

WATER CUT DETERMINATION IN LIQUID-LIQUID FLOW USING ELECTRICAL CAPACITANCE METERING

28TH JULY 2019

PRESENTER: YESSICA ARELLANO

PRIETOY@UNI.COVENTRY.AC.UK

SUPERVISORY TEAM: O. HAAS, H. AHMED, A. HUNT, L. MA

Outline

I – Background

II – Electrical Capacitance Measurement (ECT)

III – Experimental results

IV – Conclusions

Multiphase flow measurement in the Oil & Gas Industry

Oil & Gas industry

- Advanced oil and gas production techniques

- Challenges:

- Marginal Fields
- Development costs
- Energy efficiency

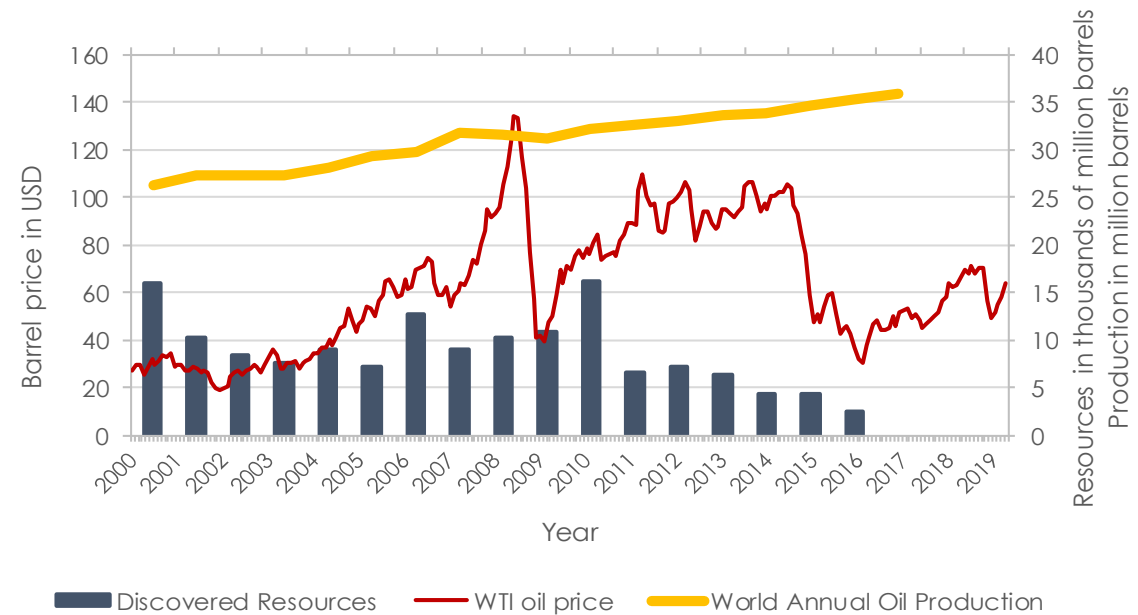
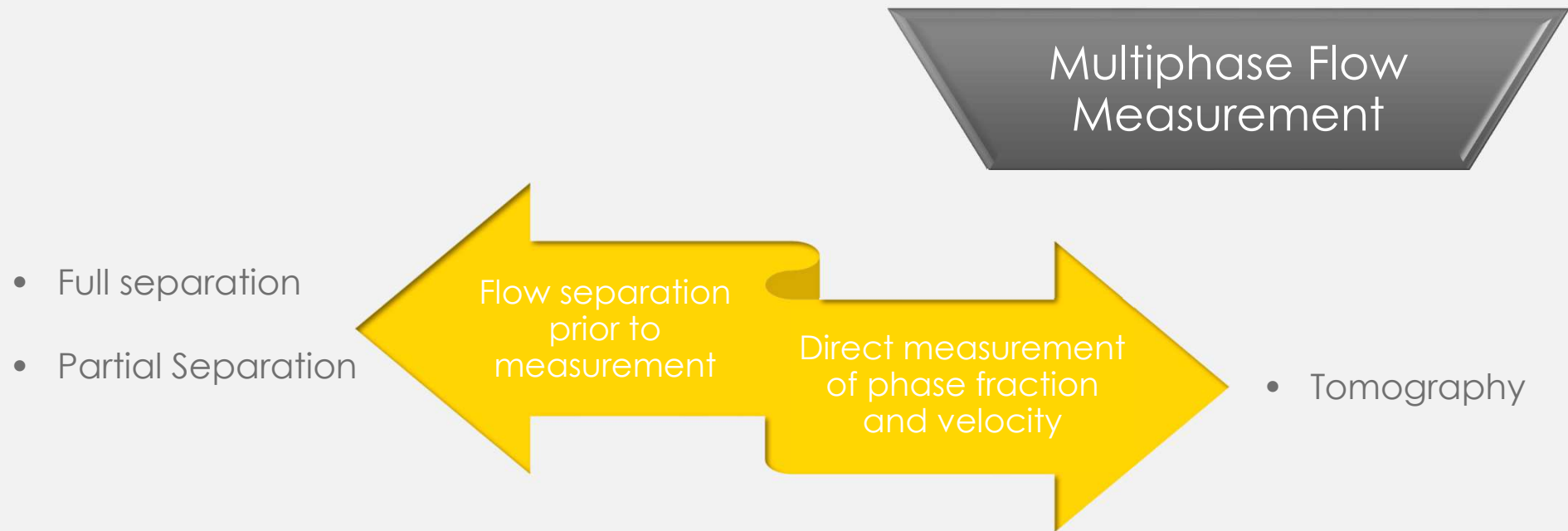


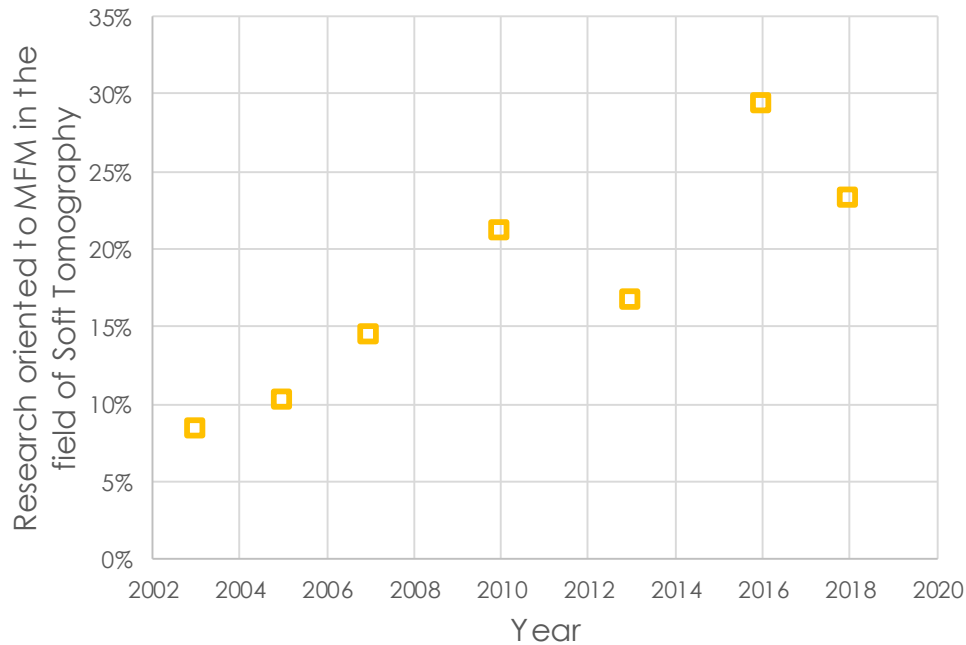
Figure source: EIA (2019, pg.1), IEA (2017, pg.1), Rodrigue, J. (2016, pg. 1.), & BP (2018, pg.14.)

Multiphase flow measurement in the Oil & Gas Industry



Adapted from Falcone, G and Harrison, B 2011:4 and kbv research [online: <https://www.kbvresearch.com/flow-meters-market>]

Multiphase flow measurement in the Oil & Gas Industry



Opportunities:

- Non-intrusive
- Non-radioactive
- No moving parts
- Fast
- Low cost

Electrical
Tomography

Multiphase flow measurement in the Oil & Gas Industry

Soft-field tomography technology based on measurement of the electric properties of the fluid phases.

Industrial experiences:

- flow pattern identification
- volumetric rates,
- velocity measurement
- hydrocarbon phase separation
- tankers loading,
- Collapse of oil foams.



ECT: Principle of operation

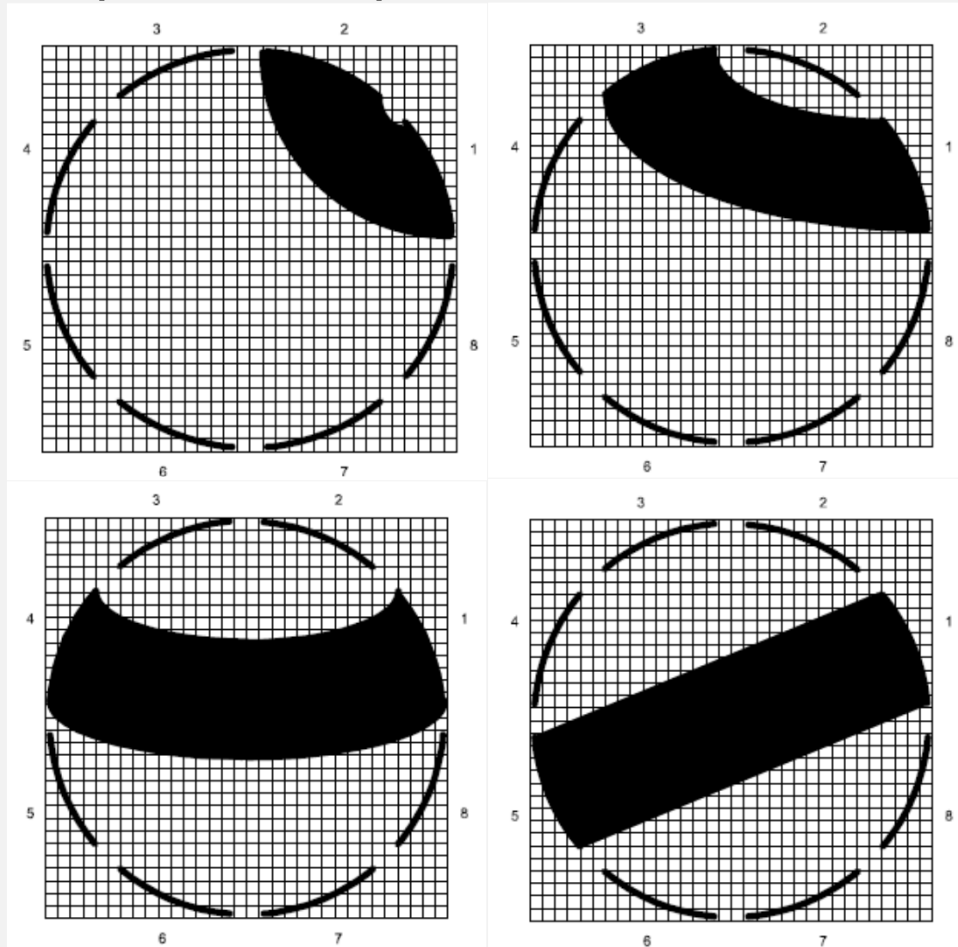
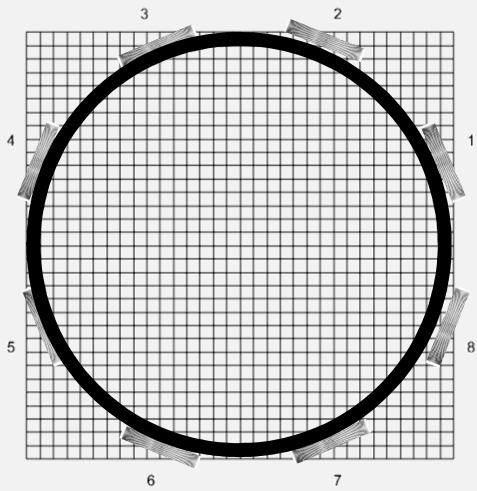
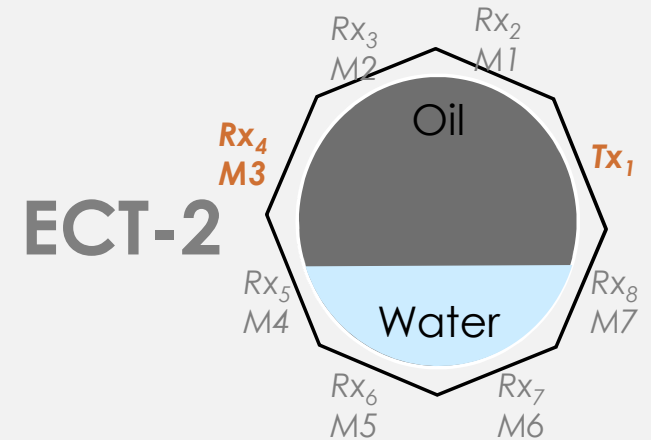


Figure adapted from Process Tomography Ltd. PTL300e operating manual (2018, AN1-22)

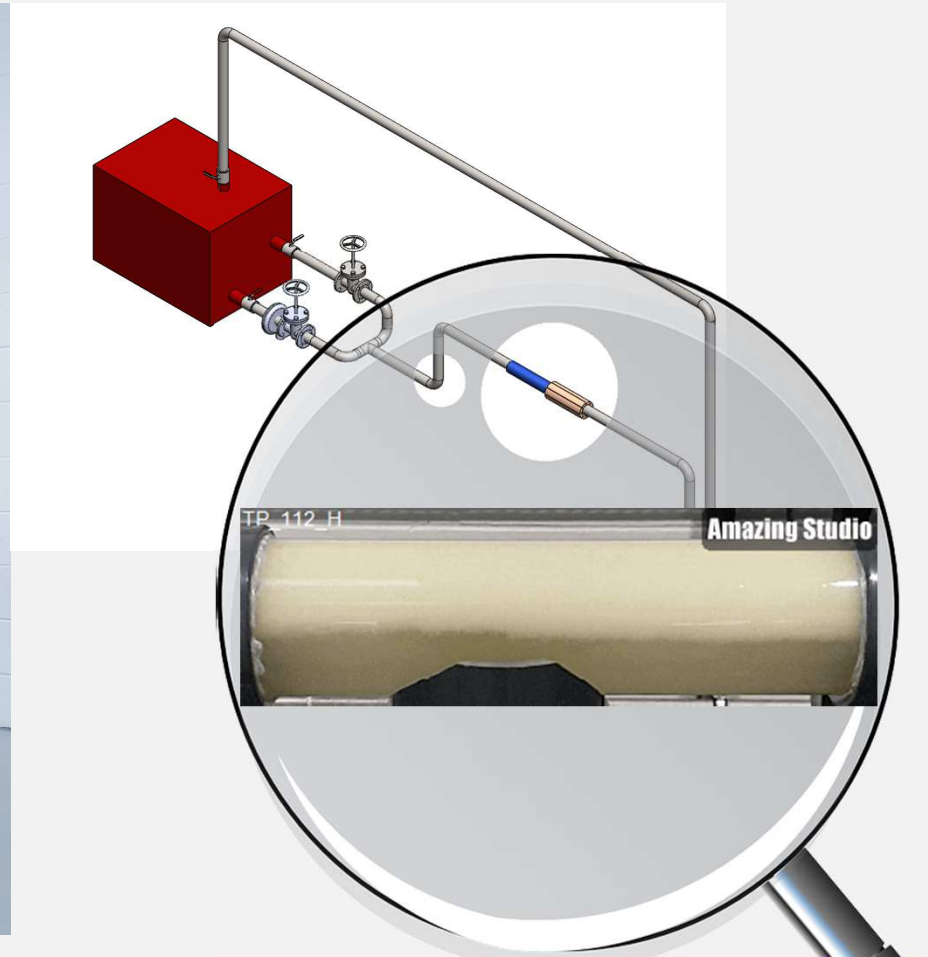
Method

- Working fluids:
 - oil $\rightarrow \epsilon_r=2.2$
 - water $\rightarrow \epsilon_r=80$
- Water cuts $\rightarrow 25\% - 75\%$
- Flow direction: Horizontal
- Full ECT system vs. capacitance measurements from a single sensor pair
- Water cut determination from capacitance metering (for the first time!)

Illustration of the ECT sensor positions around a horizontal pipe



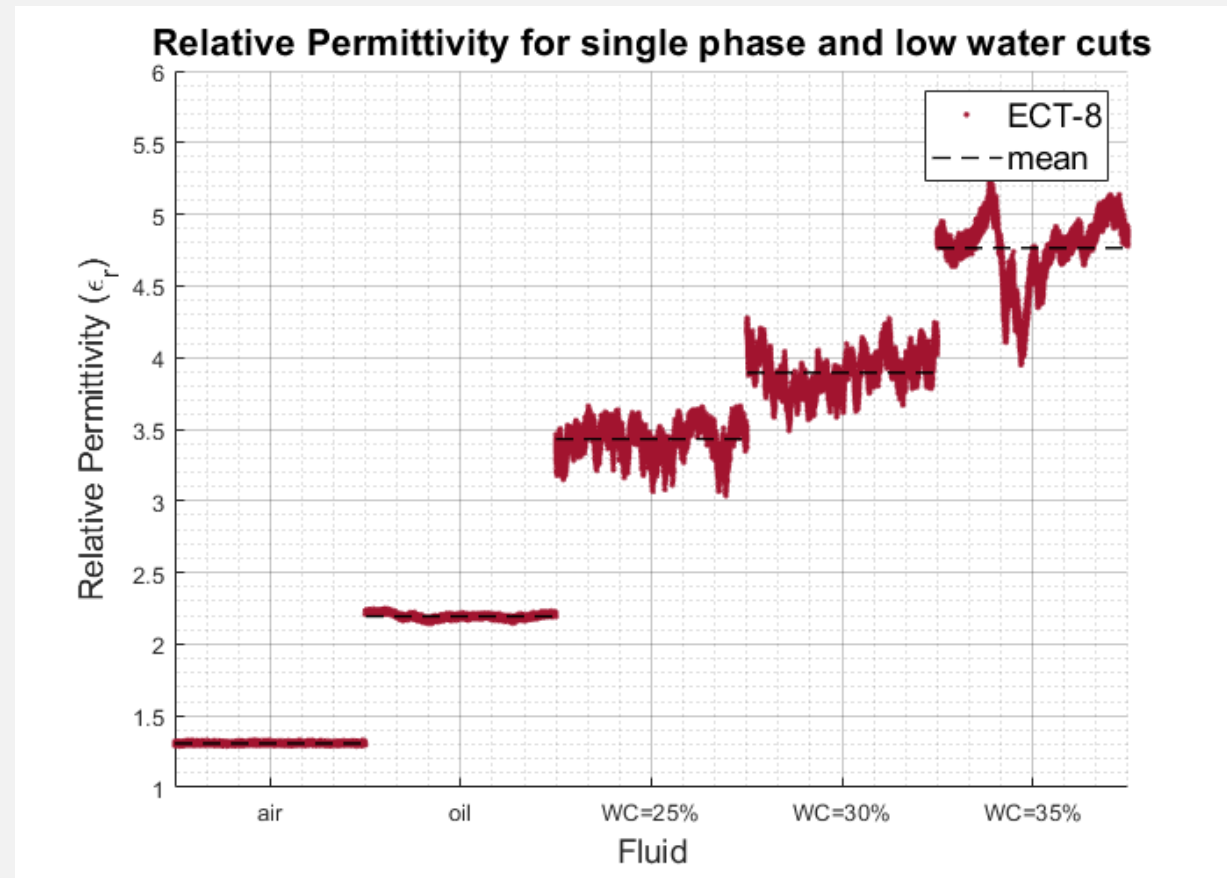
Experimental facilities



Photograph courtesy of iPhase Ltd

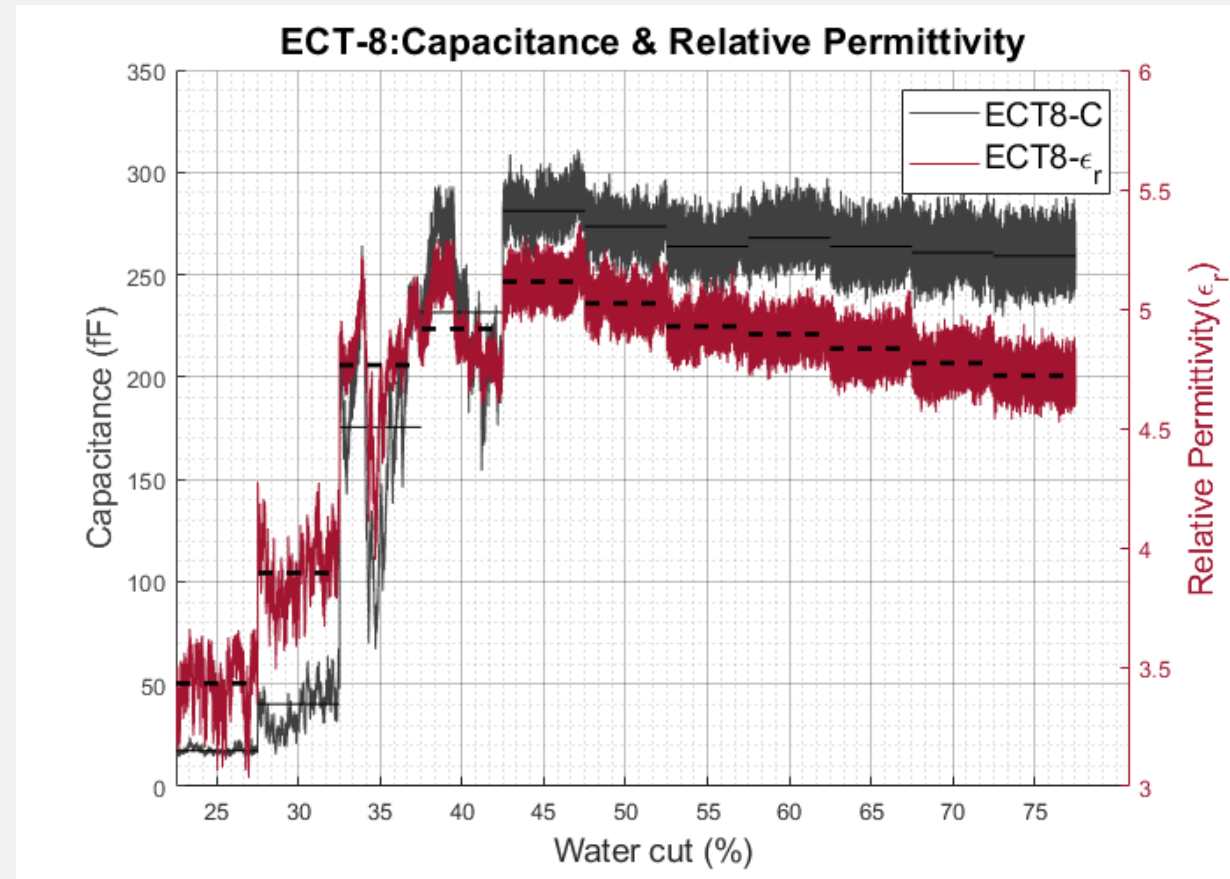
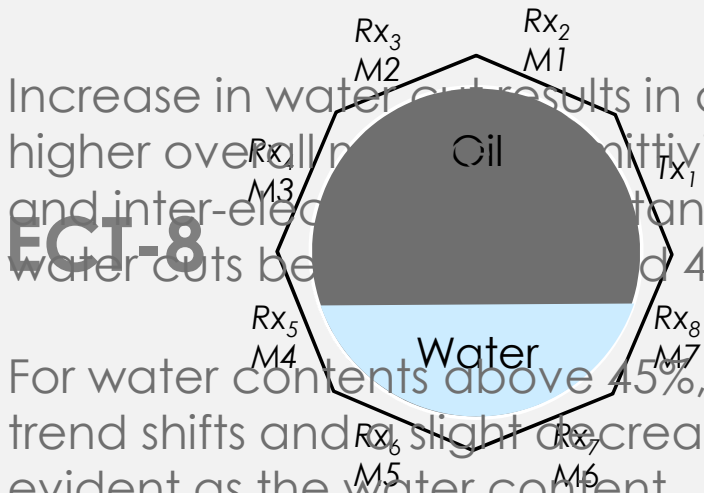
ECT-8: Single-phase and low water cut measurements

- The results show two clear different levels of relative permittivity for single-phase flows (air and oil)
- As the water content increases in the oil-water flow from 25% to 35%, the measured relative permittivity also increases.
- The multiphase flow measurements show relative permittivity larger than the single-phase flows, with an increasing difference as the water cut increases.



ECT-8: Multi-phase flow measurements

- Increase in water cut results in a higher overall permittivity and inter-electrode capacitance for water cuts below 45%.
- For water contents above 45%, the trend shifts and a slight decrease is evident as the water content continues to increase.

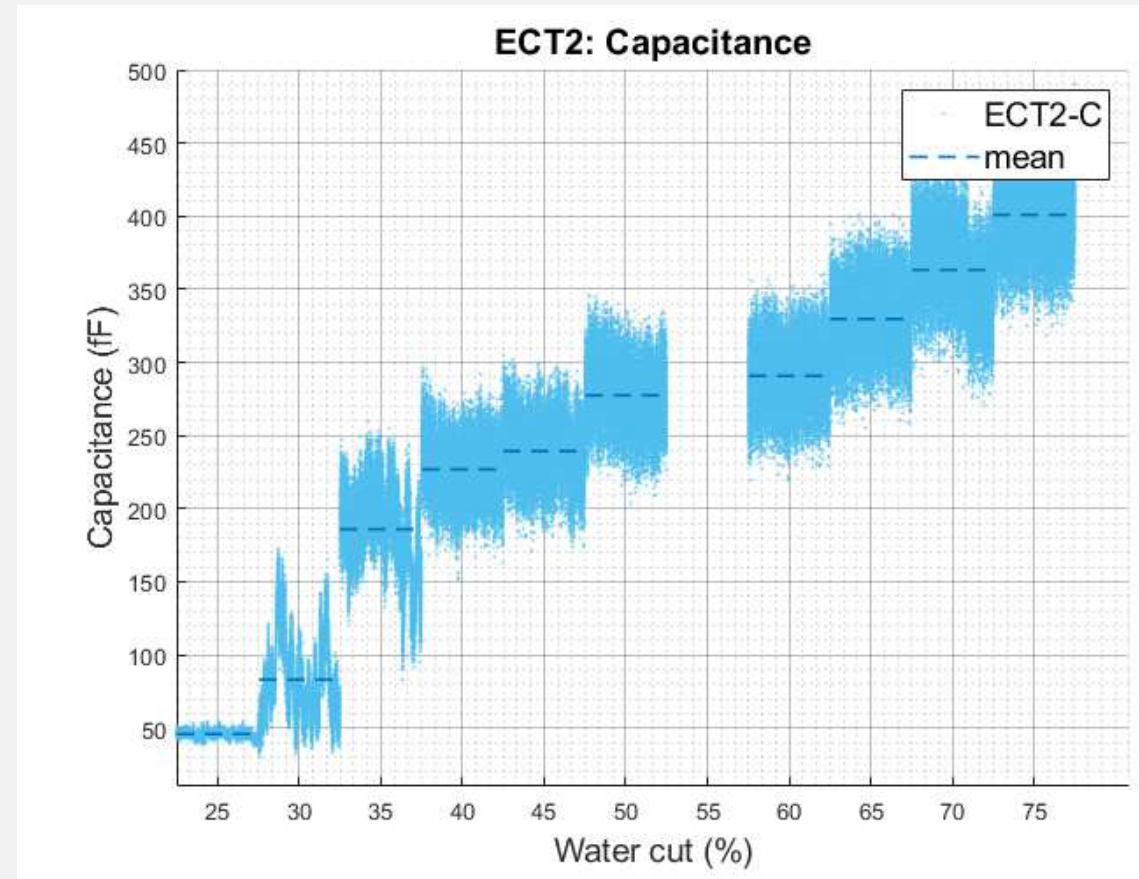
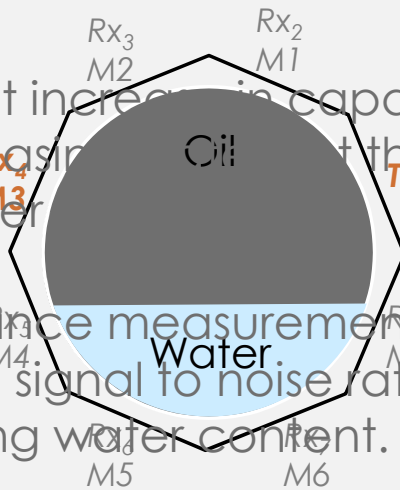


ECT-2: Multi-phase flow measurements

- Consistent increase in capacitance with increasing water cut throughout all oil-water

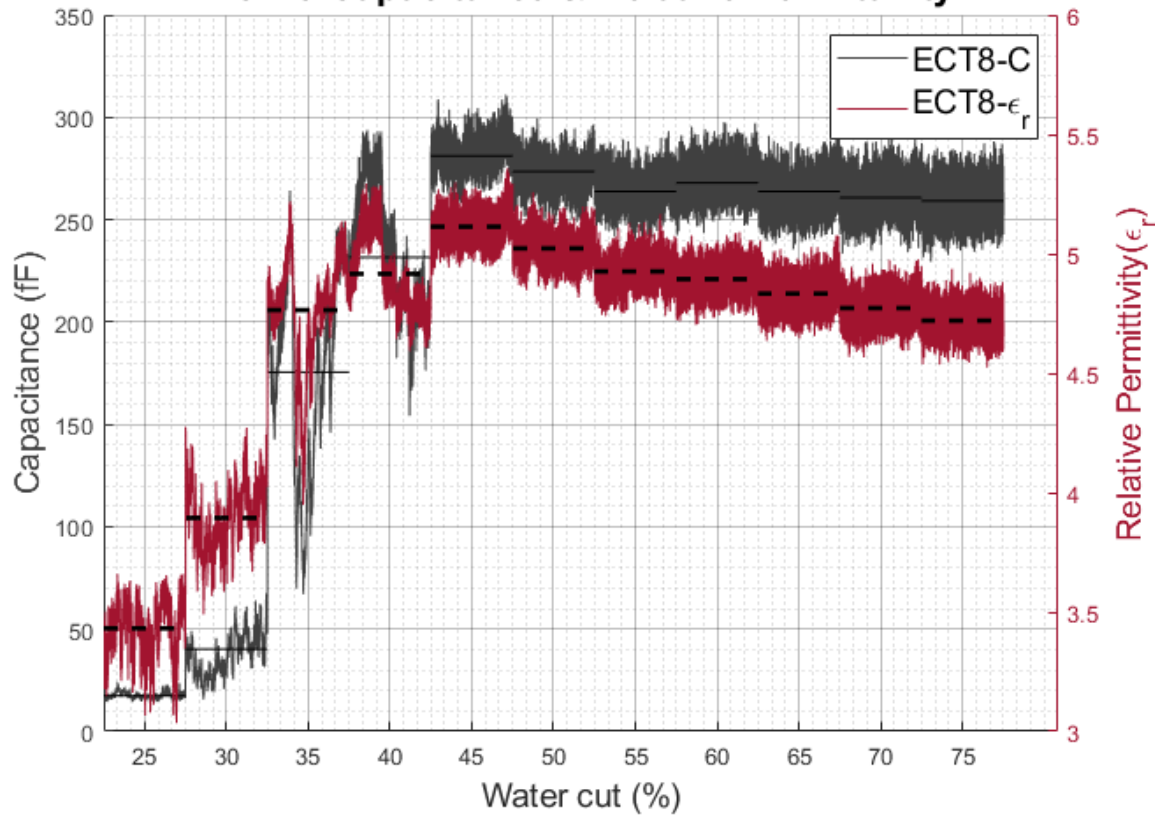
ECT-2

- Capacitance measurements show improved signal to noise ratio with decreasing water content.

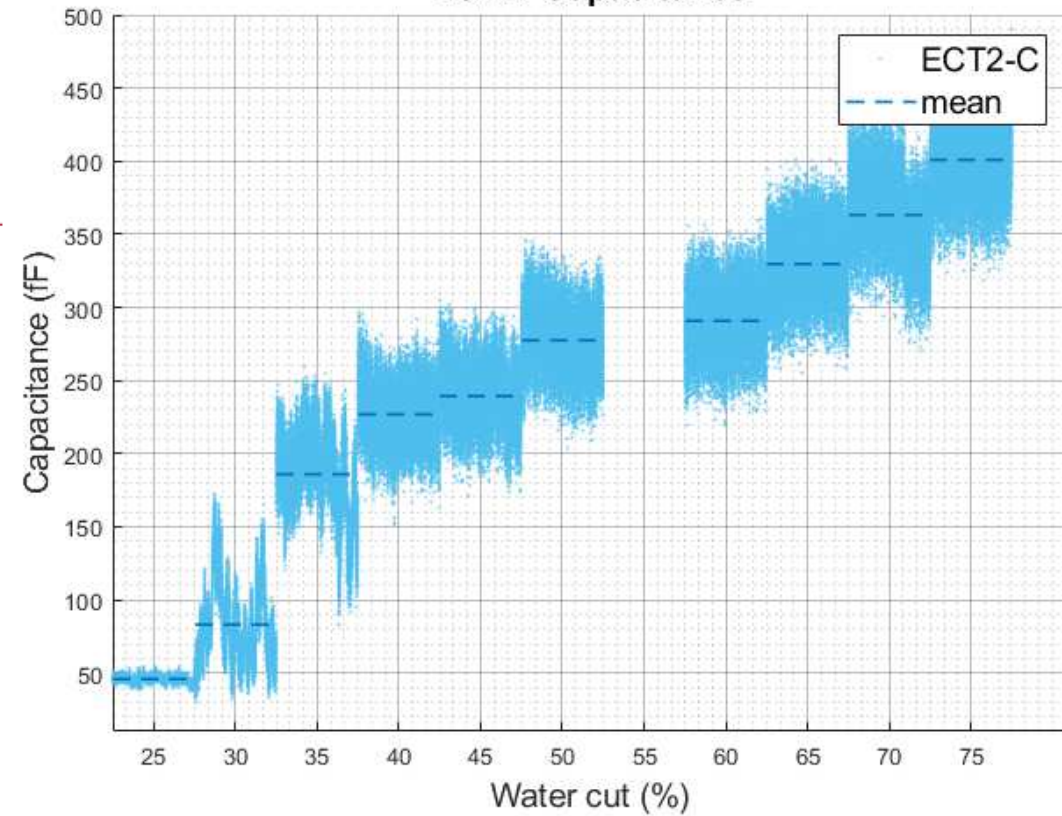


ECT: Multi-phase flow measurements

ECT-8: Capacitance & Relative Permittivity



ECT2: Capacitance



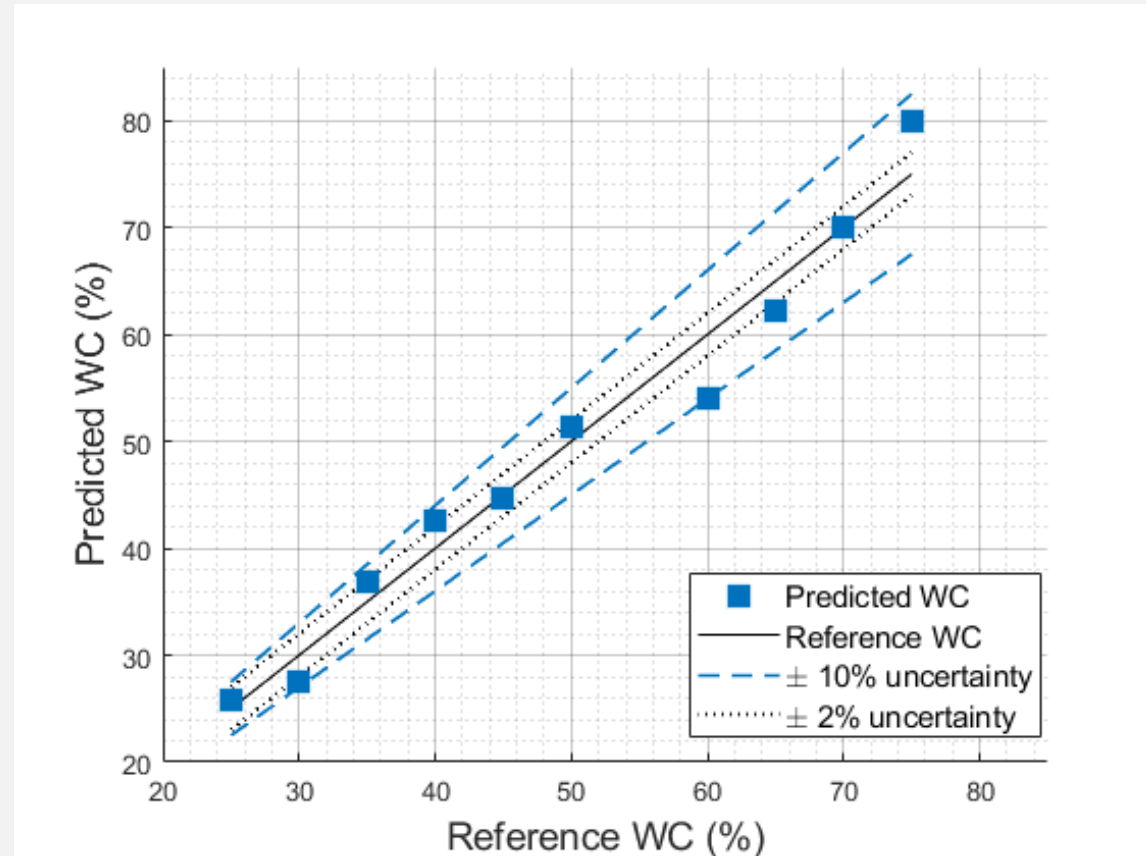
Water cut determination

- It was determined that for oil flow rates ranging from 3 to 9m³/hr, the capacitance varied with water cuts at a ratio given by:

$$C_{M3} = [2931(WC) - 73570]^{\frac{1}{2}}$$

where C_{M3} is the capacitance in pF measured from the electrode pair Tx1-Rx4 and WC is the water volumetric fraction expressed in percentage.

- The developed correlation describes over 96% of the variability of the measurement with an overall fitting inside the $\pm 10\%$ deviation range.



Conclusions

- The 8-sensor ECT meter was able to recognise changes in liquid-liquid concentration for low water ratios.
- Electric capacitance meters are sensitive to changes in flow concentrations regardless of the conductive properties of one of the phases or its volumetric fraction.
- Water cut prediction from single-electrode pair measurements provides an uncertainty range below 10% over a spectrum of water cuts from 25% to 75%.



18th International Flow Measurement Conference

Portugal | Lisbon | LNEC | 26-28 June 2019

Muito Obrigado!



Coventry
University

YESSICA ARELLANO

FLUIDS AND COMPLEX SYSTEMS RESEARCH CENTRE

PRIETOY@UNI.COVENTRY.AC.UK