FEAC305 Development of an In-Well/ Oil/Water Separator (Centrifugal Downhole Separator)

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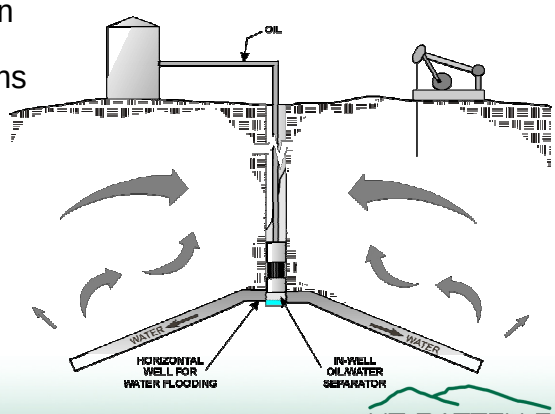
Objective of CDHS Project

- Evaluate centrifugal separators for oil/water mixtures
  - use industry functional criteria
- Evaluate modification requirements for down-hole applications
- Perform field demo if warranted



Industrially Supplied Functional Criteria

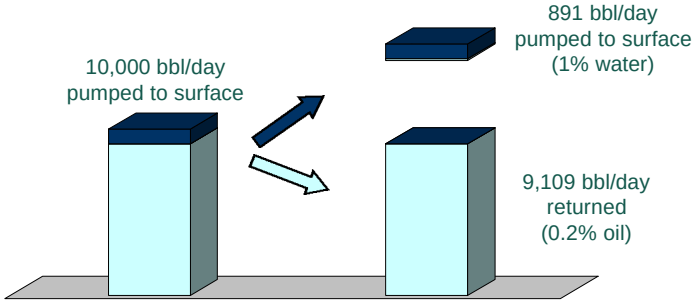
Desired Criteria	Achieved
• Flow rate: 2000 to 10,000 barrels per day	15 bbl/day
• Diameter: 6 inches for 7-inch well	2”D × 4”H
• Temperature: 100 to 180°F	75-150°F
• Water to oil ratio: 1:10 to 10:1	1:19-10:1
• Solids: 0-3%, range from sand to clays	initiated
• Product quality: <2000 ppm (0.2%)	<0.2%
• Reliability: 18 months between failures	27 mo.
• Gas processing: Can it be done?	Yes, 21%

Benefits and Value of CDHS for Down Hole Applications

- High g forces for efficient separations
  - < 1% cross-phase contamination
  - < 10-micron drop size separations
- Developed for remote operations
  - 20,000 hr (2.2 yr) operation prior to maintenance
- Scalable in the vertical direction
- Potential to achieve higher capacity and better separations than traditional units
- Processing of gas-rich streams
- Can be operated over the spectrum of water:oil ratios

Benefits and Value
Impact of Separation Efficiency

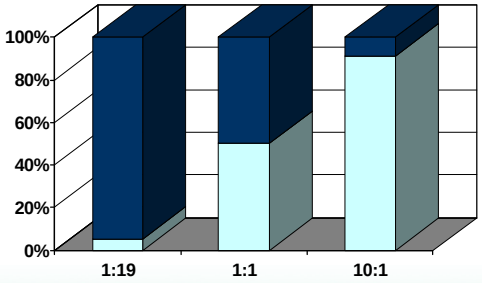
- At minimum we get a cost avoidance of
  - $3,200 to $68,300 per day based on trucking cost, or
  - $2,700 to $6,400 per day based on water disposal fees



Based on Centrifugal Separator Results

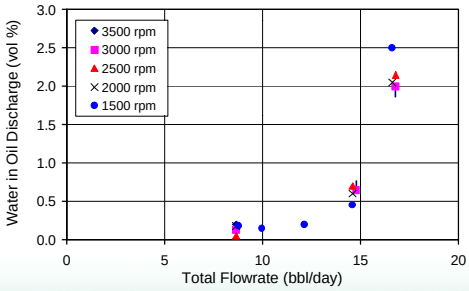
Accomplishments
Range of Testing Scenarios

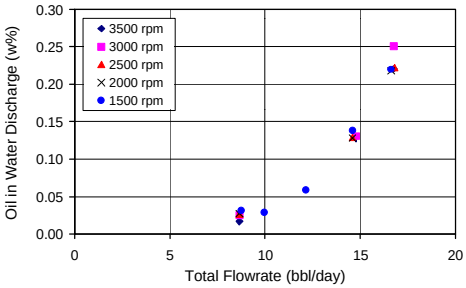
- Tests with two different crude oils
  - Gulf of Mexico light crude
    - 10 cP
  - North Sea heavy crude
    - 417 cP
- Tests with different water to oil ratios
  - 1:19 (water to oil)
  - 1:1 (water to oil)
  - 10:1 (water to oil)



Accomplishments
Effect of Rotor Speed

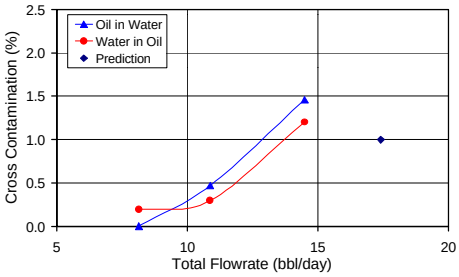
- Typical data collected
  - Gulf of Mexico light crude 10:1 water to oil feed, 1.00" weir
  - Rotational speed has minimal impact on performance





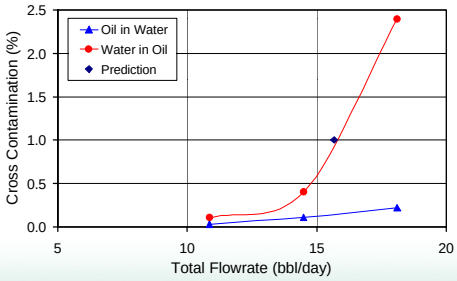
Accomplishments
Effect of Weir Size (1:1 water to oil)

- Weir size influences results
- Model result unpredictable



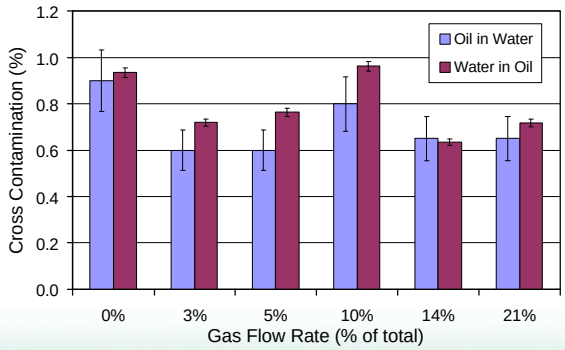
0.975" weir

0.950" weir



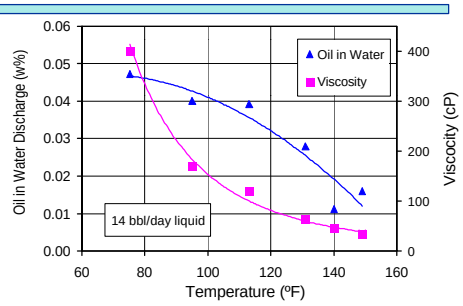
Accomplishments
Effect of Entrapped Gas

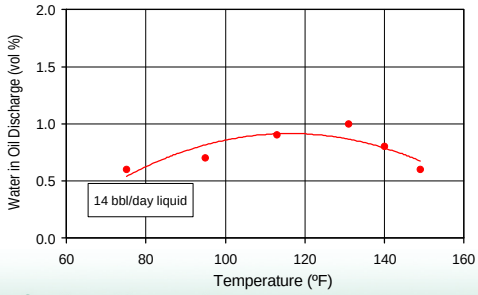
- Tests with GOM light crude
  - 0-21% of total flow (1:1 water to oil)
  - Gas had no impact on separation efficiency



Accomplishments
Effect of Temperature and Viscosity

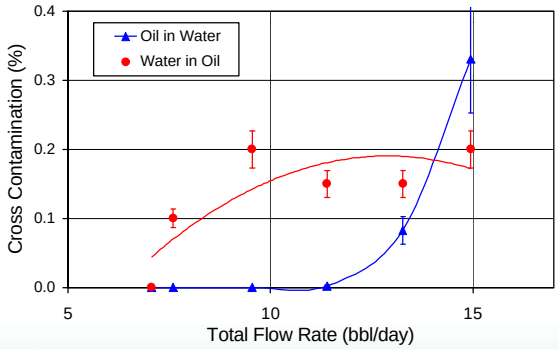
- North Sea heavy crude
  - 75-150°F
  - Improved performance with higher temperature





Accomplishments
Effect of Low Water Content

- GOM light crude, 19:1 oil to water
  - Excellent separation, exceeding industry criterion



Problems

- Mathematical model does not predict performance of crude oil/water separation in all cases
- Solutions
  - modify model to include variable dispersion coefficients
  - collect empirical data suitable for scale-up

Industrial Partner Contributions

- Petroleum companies (Chevron, Phillips, Texaco, Unocal)
  - develop functional criteria for CDHS
  - supply samples/recipes for crude oil and water
  - provide input on development plans and separator design
  - support field demo if results warrant
- Vendor companies
  - assist with design modifications for down-hole operation
  - construct field demo unit
  - commercialize system if results warrant

Status of Milestones

- Define functional requirement - Jun. '98
- Complete bench-scale testing - Sept. '00
- Complete prototype fabrication - Dec. '00
  - 4 to 8 times larger capacity than bench scale
- Install prototype - Feb. '01
- Test prototype - Sept. '01
- Provide design recommendations - Sept. '02
  - possibly revise mathematical model

Conclusions

- Excellent feed-back from industrial partners during review meetings
- Separation achieved for high oil to water ratios
  - water to oil ratios of 10:1 to 1:19 (through transition point) studied
- Gas in feed does not significantly influence the performance
- Increased temperature improves performance of heavy crude oil/water separations
- Achieved <2000 ppm oil in water suitable for reinjection