Subsea Processing – Beyond Pump and Compressor

Perth, 13th March 2019
Si Huai Yeaw - Aker Solutions
Agenda

- Subsea Processing Building Block
- Large portfolio of subsea separation equipment / technology
- Applications
  - Produced Water Injection
  - Seawater Treatment and Injection
  - CO2 Removal
Global responsibility

We see ourselves as a key partner in helping provide the sustainable energy solutions the world needs – it’s both the right thing to do and also good business.”

Luis Araujo, CEO of Aker Solutions
Subsea Processing Building Blocks

Gas Processing
- Gas Treatment
- Gas Liquid Separation

Oil-Water Processing
- Oil Water Separation
- Oil Treatment
- Water Treatment
- Sea Water Treatment

Boosting
- Compressor
- Pump

Production Wells

SWI&T

Host Facilities

Injection

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Large portfolio of subsea separation equipment

**Horizontal gravity separators**
- 2 & 3 phase separators
- Pipe separator
  - Qualified

**Scrubbers/Gas liquid separators**
- Bulk separation
- Dry gas for compression
  - Qualified

**Solids management**
- Gravity separator internals
- Desanding cyclones
  - Qualified

**Water treatment**
- Produced water
- Sea water
  - Qualification ongoing

**Gas treatment**
- Dehydration
- CO2
  - Qualification ongoing
**Wide range of system solutions – some examples**

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<th>Bulk oil/water separation</th>
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<td>■ 3-phase gravity separators</td>
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<td>■ Multiphase pump systems</td>
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<td>■ Wellstream compression systems</td>
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<td>■ Hydrocyclones</td>
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<td>■ Subsea CFU</td>
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<td>■ Simple scrubber design</td>
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Produced Water Injection

- Produced water quality requirements for injection in production reservoirs vary, but typically <100 ppm Oil in Water

Technology status:
- 3-phase separator: Qualified and proven for subsea
- CFU: In development (TRL 4 2019)
- WIP: Qualified and proven for subsea
Compact Flotation Unit (CFU)

- Field proven topside
- High performance
  - Can achieve <30 ppm OiW
- Large operating range
- Robust, low risk of clogging
- High turndown capability
- Ongoing JIP activities to qualify for subsea – TRL 4
Pilot: Test at Statoil P-lab (Norway)

- Objectives: Verify performance and function in high pressure operation. Map performance and operational envelope
Subsea seawater injection system

Delivered System:

Tyrihans Subsea Raw Sea Water Injection (SRSWI)
- No filtering or chemical treatment of the injected water
- 2 x 2.7 MW subsea pump modules
- 2 x subsea transformers
- Overtrawlable structure
- SCM and CM modules

31 km step-out, 270 m water depth,
>500 m³/h injection rate at 205 bar

- Water to be injected may require treatment
- Aker Solutions has a cooperation with NOV to produce the required quality
Next steps in sea water treatment

- Collaboration agreement between Aker Solutions and NOV for Seabox™ and SWIT™
- Seabox covers coarse filtration and sterilization
- SWIT includes sulphate removal and low salinity

Seabox
- Covers coarse filtration and sterilization

SWIT
- Includes sulphate removal and low salinity

20,000 bpd low salinity / sulfate free solution
Total weight ~ 320 tonnes
SWIT™ Technology In Full

Seabox™
Water disinfected.

UltraFiltration
Sediments > 0.1 micron removed

Membrane Pump

Nano/Reverse Osmosis
All sediments removed. Sulphate removed. Salt reduced.

*courtesy of NOV
CO2 Removal - Two Important Subsea Building Blocks

Compression System

- Compression system proven by Åsgard
- SCS 2.0, offering 50% reduction in weight

Selective Membranes

- New polymer qualities with robust properties
- Compact arrangement for subsea developed

Depending on arrangement 90 – 97 % CO₂ can be separated from well stream.
Concept involving CO2 membrane bulk separation

- Åsgard compression technology
- Adapted to CO₂
- Limitations in pressure ratio

- Two stages membrane separation
- Constraints in available pressure ratio
- High G/L temperature favorable
Ongoing CO2 Membrane JIP Activities

- To obtain knowledge about the performance of various membrane qualities within the relevant operational subsea window
  - Data for membrane productivity (flux) and selectivity

- Specify the operational window for the most applicable membrane quality

- Obtain knowledge about the sustainability of membranes, potting materials and glued systems vs relevant conditions
  - Acidic water/gas phases @ HP and HT
  - Condensed HC’s @ HP and HT

- Evaluate the technical and economic justification for subsea bulk separation of CO2 for offshore CO2 EOR applications

- Establish a milestone to justify further development of the technology concept
Summary

- Subsea processing is made up of more than compressor and pump technology.
- Building blocks approach to provide flexibility, standardization, and cost reduction.
- Large range of subsea separation and treatment technology, varying degree of technology maturity.
- Continuous development and qualification activities.
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