Esforço conjunto para melhor eficiência das BCS

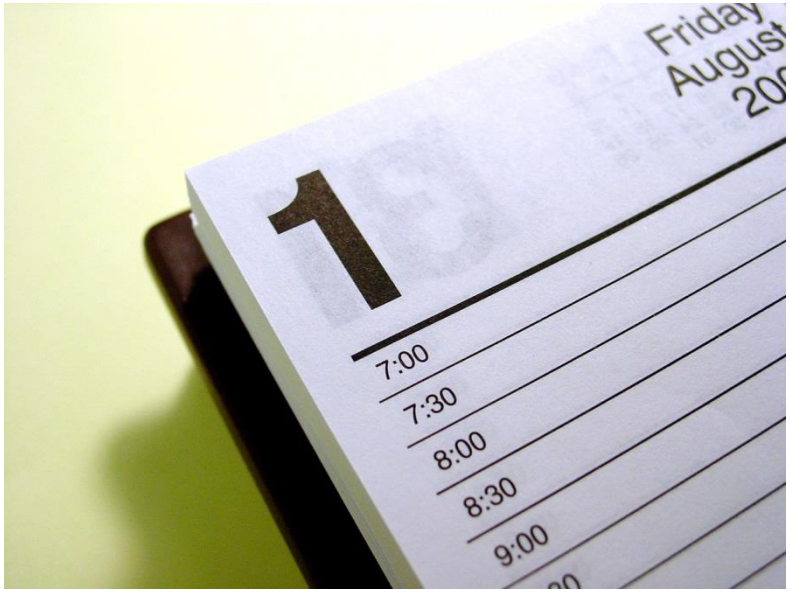
Ivan Leitão Junior – Statoil

Seminário sobre Aumento do Fator de Recuperação no Brasil

23 março 2017

Topics

- Statoil
- Main challenges
- Objectives
- Projects
- Results
- Conclusions



Statoil

Statoil is an international energy company with operations in 30 countries. Building on 40 years of experience from oil and gas production on the Norwegian continental shelf, we are committed to accommodating the world's energy needs in a responsible manner, applying technology and creating innovative business solutions.

We are headquartered in Stavanger, Norway with approximately 20,500 employees worldwide, and are listed on the New York and Oslo stock exchanges. More information on www.statoil.com

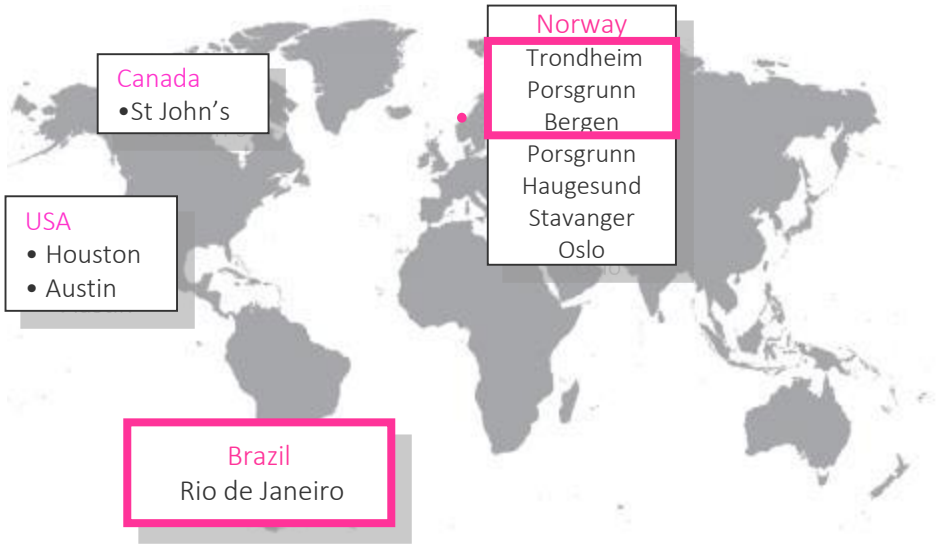
Caring

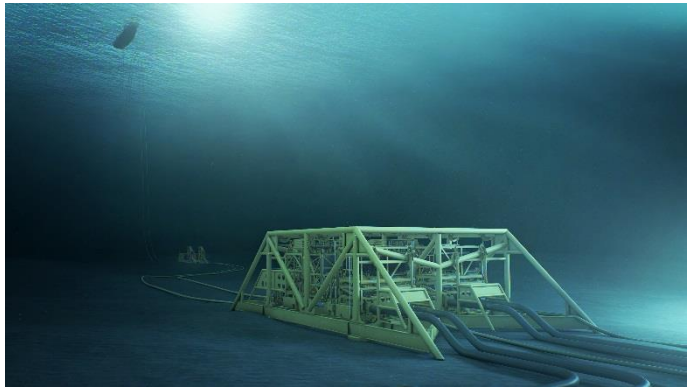
Open

Collaborative

Courageous

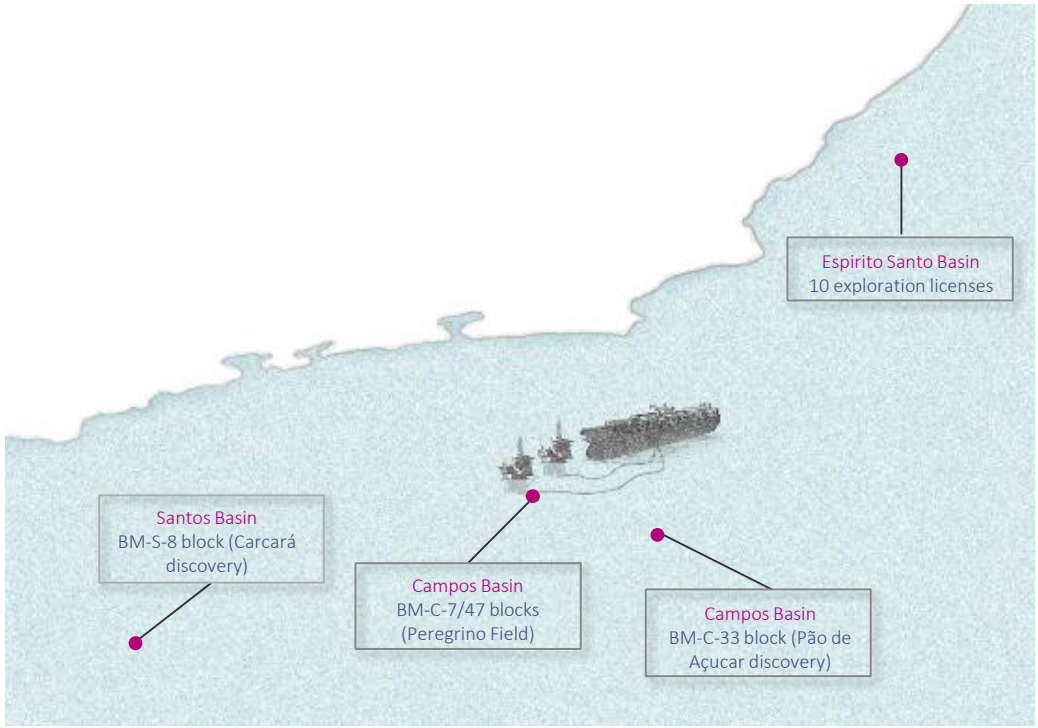
Statoil | Research and Technology in IOR





Research and technology are critical success factors to achieve safe operations and get the most out of our fields.

Statoil | Brazil



Campos Basin

BM-C-7/47 (operated – 60%):

- Producing asset, Phase 2 in execution
- 14 API crude

BM-C-33 (operated – 35%):

- Pre-salt discoveries, concession terms
- Gas, condensate, light oil

Santos Basin

BM-S-8 (operated – 66%)

- Pre-salt discovery, concession terms
- >30 API oil, associated gas

Espirito Santo Basin

- 10 licenses, 6 from Round 11

Statoil | Peregrino Operations

+ 100 million barrels produced (since 2011)	8º bigger field in prodution (Source: ANP)	
100.000 bbl/day prodution capacity	Peregrino Phase 2 Life Extension	

Statoil | Heavy oil

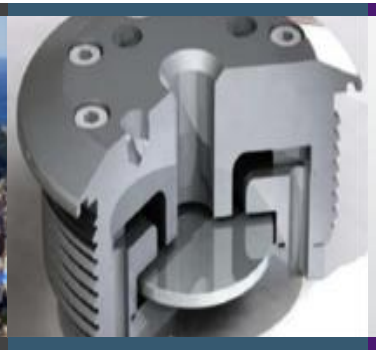
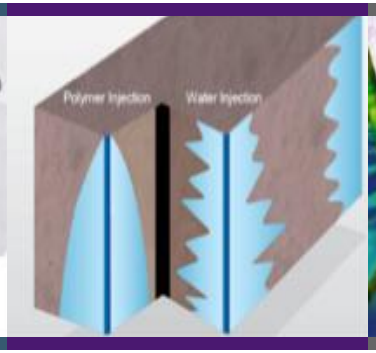
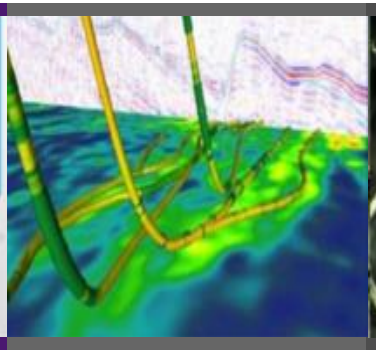
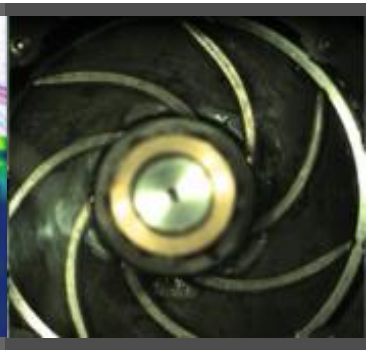
Characteristics

Viscosity impacts the transport and storage
Density impacts in separation
Low gas content affects the energy needs.

Needs

Pumps to produce and transport the oil
Big installations for processing
Intensive heating in the separation, transportation and storage processes.
Specific refineries

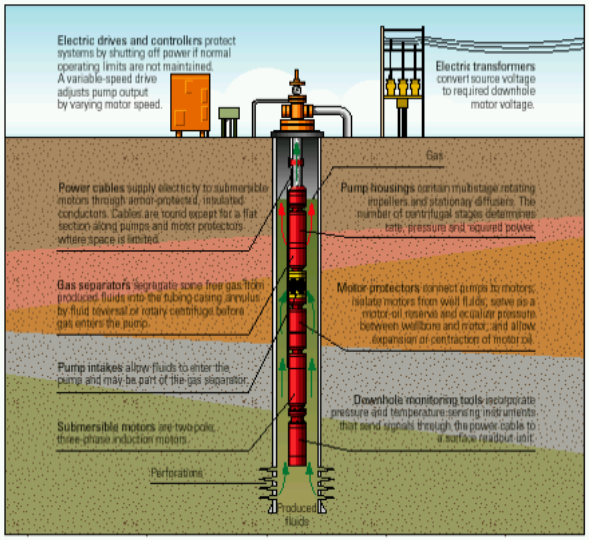
Statoil | PRG Technology Implementation

MLT	AICD	Polymer Injection	ERW	ESP
Higher reservoir exposition and lower costs	Inflow control in producing wells	Reservoir “wash”	Areas far away from the platform	Artificial lift method
				

among others...

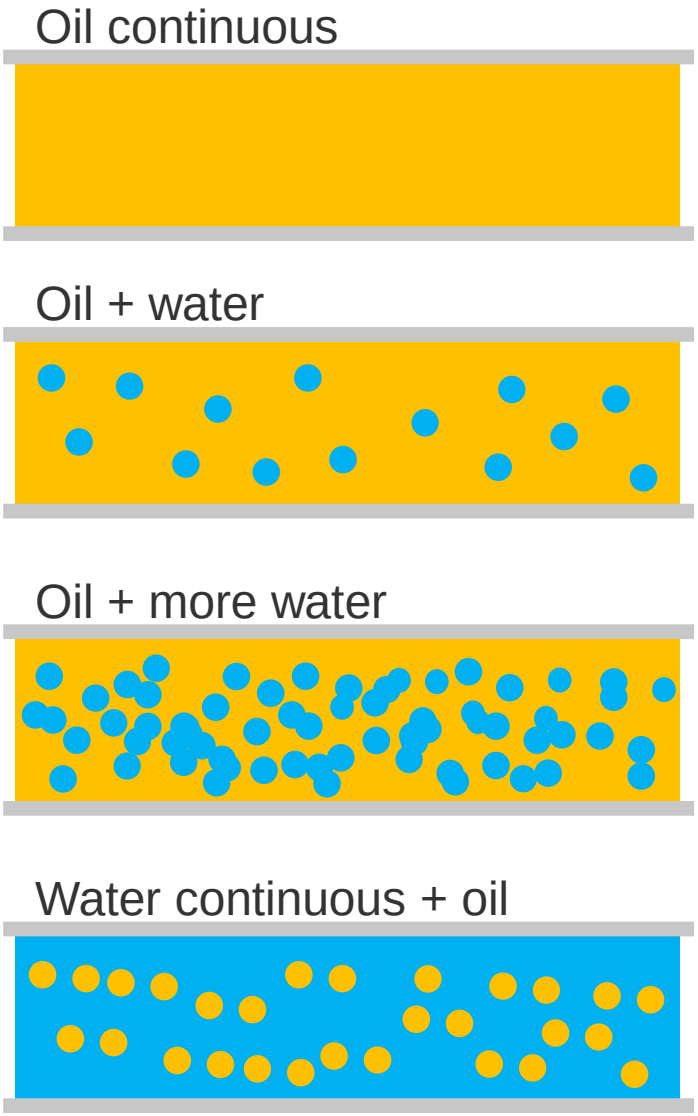
Main challenges

- Many viscous oil fields require artificial lift in order to have a sufficient production
- Electrical submersible pumps (ESP) are frequently used
- During operation unstable behaviour is observed frequently



Main challenges

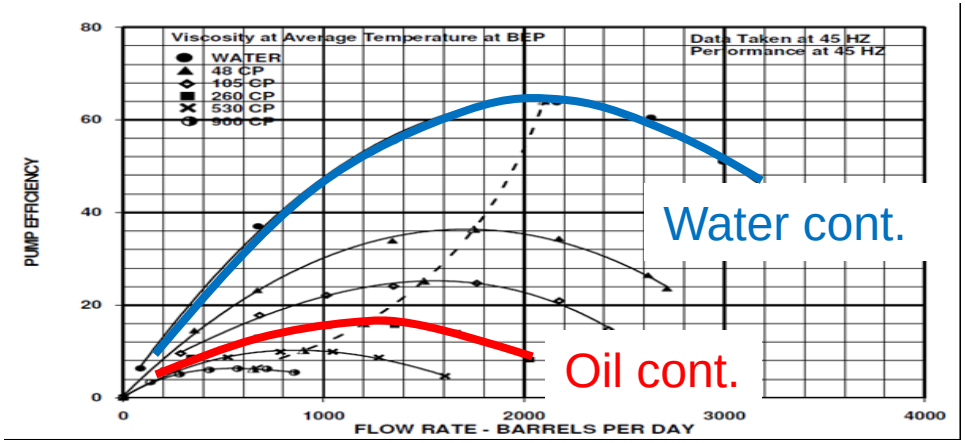
- Emulsion can be created
- Conditions:
  - Shear rate
  - Two-fluids
  - Surfactant
- The viscosity of the emulsion is higher than the original fluids viscosity

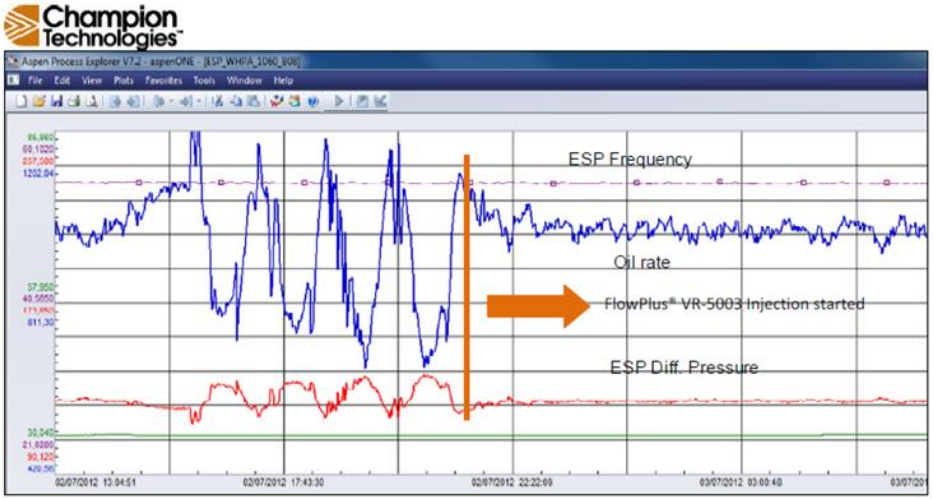


Main challenges

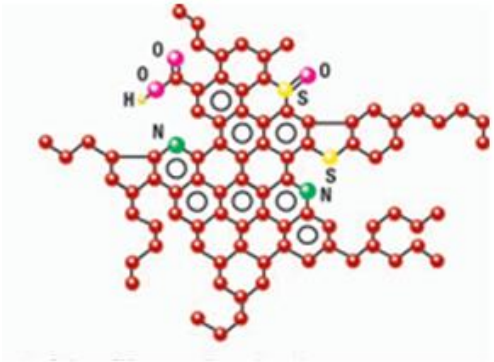
Facts:

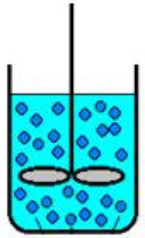
- Water continuous production can increase performance in comparison with oil continuous production
- For mature wells, produced water is sufficient for maintaining water continuous flow
- An emulsion may change phase depending of the imposed mechanical work on it





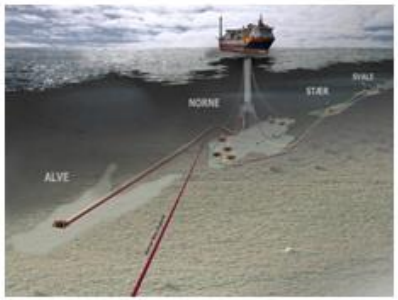
Main challenges





- By understanding small and medium scale we believe that we can improve the full scale performance.
  - Fluid characteristics
  - Rheology
  - Bench scale
  - Transparent model system
  - Porsgrunn – pilot scale, live system

Photo: Markus Johansson / Statoil



Objectives

- Main deliverables:
  - Improve understanding of the emulsions being created in the ESP
  - Study efficiency and stability of ESPs with emulsions and how to influence it
  - Verify that by improved control of the ESP we can enhance production and increase run-life
  - Optimize the use of production chemicals

Projects | Combined effort

Brazilian projects

Fluid properties for viscous oils

Heavy oil and emulsions

Norwegian projects

Performance of multi-stage centrifugal pumps

Automatic ESP Control

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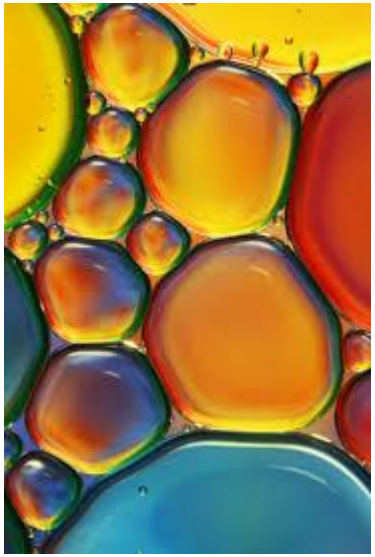
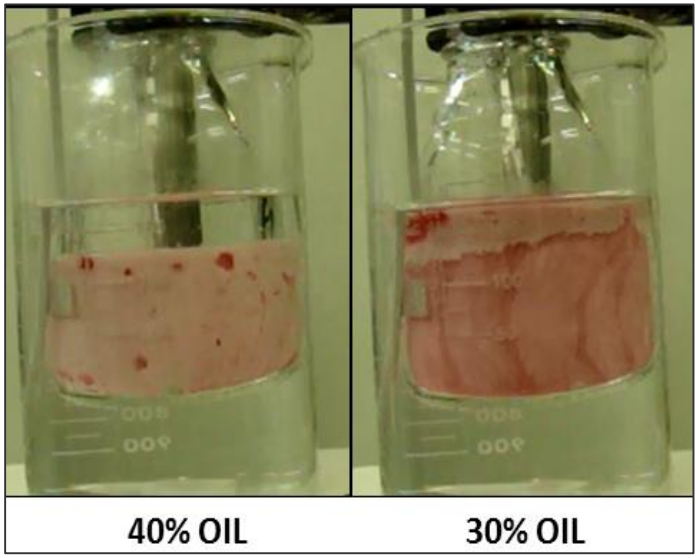
Projects | Fluid properties for viscous oils

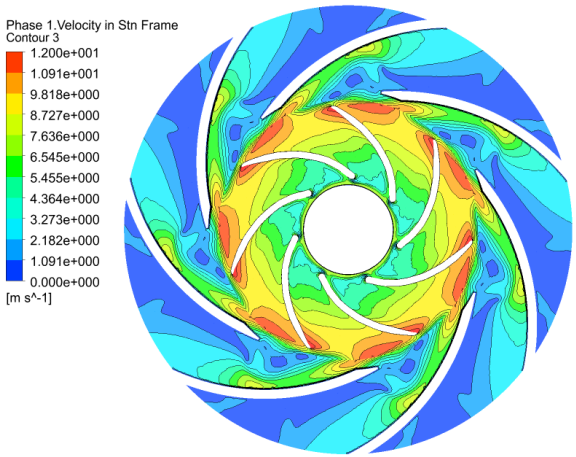
- Objective of the project:
  - Further develop analytical protocol for characterization of viscous oils
    - Gas desorption kinetics and foaming/swelling
    - Characterization of emulsions



Projects | Heavy oil and emulsions

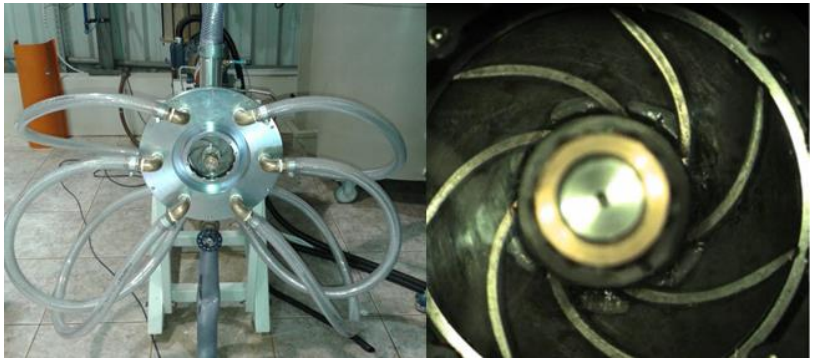
- Objective of the project:
  - Develop a methodology for “bench scale” characterization of emulsions being generated in an ESP
  - Increase knowledge of the emulsions
  - Enhance understanding of emulsion phase inversion
  - Verify conditions to invert the emulsions in lab (bench-scale and ESP)
  - Model (CFD) emulsion behaviour in ESP





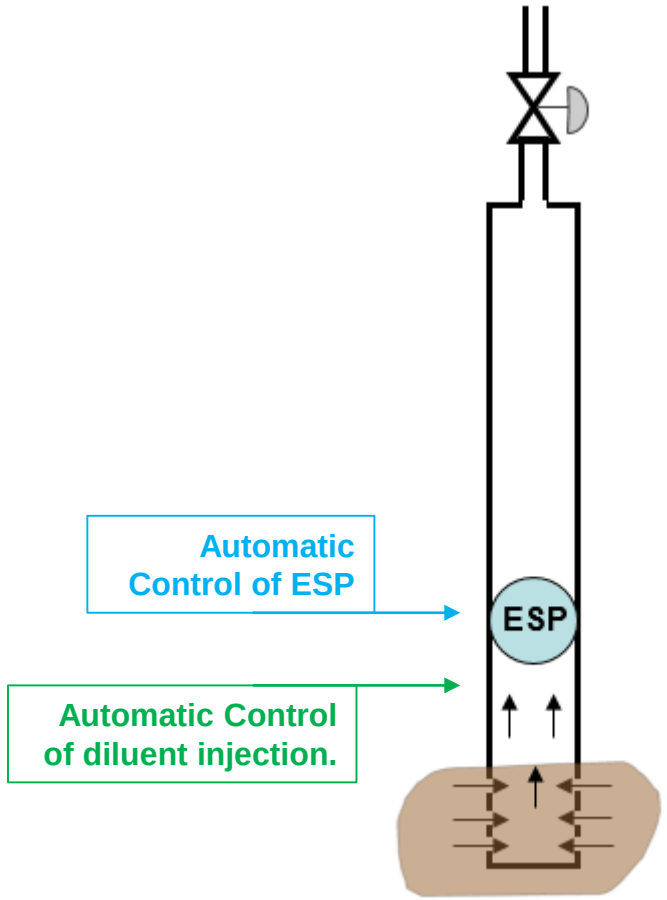
Projects | Performance of multi-stage centrifugal pumps

- Objective of the project:
  - Investigate the behaviour of emulsions in ESPs and measure pump performance in lab
  - Different fluids are being tested: water, oil, water/gas, oil/gas, water/oil (emulsion) and water/oil/gas

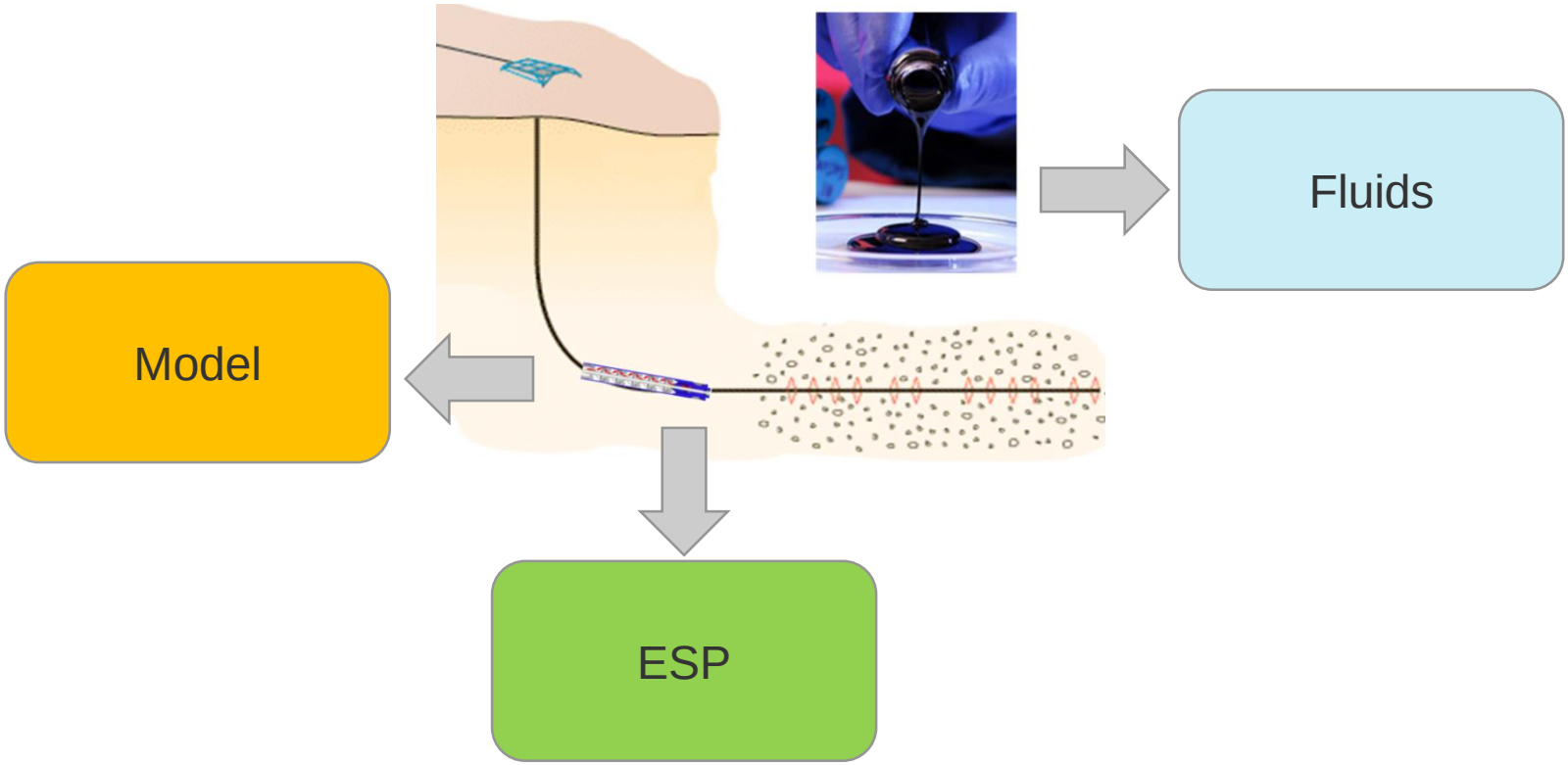


Projects | Automatic ESP control

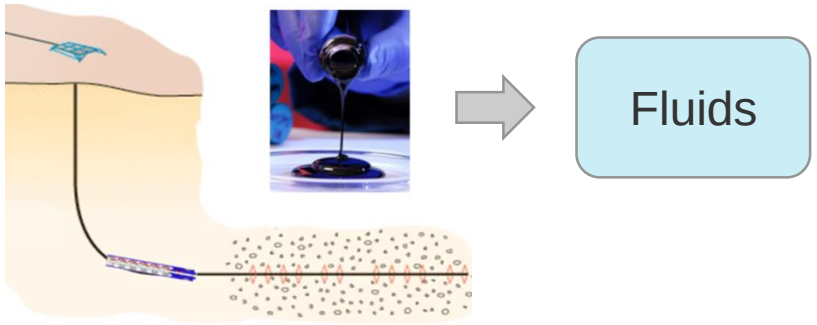
- Objective of the project:
  - Automatic control of ESP pump intake pressure in an energy efficient way.



Results | Types

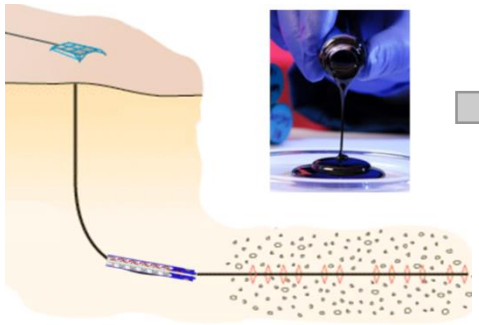


Results | Fluids



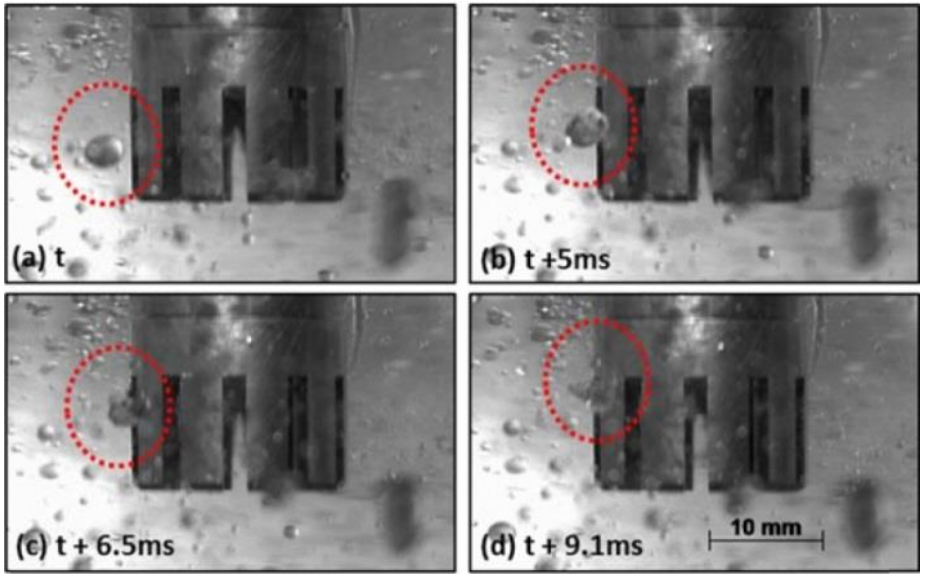
- Results:
  - Emulsions have been generated using synthetic and crude oils using stirred tank and narrow gap reactors
    - Images of break-up of oil droplets in narrow gap and stirring tank.
  - Emulsions have been characterized:
    - Droplet size distribution, Emulsion viscosity, Interfacial rheology

Results | Fluids

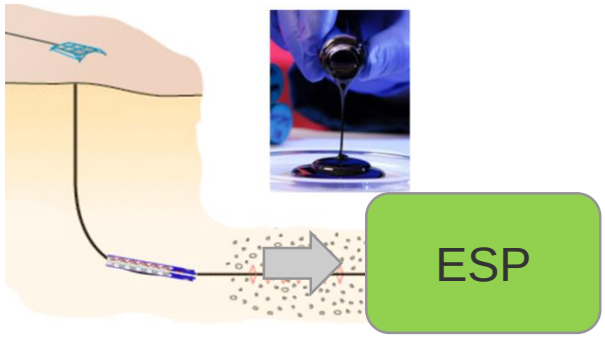


Fluids

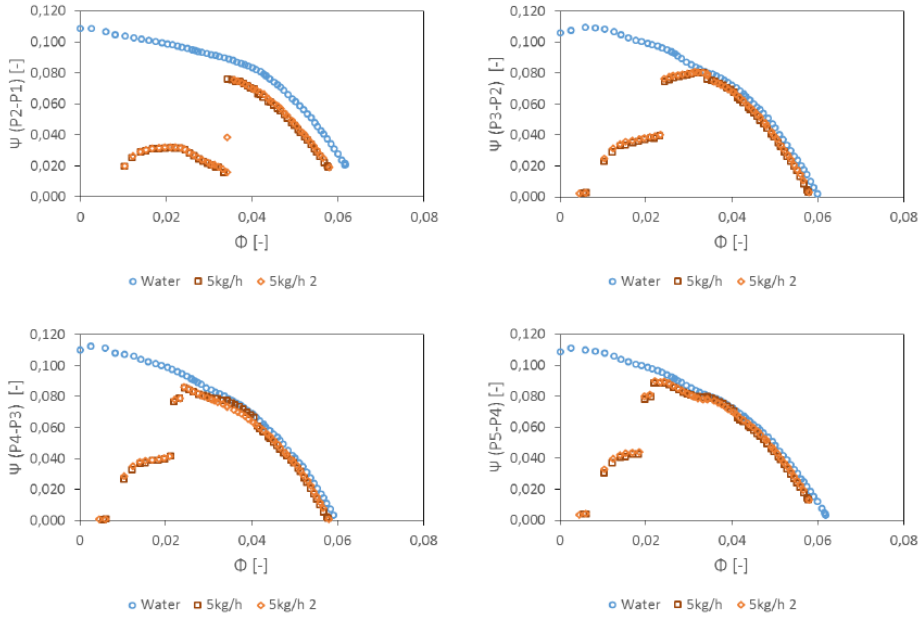
- Results:
  - Emulsions behaviour are depending of:
    - Water-cuts
    - Shear rate (and format of the mixer)
    - Time of mixing
    - Time after mixing
  - Chemicals were used to invert the emulsions



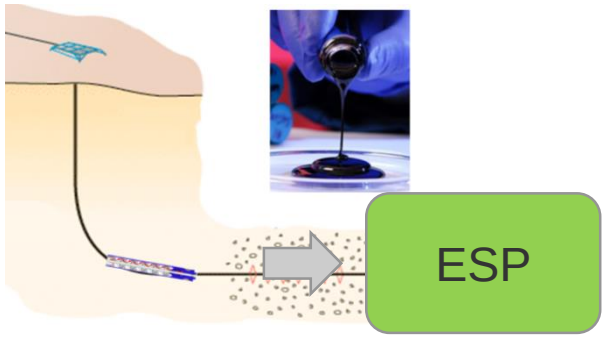
Results | ESPs



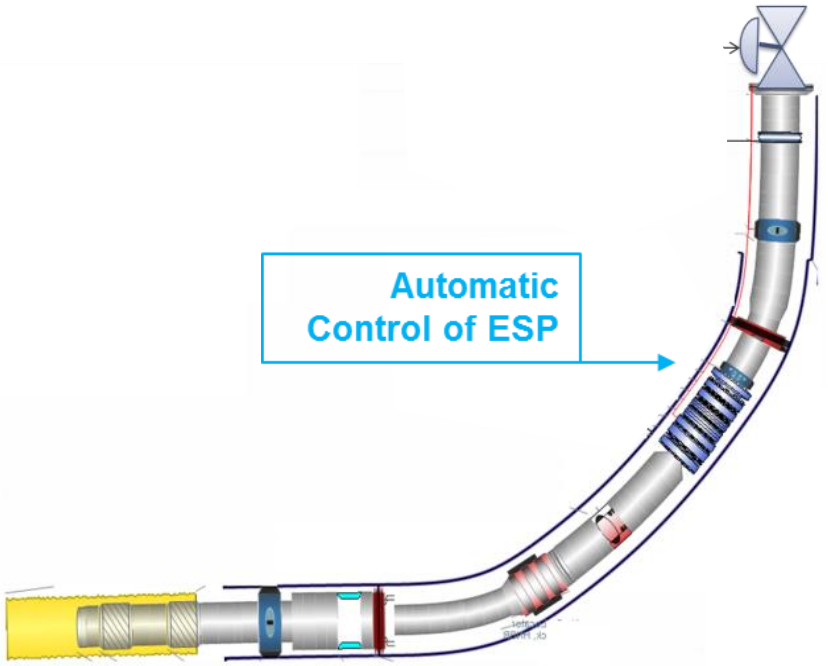
- Results:
  - Measured the performance of each stage in an ESP for different fluids (Water, Oil, Water/Gas, Oil/Gas, Oil/Water)
  - Evaluated the inversion point of the emulsion behaviour for different:
    - Water cuts
    - Frequencies
    - Emulsion breakers



Results | ESPs

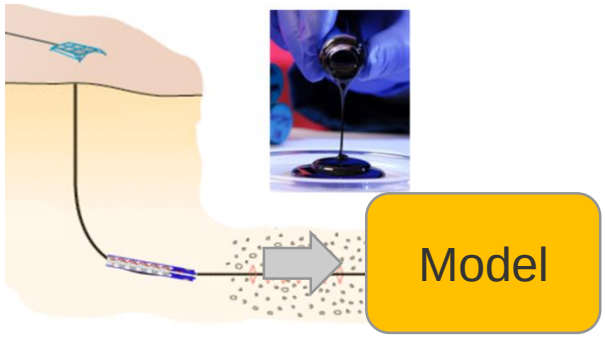


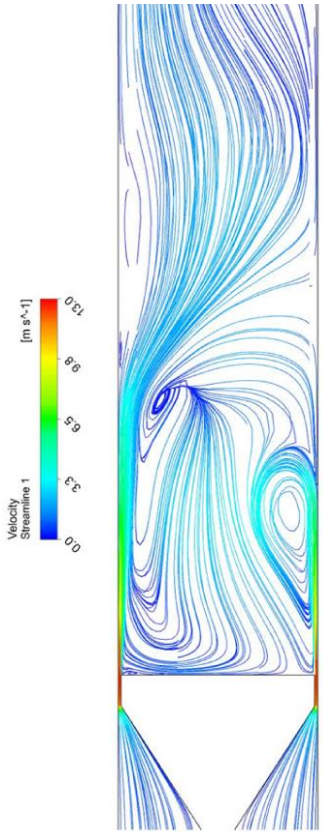
- Results:
  - Verified the efficiency of ESP performance in the flow loop
  - In Peregrino field, tested invert emulsion
  - Prepared automation system to control ESPs



Results | Models

- Results:
  - CFD models developed for single stage ESP and narrow gap reactor
  - Unstable flow regimes in narrow gap reactor observed
  - Comparison of CFD models and observations from lab experiments indicate that droplet break-up may take place in eddies and high shear flow fields
  - Still working on a methodology for transferring data from lab scale measurements to predicted behaviour in ESP





Conclusions

- Water in oil emulsions have been prepared and characterized
- Images of droplet being generated show that a single droplet may be split to two or more droplets and an elongation “mother droplet” occurs before break-up
- CFD modelling of ESP and narrow gap has identified high shear regions and is being used to develop a bench-scale methodology for characterization of emulsions being generated in an ESP
- Automatic control of ESP lifted wells was prepared to improve the performance of the pump and increase efficiency – thus increase the life time of the ESP
- Frequency, water-cut and emulsion breaker can influence the phase of the emulsion, impacting directly the performance of the ESP. Test performed in the field confirmed the strategy, but it cannot be managed in all situations
- R&D investments in a sustainable business model; technical, industrial and regulatory. International cooperation was critical for the project
- ANP flexibility on R&D conceptual understanding and qualification when it comes to regulation

Thank for the companies involved

Statoil. The Power of Possible

Combined efforts towards an efficient operation of ESP

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