Efficient and Flexible Crude Oil processing technology for Oil Separation facilities.

Recent Advances in Offshore Technology
St. John’s, Newfoundland
Wednesday 1st of October 2014
Outline

• Introduction
• Electrocoalescence
  – Separation challenges encountered with oil production
• VIEC® Technology
• Oil Production with VIEC® Technology
• Predicting separation performance:
  – Laboratory testing
  – Scale-up of test results
• Case studies
• Summary
VIEC® is the optimum solution for separation of water from oil, improving production capacity, eliminating emulsion issues, reducing heating demand as well as space and weight requirement.
Electrocoalescence

• Separation of water-in-oil emulsions can be split into two main processes:

**Coalescence**

Controlling factors:
- Crude oil viscosity
- Interfacial tension
- Droplet sizes
- Droplet number density
- Presence of stabilizing surface active components

**Sedimentation**

Controlling factors:
- Crude oil viscosity
- Droplet size
- Density difference

\[ v = \frac{g \Delta \rho}{18 \mu} d^2 \]

Good separation usually requires both efficient coalescence and sedimentation.
Electrostatic effect on Separation of Oil and Water

- Electrocoalescence is a well-known and field proven principle for separating oil and water.
- An external electrical field polarizes water droplets causing them to attract to each other.
- The enlarged droplets will coalesce and sediment out more efficiently (Larger dispersed phase droplets settle faster following Stokes Law)

\[ F \propto \varepsilon_c E_0^2 \frac{r_1^3 r_2^3}{S^4} \]

**Dipolar electrical force**

\[ \nu_s = \frac{\Delta \rho gd^2}{18\mu} \]

**Stokes’ sedimentation law**

George Gabriel Stokes (1819-1903)
Electrostatic effect on Separation of Oil and Water

Force components of induced dipole-dipole forces between two neighboring droplets
## Conventional approach

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<thead>
<tr>
<th>Measure</th>
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<th>OPEX impact</th>
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| Increase process temperature    | • More/larger utility equipment  
• Higher material grade requirement | • Increased energy demand    |
| Increase chemical dosage        | • Larger weight  
• Larger space requirement for process facility | • Increased chemical consumption |
| Increase vessel sizes           | • Larger weight  
• Larger space requirement for process facility |                            |
| Increase number of treatment stages | • Larger weight  
• Larger space requirement for process facility  
• More process equipment  
• More piping and utility equipment | • Increased maintenance     |
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Applying electrocoalescence represents a more efficient and cost-effective way of resolving separation challenges
When processing crudes, the advantages of introducing electrocoalescence earlier in the process train are significant.

Breaking the emulsions and separating out as much water as possible in the early stages will help establish the following operational benefits:

- Reduced energy demand
- Reduced emulsion layers
- Improved level control
- Potential for increasing production
- More robustness
- Optimal inlet conditions for a traditional electrostatic coalescer downstream
Screenshots showing level profile readings without VIEC (Left panel) and with VIEC (Right panel).

A significant improvement in interface development is visible with VIEC compared to without VIEC.
Wärtsilä has implemented the principle of electrocoalescence in its VIEC Technology (Vessel Internal Electrostatic Coalescer).

The VIEC technology has two characteristic features that distinguish it from conventional electrocoalescers:

- Fully insulated electrodes using a specialized insulating material suitable for the chemical and electrical environment.
- Integrated transformers in each electrode supplied by a low voltage feed (230V)

VIEC Insulated electrodes tolerate free water and gas allowing for placement in upstream process.
VIEC® Technology cont.

**TYPICAL APPLICATIONS**
- Installed in production and test separators
- Reference list covers crude oils API 12-50
- Improved Heavy oil / high viscosity separation
- Bulk Water Removal giving (2–10 % WiO)
- Export oil quality (< 0.5 % WiO)
- Suitable for both retrofit and new builds

**TECHNICAL FEATURES**
- Insulated electrodes tolerating 100% gas/water
- Power consumption 10-50 kW per wall
- Low voltage installation (230 V)
- ATEX/PED compliant
- UL certified for US/Canadian applications

**INSTALLATION/OPERATION**
- Installed through 18” – 24” manholes
- Installation time 4-6 days
- No welding, bolted connections only
- Fully automated - no operator interaction
- Local/remote on/off control available
- Data logging providing advanced diagnostics

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**VIEC® CONFIGURATION**
- VIEC® plates and earth plates are mounted in racks.
- The assembled racks forms a complete VIEC® walls.
- Each VIEC® plate is connected to a penetrator on top of the separator via a conduit system.
- All VIEC® plates are cabled to an electrical room in safe location and connected to the VIEC® cabinet(s)
To have necessary confidence in the performance of separators, design of separation solutions should be based on more than simple design rules. Wärtsilä has developed a framework for consistent prediction of separation performance by combining separation testing and modelling.
Scale-up of separation performance cont.

- Only results from flow loop tests are used for predicting separation performance in a full scale separator, to take into account important dynamic effects.
- Scale-up is accomplished by taking advantage of the scale invariance following of two relatively “simple” parameters. This is possible due to the dominant nature of the electrostatic effect on separation performance.

\[
\alpha = \frac{t_E \gamma^2 \varepsilon_c E^2}{\mu \left[ \left( \frac{\pi}{6\phi_0} \right)^{\frac{5}{3}} - 1 \right]}
\]

Effect of electrical field on droplet growth

\[
\beta = \frac{t_R \Delta \rho g d^2}{\mu H}
\]

Effect of droplet size on sedimentation rate

* Definition of the variables and a more detailed explanation can be found in the paper
Optimizing
- Reduce separator size
- Reduce de-salter fresh water consumption
- Reduce fluid heating requirement
- Reduce chemical dosing
- Increase flexibility for tie ins

Cost of heating
- Enables separation at higher viscosities /lower temperatures
- The VIEC Technology can potentially reduce the heat load by 50%, hence reducing power consumption and emissions

Cost of weight/space
- Enables reduced vessel sizing and removal of equipment.
- The VIEC Technology can potentially reduce the size of a separator or eliminate separator vessels.

Heavy oil processing
- Enables improved dehydration when processing heavy oils.
- The VIEC Technology will provide separation of water at viscosities up to 100 cP.

Production capacity
- Enables increased production with existing separators
- The VIEC Technology allows de-bottle necking and tie-ins giving flexibility in utilizing the existing separation equipment

Customer value proposal
- Optimize design
- Estimate performance
- Verify performance
- Separation performance verification (based on actual crude oil samples)

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OPTIMIZATION OF OIL SEPARATION TRAINS WITH VIEC® TECHNOLOGY
Canada field development

• Case details:
  – Heavy oil field offshore in Canada
  – API gravity of 20
  – Field to be produced to a platform
  – Design oil flow rate: 150 MBOD
  – Design water flow rate: 350 MBWD
    (water cut ranging from 33 to 83%).

• Benefits sought by client:
  – Reduce energy for heating by reducing process temperature at medium pressure stage
  – Reduce size of medium pressure separator
  – General risk mitigation
Canada field development

- Following benefits with VIEC technology were identified by performing a oil study:
  - Process temperature at medium pressure stage (MP) could be reduced from 90 °C down to 60 °C.
  - Length of MP separator reduced from 29 m to 21.5 m.
  - Less dependence on demulsifier type
  - Reduced demulsifier consumption

![Emulsion (Untreated)](image1)

![Emulsion After Exposure to Electrostatic Field](image2)

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Canada field development

Element | Nameplate Capacity
---|---
Total Oil Production | 150 kbd 23,900 m³/d
Total Water Production | 283 kbd 45,000 m³/d
Total Gas Handling | 235 MSCFD 6,700 km³/d
Total Water Injection Rate | 360 kbd 57,300 m³/d

Design optimization

- Pre FEED Design Basis based on conventional design.
  - MP Sep 5.000 x 29.000 Operating temp 90 deg C, Spec < 15% WC
- FEED Design Basis using VIEC technology
  - MP Sep 5.650 x 27.000 Operating temp 70 Deg C, Spec < 15% WC
- After Oil Study using VIEC LW Technology:
  - MP Sep 5.400 x 21.500 Operating temp 60 Deg C, Spec < 10%WC

Remarks

- Dimensioning criteria is the residence time of water and the peak oil case.
- Retention time reduced from 10 minutes to approx 7 minutes
Canada field development

**CHALLENGE**

- Optimize design wrt to separator size and heat consumption.
- Heating fuel by gas/diesel. High cost for heating.

**SOLUTION**

- VIEC implemented in design: Separator vessel reduced in size from 5.65 m x 27.5 m to 5.4 m x 21.5 m.
- Temperature decreased from 90 ºC to 60 ºC.
- Produced oil quality 10% BS&W.
Canada field development
Benefits of the technology

No need to recycle produced water to keep water cut above inversion point

Elimination of water in upstream process reduces sizes of downstream equipment:

Design water cut reduced from 20% to 10% affecting heater and piping design

LP Separator - ~ 2 m reduction in length and 20 metric tonnes savings

Application of VIEC® technology will provide Operations with ability to optimize annual OPEX budget

Qualification process identified a potential 100 – 200% reduction in demulsifier levels when benchmarked against comparably sized separation trains in the Oil company portfolio

Final design 5.4 m x 21.5 m versus FEED design 5.65 m x 27 m

Reduced separator size allowed the contractor to preserve platform dimensions and optimize the deck layout for other equipment.

Capital and weight savings of 50 metric tonnes compared to previous design
Goliat Project, ENI

CHALLENGE

• Space restrictions
  − Need for compact process layout
• Expected emulsion problems

SOLUTION

• VIEC® installed in a LP separator with a downstream fresh water injection:
  − Removal of one coalescer
  − Reduced fresh water consumption

CUSTOMER BENEFIT

• Capital Cost Savings: 4.9 million USD (CAPEX)

*Cost includes vessel structural support, piping, instrumentation etc.
Gudrun Project, Statoil

CHALLENGE

• Compact separation; design optimization
• Reduce number of vessels; no electrostatic coalescers
• Expected emulsion problems when adding fresh water for desalting upstream 2nd stage separator

SOLUTION

• Oil feasibility study executed: With VIEC® almost full separation happens in the process during the first 30 seconds, leading to a residual water-in-oil <0.3%
• VIEC® implemented in design: Produced oil quality guaranteed at 0.5% BS&W without electrostatic coalescers

CUSTOMER BENEFIT

• Capital Savings: 5.1 million USD (CAPEX)

*Cost includes vessel structural support, piping, instrumentation etc.
Gina Krog Project, Statoil

CHALLENGE

• Reduce size of oil processing train
• Decrease CAPEX

SOLUTION

• Install VIEC® technology in 1st and 2nd stage separators, and introduce fresh water between the separators
  − Removes the need for two coalescers
  − Reduces the footprint of processing module by at least 2 x 40m²

CUSTOMER BENEFIT

• Capital Savings: 7.5 million USD (CAPEX)

*Cost includes vessel structural support, piping, instrumentation etc.
Summary

- Use of high-voltage electrostatic fields is a very effective method of separating water-in-oil emulsions.
- Significant benefits exist by applying electro coalescence as early as possible in heavy oil separation trains.
- VIEC technology allows for early stage application of electrocoalescence.
- Benefits of electrostatic separation can be predicted and quantified in advance by performing relevant separation tests in combination with scale-up laws. Consistent scale-up laws can be formulated easier for an electrostatic process due to dominance over other processes.
- Untapped potential for significant operational savings by introducing state of the art separation technology.
Thank you!

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