Dissolved Gas Flotation – Bubble Benefits

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Introduction / Contents

Floatation technology is one of the main methods for removing contaminants from waste streams resulting from remediation, stimulation, completion and workover fluid activities. Not only is there a need to increase the efficiency of these systems; there is also a need to reduce the size and weight of the equipment.

Contents
- What is Flotation
- Available Technologies
- Results of Field Testing
- Summary
Flotation Process

- Float solids, oils, and other contaminants
- The floated contaminates are skimmed and removed
- Attachment of gas bubbles to oil droplets is the key factor
Flotation Process – Stokes Law

\[ V_s = \frac{2}{g} \frac{r^2 g (\rho_p - \rho_f)}{\eta} \]

- \( V_s \) - Oil settling velocity (cm/sec)
- \( r \) - Stokes radius of the oil droplet (cm)
- \( g \) - Standard gravity (cm/sec^2)
- \( \rho_p \) - Density of the oil (g/cm^3)
- \( \rho_f \) - Density of the water (g/cm^3)
- \( \eta \) - Fluid viscosity (dyne sec/cm^2)
Flotation Process – Stokes Law

\[ V_s \approx \rho_p \]

- \( V_s \) - Oil settling velocity (cm/sec)
- \( \rho_p \) - Density of the oil (g/cm\(^3\))
Flotation Systems

- Dissolved Air Flotation (DAF)
- Induced Gas Flotation (IGF)
- Sparging System
- Dissolved Gas Flotation (DGF)
Dissolved Air Flotation (DAF)

- Air is compressed and dissolved into the water stream
- Bubble size is very small and results in good separation
- System requires a compressor and saturation tank
- Not suited to off-shore applications due to large footprint/weight and high maintenance requirements
Induced Gas Flotation

- System can be Mechanical or Hydraulic

- Mechanical
  - Uses motor and paddle to shear gas out of the water
  - As the paddle spins in the water, it agitates the cell with small bubbles
  - The mechanical portions require some maintenance
Induced Gas Flotation – Mechanical Design

Figure 1a. Mechanical system.
Induced Gas Flotation

- System can be Mechanical or Hydraulic

- Hydraulic
  - Uses a recirculation pump to drive an educator, which induces fine gas bubbles into the water.
  - Each flotation cell is filled with many micro-fine gas bubbles.
  - The recirculation pump recycles from 25% to 125% depending on the equipment design.
Induced Gas Flotation – Hydraulic Design

Figure 1b. Hydraulic system.
Gas Sparging

- This system uses a porous stainless steel tube to sparge small gas bubbles into the water.
- The gas bubbles are very small and provide good results.
- The sparge tubes, however, are prone to plugging with scale and/or hydrocarbons.
Dissolved Gas Flotation

- Back pressure is key to system operation and can be tuned
- Utilizes a dual sided impeller to pull both water and gas
- Gas is dissolved into the water creating very fine bubbles.
- Gas/water mixture flows across a globe valve creating a pressure drop
- Gas breaks out of solution with pressure drop
- Discharge from globe valve is sent to a gas floatation unit
- Fine bubbles produced by the dissolved gas aid in oil separation
## System Comparison

<table>
<thead>
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<th>System</th>
<th>Prone to Fouling</th>
<th>Suited to Off-Shore Operation</th>
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<tbody>
<tr>
<td>DAF</td>
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<tr>
<td>Sparging System</td>
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<tr>
<td>IGF</td>
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<td>Yes</td>
</tr>
<tr>
<td>DGF</td>
<td>No</td>
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</table>
Bubble Formation

Bubble Density

DGF  >>  IGF
DGF Bubble Formation

DGF Pump Off
DGF Bubble Formation

DGF Pump On 5 Seconds

Image: DGF Pump in action with visible bubble formation.
DGF Bubble Formation

DGF Pump On 30 Seconds
DGF Bubble Size Control

Data collected with a Microtrac S3500 Particle Size Analyzer
Siemens Water Technologies DGF pump used for testing

DGF technology can create gas bubbles from 1 to 175 microns
DGF Flexibility

- Ability to adjust to changing water chemistry in real time
- Ability to adapt to varying oil droplet sizes in a matter of minutes

DGF Efficiency Optimization

1. Measure Influent Oil and Grease
2. Measure Effluent Oil and Grease
3. Adjust DGF Back Pressure
4. Repeat Until Optimized

Repeat Until Optimized
DGF Flexibility

DGF Oil & Grease Removal Efficiency

Efficiency (%) vs DGF Pressure (PSI)
## System Comparison

<table>
<thead>
<tr>
<th>System</th>
<th>Prone to Fouling</th>
<th>Suited for Off-Shore</th>
<th>Mechanical Parts</th>
<th>Bubble Density</th>
<th>Flexible Operation</th>
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<tbody>
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<td>Few</td>
<td>High</td>
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</tbody>
</table>
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Thank you for your attention!