SPE ATCE SINCE 1924
SOCIETY OF PETROLEUM ENGINEERS
ANNUAL TECHNICAL
CONFERENCE AND EXHIBITION
San Antonio, Texas, USA
9-11 October 2017
Henry B. Gonzalez Convention Center
www.spe.org/atce/2017

SPE-187109-MS

Partial Processing: Produced Water Debottlenecking Unlocking Production on Offshore Thailand MOPU

Hank Rawlins, PhD, P.E.
eProcess Technologies

eProcess TECHNOLOGIES

SPE International Society of Petroleum Engineers

Slide 2

Too Much Water

- Produced water as a hindrance to hydrocarbon production
- Problem with ageing fields and facilities
- Water fills up space and volume in facility where oil & gas should be

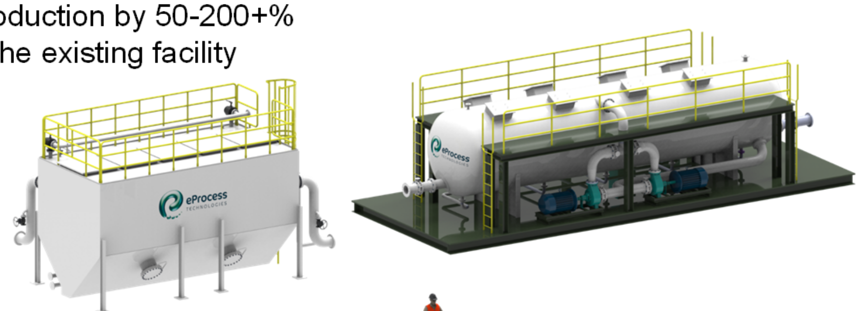
SPE ATCE SINCE 1924

Slide 3

What is Partial Processing?

PARTIAL removal of <u>throughput constraining phase</u> from oil & gas production, using compact processing equipment, where traditional separation technologies cannot be used;

- Gas or water constraining phase
- Space or weight constraints facility
- Unlock production potential in mature or marginal fields
- Increase hydrocarbon production by 50-200+%
- Maximize capabilities of the existing facility



Basis : 25,000 BWPD @ 100 psig

SPE-187109-MS • Partial Processing • Hank Rawlins

Slide 4

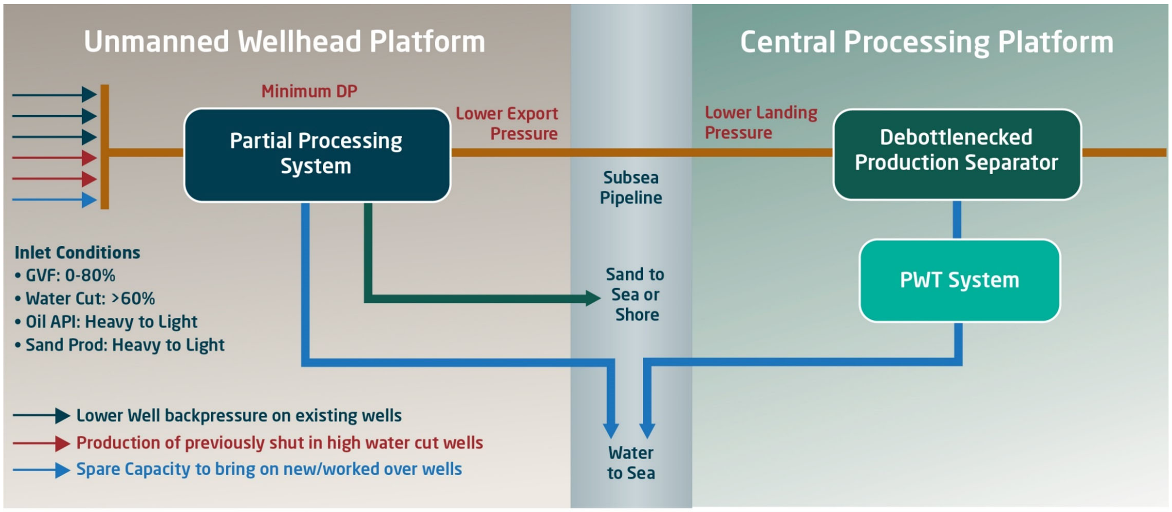
High Watercut Production – Liquid Constrained System

Flowlines between WHP and CPP
Flowlines between WHP and shore-based processing facilities
Process plant on CPP operating above design capacity
<u>Water Management problem rather than Water Treatment Problem</u>

SPE-187109-MS • Partial Processing • Hank Rawlins

Slide 5

Example Design

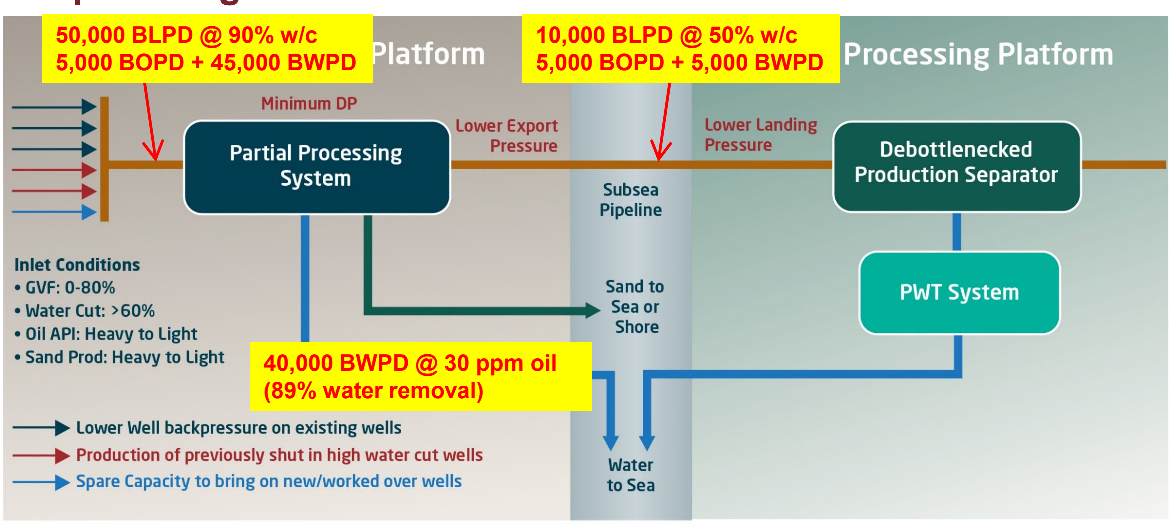


Creates up to 80% spare capacity in the infield pipeline from WHP to CPP

SPE-187109-MS • Partial Processing • Hank Rawlins

Slide 6

Example Design: Mass Balance



Creates up to 80% spare capacity in the infield pipeline from WHP to CPP

SPE-187109-MS • Partial Processing • Hank Rawlins

Slide 7

Development History: Liner Development (1989-1995)

Location: USA
Operator/Field: Conoco, Grand Isle
Dates: 1989
System Design:
- 1st Pilot Test of Preseparating and Dehydrating Applications

Location: Australia
Operator/Field: Esso / Longford
Dates: 1991-1992
System Design:
- 1st commercial dehydrating system removing water from condensate
- 10% water to <1%

SPE ATCE SINCE 1924

SPE-187109-MS • Partial Processing • Hank Rawlins

Slide 8

Development History: System Development (1995-1998)

Operator/Field: BP, Wytch Farm (UK)
Dates: Dec 1996-Jun 1997
System Design:
- G-L: Auger, GLCC, and Tee-Sep
- L-L: Preseparator and Deoiler

Operator/Field: Thai Shell, Lan Krabu (Thailand)
Dates: Nov 1996-Mar 1997
System Design:
- G-L: Auger Separator
- L-L: Preseparator and Deoiler

Both field trials part of 8 member JIP
- Arco, BP, Elf, Halliburton, Petrobras, Saudi Aramco, Shell Expro, and Unocal

SPE ATCE SINCE 1924

SPE-187109-MS • Partial Processing • Hank Rawlins

Slide 9

Commercial Systems

2012, North Sea UK Sector

- Apache Forties Bravo
- 36 API oil at 80 C
- Two-stage produced water debottlenecking
- 120 MBPD produced water, <10 ppm mg/l oil
- Doubled oil production

2013, Congo

- Perenco Emeraud
- 22 API oil at 24 C
- Three-stage produced water debottlenecking
- 80 MBPD produced water, <30 mg/l oil
- Quadrupled oil production

Slide 10

Design Setup: for Water Constrained Systems

Locate on Production Manifold to remove, treat and dispose of a BULK PORTION of the constraining water phase

Stage 1: Preseparation

- Multiphase flow steam
- Bulk oil-water cyclone
- 10-20% oil to <0.2-0.5%
- Can handle 40% free gas
- Low pressure drop

→

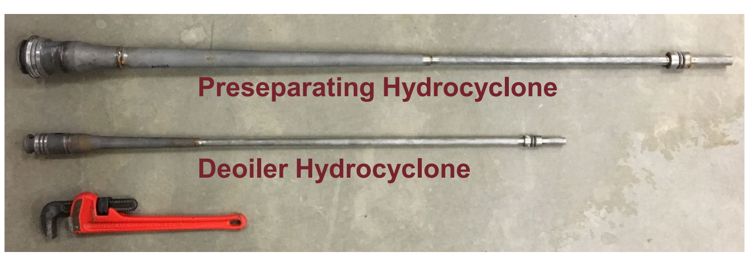
Stage 2: Deoiling

- Separated water stream
- Deoiler cyclone
- 0.2% to 30-50 ppm
- No free gas
- Med-High pressure drop

→

Stage 3: Tertiary

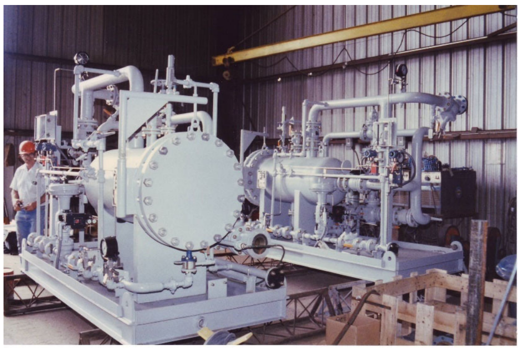
- Oil polishing (optional)
- Compact flotation unit
- To 10-30 ppm
- Uses effervesced gas
- Low operating pressure

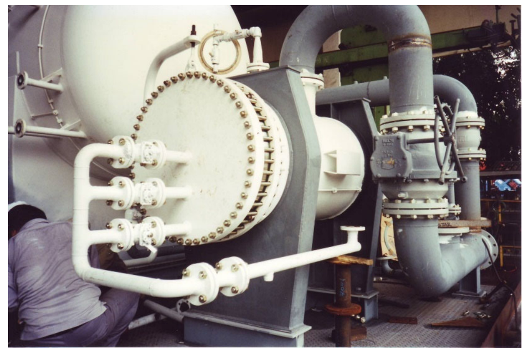


Slide 11

Design Guidelines: for Water Constrained Systems

Watercut must be >60% (water continuous liquid phase)
Inlet flow regime must NOT be severely slugging
Gas void fraction >40% requires initial Gas/Liquid separation step
Emulsion stability may adversely affect performance





SPE ATCE SINCE 1924

SPE-187109-MS • Partial Processing • Hank Rawlins

Slide 12

Case Study: Gulf of Thailand, Songkhla Province

Field Design:
- Two fields, each with MOPU and FSO
- MOPU – gas/liquid separation
- FSO – water separation and treatment
- Produced water pumped back to the MOPU for re-injection

Field 1:
- Current: ~40 MBLPD @ ~90% watercut
- Potential: ~80 MBLPD

Field 2:
- Current: ~60 MBLPD @ ~90% watercut
- Potential: ~100 MBLPD

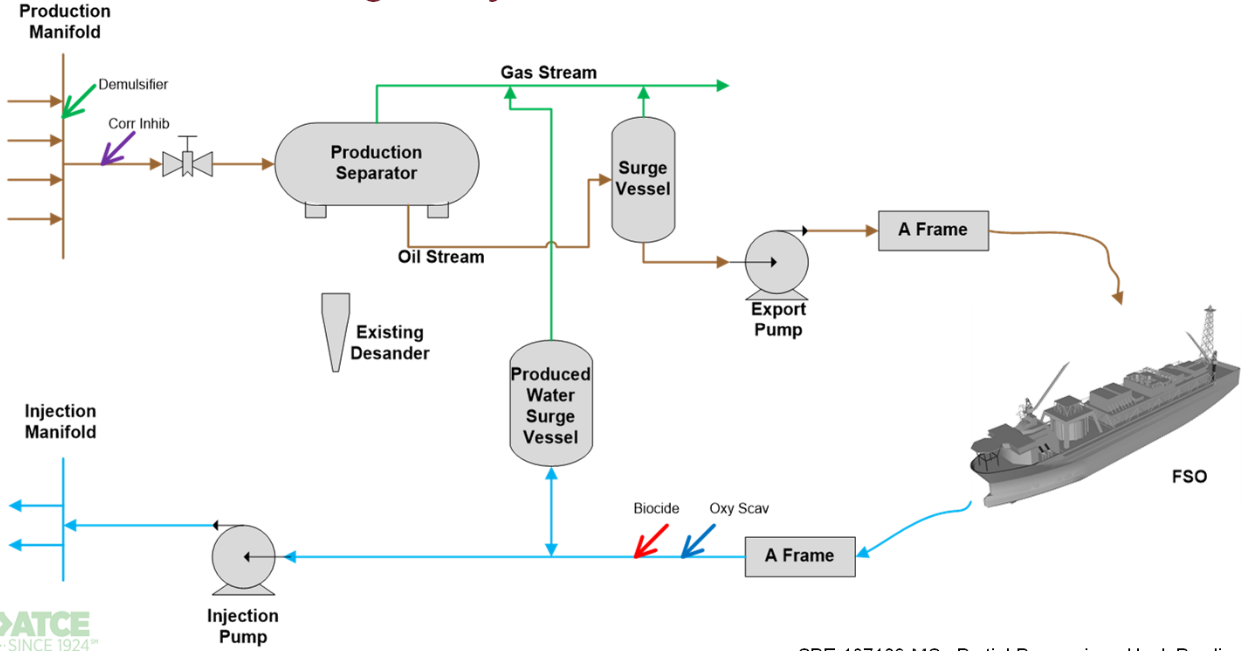
Fluids Properties:
- Oil: 25 API
- Temperature: 75 C

SPE ATCE SINCE 1924

SPE-187109-MS • Partial Processing • Hank Rawlins

Slide 13

Process Overview: Original System



SPE ATCE SINCE 1924

SPE-187109-MS • Partial Processing • Hank Rawlins

Slide 14

Situation Assessment

The Problem:

- Each MOPU process system at full capacity
- Infield drilling campaign completed to bring on new ESP wells but NO capacity for additional production
- Primary bottlenecks: G-L separation vessel and flowlines to/from FSO

The Challenge:

- Separate & treat water on MOPU to increase combined production:
  - Total Liquids: ~100 MBLPD to >180 MBLPD
  - Oil Production: 10,000 to 18,000 BPD
- Re-inject separated water on MOPU with water quality <50 ppm oil
- Must be highly automated to minimize operator interaction

SPE ATCE SINCE 1924

SPE-187109-MS • Partial Processing • Hank Rawlins

Slide 15

Field Trial: Single Liner Portable Kit

Single liner field trial

Capacity: 190-290 BPD

Two-Stage System

- Preseparation Hydrocyclone
- Deoiling Hydrocyclone

Performance envelope identified

Effects of water clarifier and demulsifier chemicals tested

SPE ATCE SINCE 1924

SPE-187109-MS • Partial Processing • Hank Rawlins

Slide 16

Field Test Results

Headline Results

- >90% of the produced water could be separated by a two-stage PP system
- Presep water outlet: 100 - 300 ppm
- Deoiler water outlet: 50 ppm
- Watercut reduced from 90% to 30-50%

Achieved With:

- Preseparator PDR ≥1.4
- Preseparator $\Delta P_{i\text{-}w} \geq 8$ psi

Other Key Observations:

- Performance achieved also with NO water clarifier or demulsifier

Preseparator Outlet
~100 to 300 ppm

Deoiler Outlet
~50 ppm

SPE ATCE SINCE 1924

SPE-187109-MS • Partial Processing • Hank Rawlins

Slide 17

Design Solutions: for Produced Water Debottlenecking

Stage 1:
- 1 x 100% Preseparation Hydrocyclone

Stage 2:
- 1 x 100% Deoiling Hydrocyclone

Full automated via on-skid PLC

Conversion of existing desanding vessel into a deoiling vessel
- Adds to existing PWT capacity

First offshore full scale Partial Processing system in SE Asia

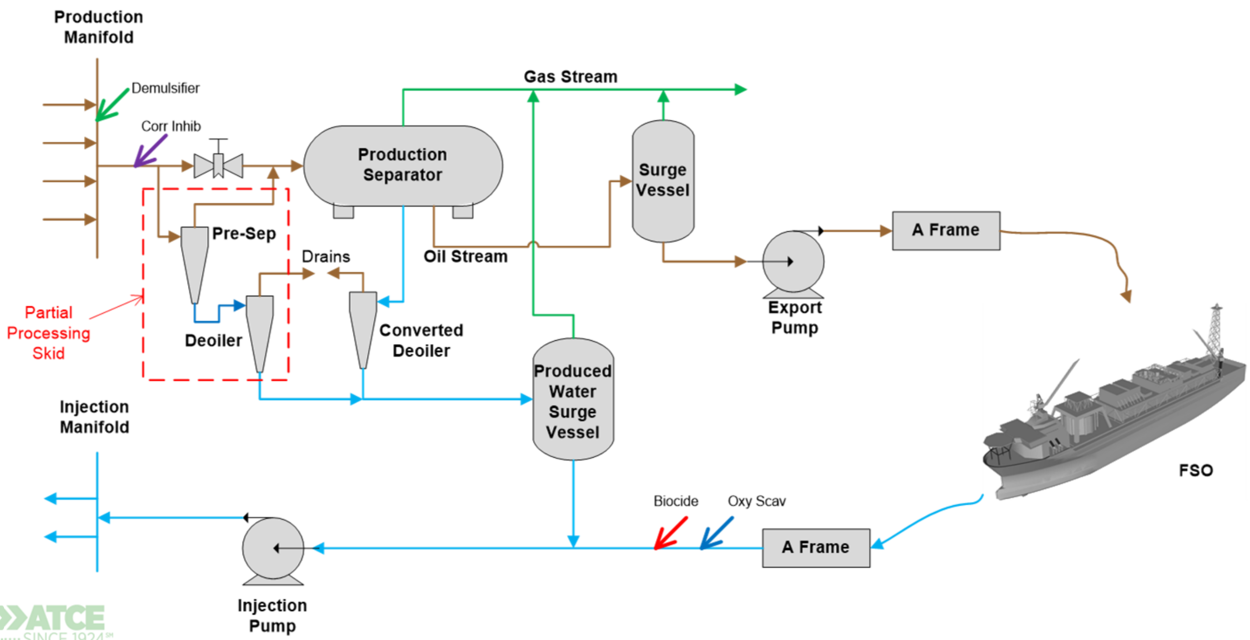
Project Schedule
- Field trial: March 2015
- Solution proposal: May 2015
- Delivery: January 2016
- Commissioning: Feb/March 2016

SPE ATCE SINCE 1924

SPE-187109-MS • Partial Processing • Hank Rawlins

Slide 18

Process Overview: with Partial Processing Retrofit



SPE ATCE SINCE 1924

SPE-187109-MS • Partial Processing • Hank Rawlins

Slide 19

Equipment Design

Design Basis

- MOPU Flowrate: 100,000 BPD / 80,000 BPD
- Flowrate to PP: 75,000 BPD / 55,000 BPD
- Max Sep. Water: 95%
- Design Pressure: 150# Rating
- Reinjection Water: 50 mg/l

Skid Size/Weight

- Footprint Available: 8.8m (L) x 3.3m (W)
- PP Dims: 5m (L) x 2.5m (W) x 3.5m (H)
- Dry: 14.5 T
- Operating: 16.0 T

SPE ATCE SINCE 1924

SPE-187109-MS • Partial Processing • Hank Rawlins

Slide 20

Fabricated Packages

SPE ATCE SINCE 1924

SPE-187109-MS • Partial Processing • Hank Rawlins

Slide 21

Installed Package

SPE ATCE SINCE 1924

SPE-187109-MS • Partial Processing • Hank Rawlins

Slide 22

Project Gains

Oil production increased by 80%

OPEX Reductions

MOPU Fuel	Fluid pumping from MOPU to FSO reduced by 73%
MOPU Power	Lower backpressure on ESP wells – more oil for same energy
FSO Fuel 1	Fluid heating reduced – most significant reduction
FSO Fuel 2	Fluid pumping from FSO to MOPU reduced by 60%
FSO Storage	Less fluid storage required – potentially reduced size of FSO
Chemical 1	Decreased biocide
Chemical 2	Decreased demulsifier
Chemical 3	Decreased oxygen scavenger
Equipment Expense	No extra pumps required for increased production

SPE ATCE SINCE 1924

SPE-187109-MS • Partial Processing • Hank Rawlins

Slide 23

Summary

Partial Processing
- Proven for small & large scale offshore applications
- Proven for cost sensitive regions such as West Africa and South East Asia
- Can be installed on unmanned facilities with very limited utilities
- Applicable to heavy oil as well as light crudes
- Systems do not have to be "pressure hungry"

Success depends on a number of factors –
- Technology – of course but not just technology
- Process Integration
- Control Philosophy
- Experience
- The right application!

Can increase mature field production by double-digit factors

SPE ATCE SINCE 1924

SPE-187109-MS • Partial Processing • Hank Rawlins

SPE ATCE SINCE 1924

SOCIETY OF PETROLEUM ENGINEERS
ANNUAL TECHNICAL
CONFERENCE AND EXHIBITION

San Antonio, Texas, USA
9-11 October 2017
Henry B. Gonzalez Convention Center
www.spe.org/atce/2017

Slide 24

Thank You!

Presented by Hank Rawlins
Technical Director | USA

hrawlins@eprocess-tech.com
www.eprocess-tech.com

SPE International
Society of Petroleum Engineers