluid into the wellbore)
Restricted Tubing Anchor

- Anchor restriction creates separate regions
- Not all fluid may fall passed the anchor
  - But gas can rise passed the anchor

Mechanical Tubing Anchor

Turbulent gas flow through the anchor
Restricted Tubing Anchor

- Anchor restriction creates separate regions

- Not all fluid may fall passed the anchor
  - But gas can rise passed the anchor

- Creates a pressurized gas volume below the anchor
Restricted Tubing Anchor

- Anchor restriction creates separate regions
- Not all fluid may fall passed the anchor
  - But gas can rise passed the anchor
- Creates a pressurized gas volume below the anchor
- Places back pressure on the reservoir

Anchor & gas pressure supports gas/liquid column

Pump displacement surpasses inflow at higher apparent producing bottom-hole pressure
What about a hydraulic anchor?

- Larger bypass area
- Tapered top & bottom surfaces
- Shorter overall length
Model Testing & Comparison

- ~1/4 scale anchor models
  - 1¾”, 1¼”, & ¾” OD
  - 3D Printed ABS
  - Cutout Profile Plates

- Qualitative Results
  - Applicability to real-world sizes & conditions are debatable
  - General comparisons between anchor types should hold

- Investigate gas flows, multiphase flow, and solids
  - Lots of assumptions
Pressure Drop Through Anchors

Simple gravity drain test using water

- Gas flow difficult to measure on a budget
- Relative comparison using water
- Given flow rate & 0.433 PSI/ft
  - How high will the fluid column build up?
  - Gives us $\Delta P$ @ a known flow rate
    - (And fluid type – Relative Comparison....)

http://xkcd.com/969/
Relative $\Delta$ PSI

- $\frac{3}{4}''$ Model – Sized for garden hose GPM
- 7” anchor approximation
- Hyd. – 3.5 GPM @ 1.7 PSI (4ft)
- Mec. – 2.7 GPM @ 1.7 PSI (4ft)
Hourglass – Orifice Shape

- Sand flowing past the anchors – 1¾” Model
- Sand flowing through an equivalent circular area

- Hyd. – 1.102 in² bypass area (0.592” Dia)
- Mec. – 0.627 in² bypass area (0.447” Dia)
  - Actual anchor bypass area 6.183 in² vs. 3.875 in²
Sand Flow Results

- As expected, the larger area flowed more
- Unforeseen – Bypass area/wall interface (addressed)
- Unexpected – Hydraulic cutout flowed slightly faster
  - Sand column properties – Not strictly analogous to gas/fluid
Gas Bubbles Through the Anchors

Aquarium air stone to generate bubbles

- **Turbulent Flow vs. Laminar Flow**

  - Stable Bubbles
  - Liquid Falling
  - Slugging Gas
  - Larger Bubbles
  - Bubbles Collecting
More Bubbles

- Tiny bubbles
- Barely flowing

Upward Vertical Two-Phase Flow Through an Annulus — Part I, University of Tulsa
Conclusions

• Hydraulic anchors are good at handling flows in the casing annulus
  – Offset “eccentric” placement
  – Tapered ends act as a funnel
  – Larger & contiguous bypass area

• Less likely to cause a restriction

• Really easy to install & set/unset

• Great for running capillary lines (chemicals)
Further Work

No substitute for real-world conditions

• Need test wells that have documented gas or solids related issues with mechanical tubing anchors

• Rod-pumped wells with gas flows that are not compatible with mechanical anchors?

• Wells that are affected by the restriction phenomenon described previously
  – Gas/fluid buildup above the anchor, backpressure on the reservoir
Rights to this presentation are owned by the company(ies) and/or author(s) listed on the title page. By submitting this presentation to the Gas Well Deliquification Workshop, they grant to the Workshop, the Artificial Lift Research and Development Council (ALRDC), and the Southwestern Petroleum Short Course (SWPSC), rights to:

- Display the presentation at the Workshop.
- Place it on the [www.alrdc.com](http://www.alrdc.com) web site, with access to the site to be as directed by the Workshop Steering Committee.
- Place it on a CD for distribution and/or sale as directed by the Workshop Steering Committee.

Other use of this presentation is prohibited without the expressed written permission of the author(s). The owner company(ies) and/or author(s) may publish this material in other journals or magazines if they refer to the Gas Well Deliquification Workshop where it was first presented.
Disclaimer

The following disclaimer shall be included as the last page of a Technical Presentation or Continuing Education Course. A similar disclaimer is included on the front page of the Gas Well Deliquification Web Site.

The Artificial Lift Research and Development Council and its officers and trustees, and the Gas Well Deliquification Workshop Steering Committee members, and their supporting organizations and companies (here-in-after referred to as the Sponsoring Organizations), and the author(s) of this Technical Presentation or Continuing Education Training Course and their company(ies), provide this presentation and/or training material at the Gas Well Deliquification Workshop "as is" without any warranty of any kind, express or implied, as to the accuracy of the information or the products or services referred to by any presenter (in so far as such warranties may be excluded under any relevant law) and these members and their companies will not be liable for unlawful actions and any losses or damage that may result from use of any presentation as a consequence of any inaccuracies in, or any omission from, the information which therein may be contained.

The views, opinions, and conclusions expressed in these presentations and/or training materials are those of the author and not necessarily those of the Sponsoring Organizations. The author is solely responsible for the content of the materials.

The Sponsoring Organizations cannot and do not warrant the accuracy of these documents beyond the source documents, although we do make every attempt to work from authoritative sources. The Sponsoring Organizations provide these presentations and/or training materials as a service. The Sponsoring Organizations make no representations or warranties, express or implied, with respect to the presentations and/or training materials, or any part thereof, including any warranties of title, non-infringement of copyright or patent rights of others, merchantability, or fitness or suitability for any purpose.