The Use of Foamer and Injection Nozzle for Increasing Gas Production

Duy Nguyen, Ph.D
Greg Conrad
Nalco Energy Services, Sugar Land, TX, USA
Foaming Technology: Yesterday, Today and Tomorrow

Yesterday

Yesterday, foamer selection was a lot like fishing. It was an art.

Investigation of key factors that govern the foaming performance and foaming mechanisms.

*“Petroleum Science and Technology” Journal, July 2009

Today

Patented nozzle for increasing gas production

Tomorrow
Contents

• Patented Nozzle

• Effect of condensate on foamer performance
  – Mechanisms

• Effect of salt on foamer performance
  – Mechanisms

• Field Trials
Downhole Injection Assembly

- production tubing
- capillary tube
- fitting
- valve body
- capillary tube
- injection cover
- production tube tip
Components of valve/sprayer subassembly

- capillary tube
- fitting
- control valve
- valve spray assembly
- production tubing
- ¼” opening
- nozzle
Video
Effect of Foamer Concentration on Unloading Efficiency

Conditions: Tap Water, No Condensate

Nalco's Patented Nozzle

30% more effective

Conventional Method
Comparison of Nalco's Patented Nozzle with Conventional Method
Conditions: Tap Water, No Condensate, 1900 ppm Foamer

- Effectiveness
- Efficiency
Oil Droplet in Lamella

Oil Droplet

Water

Bubble 1

Bubble 2
Lamella Rupture

Surface tension gradient

Bubble 1

Bubble 2
Escaping Oil Droplet

Oil Droplet

Bubble 2
DILATIONAL ELASTIC MODULUS (E)

A measure of the ability of a surface to recover from applied stress
Resistance to deformation

\[ E \text{ (dyne/cm)} = \frac{\text{surface stress}}{\text{strain per unit area}} \]

\[ E = \frac{dy}{dA/A} \]
Oscillating Drop Tensiometer (A.K.A. The TRACKER)

- Piston Clamp: Driven by DC Motor
- Syringe clamp
- Syringe piston
- Curved needle
- Halogen lamp

B = Glass sample cuvette
C = CCD camera

Drop Shape Analysis

Definition -> Dilatational Modulus, $\varepsilon$:

$$\varepsilon = \frac{d\gamma}{d \ln A} = \frac{d\gamma}{dA / A}$$
Correlation between %Unloading and Elastic Modulus with Condensate

% Unloading @25 min vs. Elastic Modulus, dyne/cm

- Betaine
- Olefin sulfonate
- Alkyl ether sulfate
Effect of Salt on Foaming Performance

- Fresh water
- 9000 ppm TDS
- 19,000 ppm TDS
- 50,000 ppm TDS
- 150,000 ppm TDS

% Unloading

- 5000 ppm foamer
Packing at the air-liquid interface

Foam Stabilizing: Area per molecule

- **Low salt**
  - Unstable foam
  - Loosely packed film
    - High area per molecule

- **High salt**
  - Stable foam
  - Tightly packed film
    - Small area per molecule
Foam Destabilizing – Reduced Electrostatic Repulsion

Low salt

Stable foam

High salt

Unstable foam

Liquid flows

Drainage

Foam Destabilizing – Reduced Electrostatic Repulsion

Low salt

Stable foam

High salt

Unstable foam

Liquid flows

Drainage
Gas Well Deliquification
Capillary String Method

- Capillary Strings with foamer is a “lift method”
- The Problems of the past are being engineered out
  - Plugging – cap string certified products
  - Collapsing – better banding practices and stronger materials
  - Foam block – patented control valve
  - Surface facility issues – use of defoamers
  - Capillary string corrosion – corrosion resistant metalurgies and matched banding materials
- Capillary strings can be used in conjunction with other lift methods to increase production
Gas Well Deliquification
Installation Recommendations

• “Cradle to Grave” philosophy – the best time to install for maximum benefit and cost is when the well is completed

• Designed for your well
  – Echometer Analysis
  – Completion design
  – Wellhead design

• Outside tubing installations

• Patented down hole injection valve
Case Study #1: McMurdy #3
Conditions: 35% Condensate

Installed patented nozzle + Foamer
Case Study # 2: McMurdy #2
Conditions: 24% Condensate

MMCF per Day

Installed patented nozzle + Foamer
Case Study #3: Verdell #1

Mcf per day

0 50 100 150 200 250 300


Installed patented nozzle + Foamer
Summary

• Fundamental understanding effect of condensate resulted in “best in class” high condensate foamer (up to 95% condensate)
  – “Selection and Application of Chemical Foamers for Offshore, North Sea” - Nalco & Britannia

• Patented nozzle for enhancing gas production
Acknowledgements

Fenfen Huang
Trier Ward
William Dudley
Copyright

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 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 uses of this presentation are prohibited without the expressed written permission of the company(ies) and/or author(s) who own it and the Workshop Steering Committee.
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 warrantees of title, non-infringement of copyright or patent rights of others, merchantability, or fitness or suitability for any purpose.