Typhonix AS
Next generation process flow control solutions

Development of a New Separation Friendly Centrifugal Pump

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TEKNA Produced Water Management 2015
Presentation Overview

- Company
- Technology Background
- Pump Development
- Prototype Testing
- Test Results
- Overall Conclusion
- Benefits
Company

Low Shear control & choke valves
Low shear pumping solutions
Multiphase sampler

Sponsors:

3-Phase Lab testing facilities
Technology Background

Field experience with produced water pumping

Ref. Mator, Tekna Conf. PW 2010
Flanigan et al. 1988
Development project

Project goal:
Develop a separation friendly multi-stage centrifugal pump for produced water applications
Test rig
Testing Parameters

Determine the influence of pump geometry, operating and process conditions on oil droplet break-up.

- Impeller geometry
- Diffusor geometry
- Pump differential pressure
- Inlet OiW concentration
- Inlet droplet size
- Crude type
- Water Salinity
- Etc.
Some Results

Pump development project:
- 17 different test set-ups.
- More than 4000 test-points.
Design established

Low shear multi-stage centrifugal pump design established

Input:
- Pump head
- Capacity
- Inlet droplet size (Dv50)
- API crude
- Allowed droplet size reduction
Process Benefits

Decoiling Hydrocyclone Separation Efficiency

Increased separation efficiency from minimal droplet growth

Inlet Oil Droplet Size, microns
From Low Shear to Coalescing

- Control shear level to obtain coalescence
- Collision based coalescence dependent on:
  - OiW concentration
  - Inlet droplet size
  - Turbulence intensity
  - Fluid viscosities
Early results
Prototype

Specifications:
• Capacity: 60 m³/h
• Differential Head: 150 m

Performance parameters:
• Outlet droplet size
• Hydrocyclone efficiency
• Hydraulic efficiency

Comparison:
• Progressive cavity pump
• Single stage centrifugal pump
## Prototype Testing

<table>
<thead>
<tr>
<th>TEST PUMP</th>
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<tbody>
<tr>
<td>CENTRIFUGAL</td>
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<tr>
<td>SCREW</td>
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<tr>
<td>PROTOTYPE</td>
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<table>
<thead>
<tr>
<th>CRUDE</th>
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<tbody>
<tr>
<td>Light oil (API 44)</td>
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<tr>
<td>Heavy oil (API 19)</td>
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<table>
<thead>
<tr>
<th>[OIL]</th>
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<tbody>
<tr>
<td>500 ppm</td>
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<tr>
<td>100 ppm</td>
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<table>
<thead>
<tr>
<th>Droplet size</th>
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<tr>
<td>6 - 7 μm</td>
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<tr>
<td>10 - 12 μm</td>
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</table>
Test results – Outlet droplet size

**Pump Outlet Oil Droplet Size**

<table>
<thead>
<tr>
<th>% Change $Dv(50)_{out}$</th>
<th>6-7 µm 500 ppm</th>
<th>10-12 µm 500 ppm</th>
<th>6-7 µm 100 ppm</th>
<th>10-12 µm 100 ppm</th>
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<th>10-12 µm 500 ppm</th>
<th>6-7 µm 100 ppm</th>
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<td>Heavy Oil</td>
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</table>
Test results – Outlet droplet size
Test results – Outlet droplet size
Test results – Outlet droplet size
Test results – Effect on HC efficiency

% Reduction in [OiW] in HC outlet compared to Centrifugal pump

<table>
<thead>
<tr>
<th></th>
<th>6-7 µm</th>
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<th>10-12 µm</th>
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</table>
Test results – Hydraulic efficiency

Hydraulic efficiency

Hydraulic efficiency [%]

Centrifugal Pump | Screw Pump | Prototype Pump

0 10 20 30 40 50 60 70 80 90 100
Conclusions

- The coalescing pump significantly increases oil droplet size
  - Coalescence is increased with increasing oil concentration
  - Coalescence is increased with reducing inlet droplet size

- The coalescing pump significantly increases hydrocyclone efficiency

- The coalescing pump has significantly higher hydraulic efficiency than a single-stage centrifugal pump

- Coalescing low shear multi-stage centrifugal pump – ready for first use
Benefits

- Increase performance of d/s produced water treatment equipment.
- Less oil in produced water.
- Both Low Shear and Coalescing
- Better suited to handle upsets.
- Robust and Reliable pump type, High Mean Time Between Failure.
- Low maintenance load.
- Less need for chemicals.