Subsea separation – an undervalued tool for Increased Oil Recovery (IOR)

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Subsea separation in the market

- Subsea separation established globally. Projects installed:
  - Africa
  - North Sea
  - Gulf of Mexico
  - Brazil

- Track record and results to point to
  - Proven, low risk technology available

- However... current market focus is on well stream boosting
  - Increasing number of (boosting) technology suppliers
  - Increasing choice of (boosting) technology
  - Thin separation prospect list
Subsea separation – The track record

Proven Track Record:
- Global Presence
  - Africa
  - North Sea
  - Gulf of Mexico
  - Brazil
- Separation
  - Gas/Liquid
  - Liquid/Liquid
- Value adding:
  - De-bottlenecking
  - Enabling production
  - Increasing production
Subsea separation – More than boosting

- Flow assurance
  - Hydrate management strategy
  - Slugging prevention

- Handling uncertainties in production profiles

- Enabling long distance transport

- Enabling deep water developments

- Maximising boosting effectiveness
Subsea separation – Enabling boosting

Diagram showing the relationship between boosting pressure and gas fraction. The diagram illustrates the use of different types of pumps, including single phase centrifugal pumps and multiphase pumps, to manage the gas fraction at different pressure levels. Key points include the new operation point and the required operation point.
Subsea separation – Case studies

• Case Study 1
  • Green oil field
  • 1000 m water depth
  • Harsh weather environment
  • Potential water breakthrough
  • Potential gas cap
  • High degree of uncertainty

Challenge: Minimize topsides. Maximize NPV.

• Case Study 2
  • Brown gas field
  • 900 m water depth
  • Subsea to beach
  • Declining reservoir pressure
  • Limited weather window for SURF scope

Challenge: Maximize Recovery. Maximize NPV.
Subsea separation – Case 1, Green oil field

• How to maximize NPV?

INCREASE RECOVERY

TOPSIDE FACILITIES

SMALLER TOPSIDE

NO TOPSIDE
Subsea separation – Case study 1

Solution 1: Water separation and disposal via proven technology

• Oil and gas free-flow to surface
• Water injected to disposal well
Subsea separation – Case study 1

Subsea Separation Solution 1

• Maximize recovery
  • Increasing recovery rate (enables lower WHFP)
  • Pressure support (if injected into production reservoir)

• Minimize topsides
  • Reduced first stage separator
  • Reduced water treatment

• Technical feasibility
  • Field proven technology
  • Feasible flow assurance
Subsea separation – Case study 1

Solution 2: Enable long distance transport

- Gas/Liquid separator
- Liquid boosting, Gas free-flow to *off-site* facilities

- ‘Game changing’
  - No local receiving facilities, opens for many new development options

![Diagram of subsea separation system]
Subsea separation – Case study 1

Subsea Separation Solution 2

- Maximize recovery
  - Increasing recovery rate (enables boosting)
  - Maximizes uptime

- Minimize topsides
  - Eliminates on-site FPSO
  - Enables use of existing facilities or dedicated facilities in shallower water

- Technical feasibility
  - Field proven technology
  - Feasible flow assurance
Subsea separation – Case study 2

• Case Study 2
  • Brown gas field
  • 900 m water depth
  • Subsea to beach
  • Declining reservoir pressure
  • Limited weather window for SURF scope

Solution:
• Distributed cooling and gas/liquid separation
• Liquid boosting
Subsea separation – Case 2 study

4 Processing stations:
- Gas pre-cooling
- Gas/liquid separation

Gas freeflow
to shore

Liquid boosted
to shore

1 liquid boosting station
Subsea separation – Case study 2

Distributed gas/liquid cooling and separation:

Four off
Subsea separation – Case study 2

Pump Station:
One off
Subsea separation – Case study 2

- Maximize recovery
  - Avoid liquid accumulation – lower pipeline dP
  - Eliminate slugging
  - Enable liquid boosting

- Minimize expenditure
  - No need for new floating facilities
  - Distributed solution developed with a focus on minimizing SURF scope
  - Maximize use of existing field infrastructure
  - Enables phased deployment to maximise NPV

- Technical feasibility
  - Qualified separation technology
Subsea separation – Case studies summary

• Subsea Separation does things boosting alone cannot do
  • Green field, Brown field, Gas, Oil...

• Flow assurance benefits
  • Slugging
  • Hydrate
  • Enables long distance transfer

• Enables use of single phase pump
  • More efficient pumping
  • More robust system: BoD, Transient conditions

• Enables increased recovery
  • Lower WHFP

• Topside equipment reduction
  • Minimize, eliminate or maximize use
Subsea separation as an IOR tool – Summary

• Proven, reliable, ready!
  • And yet, undervalued...

• Subsea Separation (combined with boosting) unlocks value
  • To see the true potential the entire system must be evaluated
  • Must be included when considering field development options - the bigger picture might be a brighter picture

• Game changing... if we let it!
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