THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

# Enhancing CSG well production through BHP control

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## Problem definition

The estimation of counter-current two-phase flow pressure profiles is important in a wide range of industrial processes, including the prediction of flowing bottom-hole pressure (FBHP) for the design of coal seam gas (CSG) wells and artificial lift.

Leaders of the CSG industry are currently using simulators containing models that were originally developed for conventional wells (co-current flow in pipe) for their CSG developments (counter-current flow in annuli).

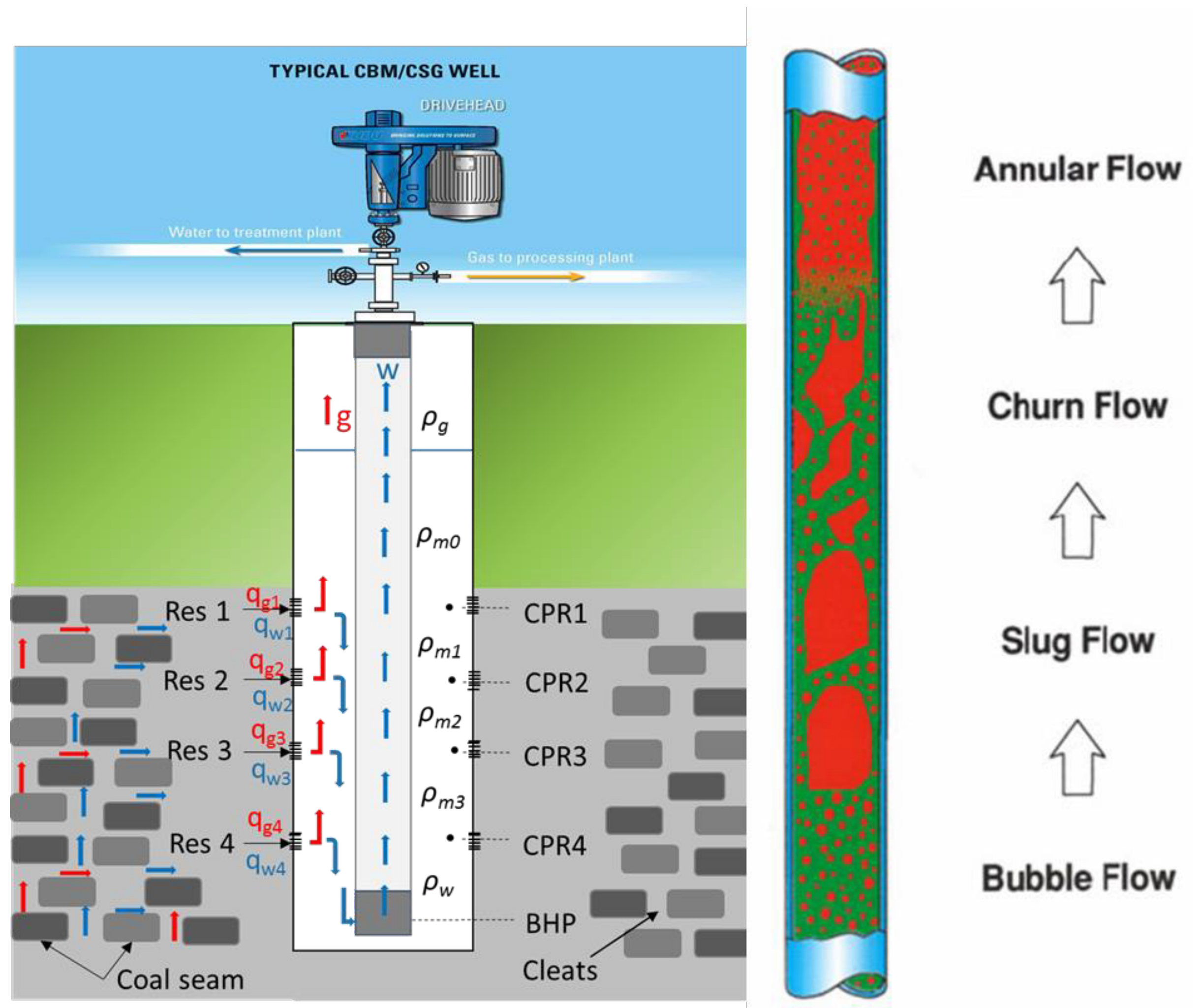


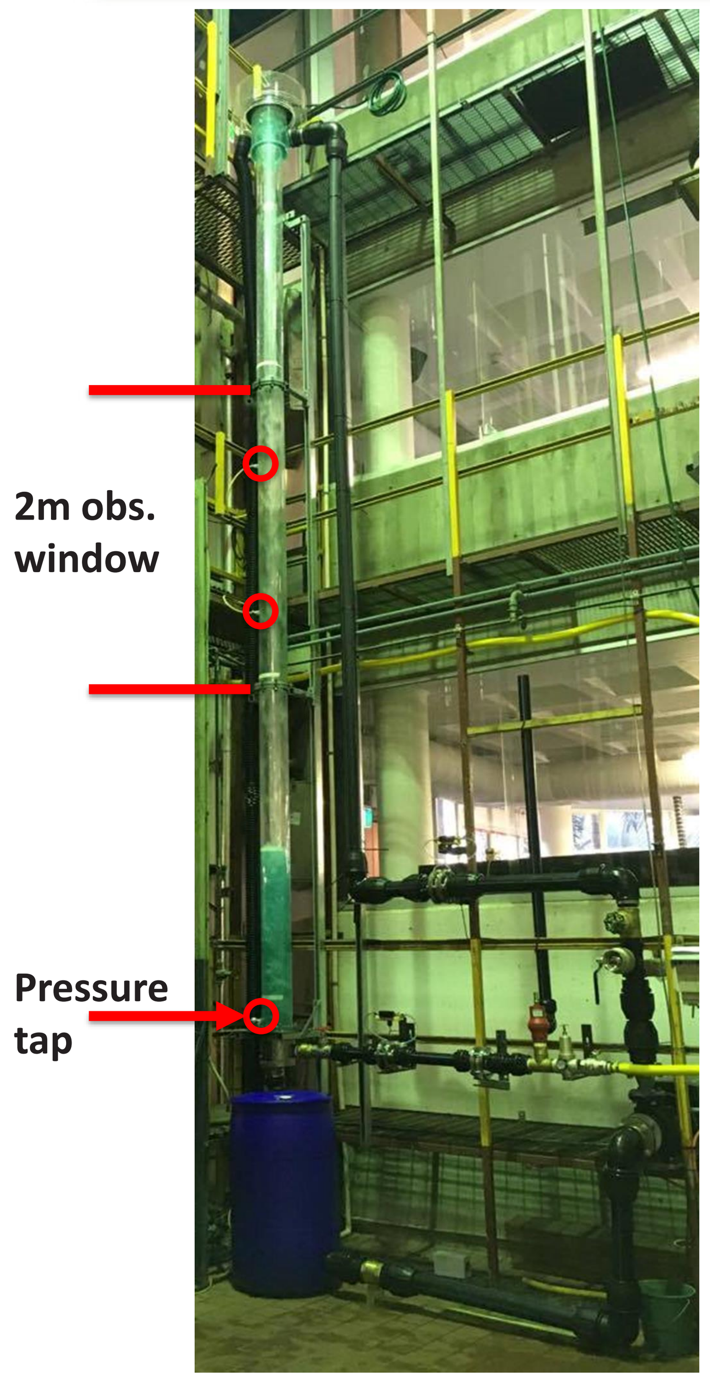

**Figure 1. Two-phase flow regimes across a well-bore**

## Project objectives

To produce a system model for predicting the FBHP in CSG wells.

1. Develop mathematical models for the pressure gradient of each unique flow regime
2. Design an experimental rig resembling a typical CSG well
3. Conduct lab tests for identification of flow regimes and measurement of associated pressure drops and hold-ups
4. Determine the conditions for onset of slugging and free flow
5. Validate/modify our mathematical models for the FBHP

## Experimental setup




Experimental measurements:

1. Flow regimes
   - Visual observation
   - Videography
2. Differential pressure and FBHP
   - Pressure transducers
3. Holdup
   - Image analysis
   - Photo diode
   - Distributed Acoustic Sensing (DAS)
4. Effect of liquid properties
   - Test formation water
5. Maximum dewatering rate
   - Detect gas carry over

| Parameter | 7" well |
|---|---|
| Casing ID | 170 mm (6.69") |
| Tubing OD | 70 mm (2.76") |
| Rig height | 8.0 m |
| Test section | 6.0 m |
| Max. air flow | 7,500 Lpm (380 MSCFD) |
| Max. water flow | 1,200 Lpm (10,000 BBLD) |

**Figure 2. Experimental setup of counter-current two-phase flow in an annulus**

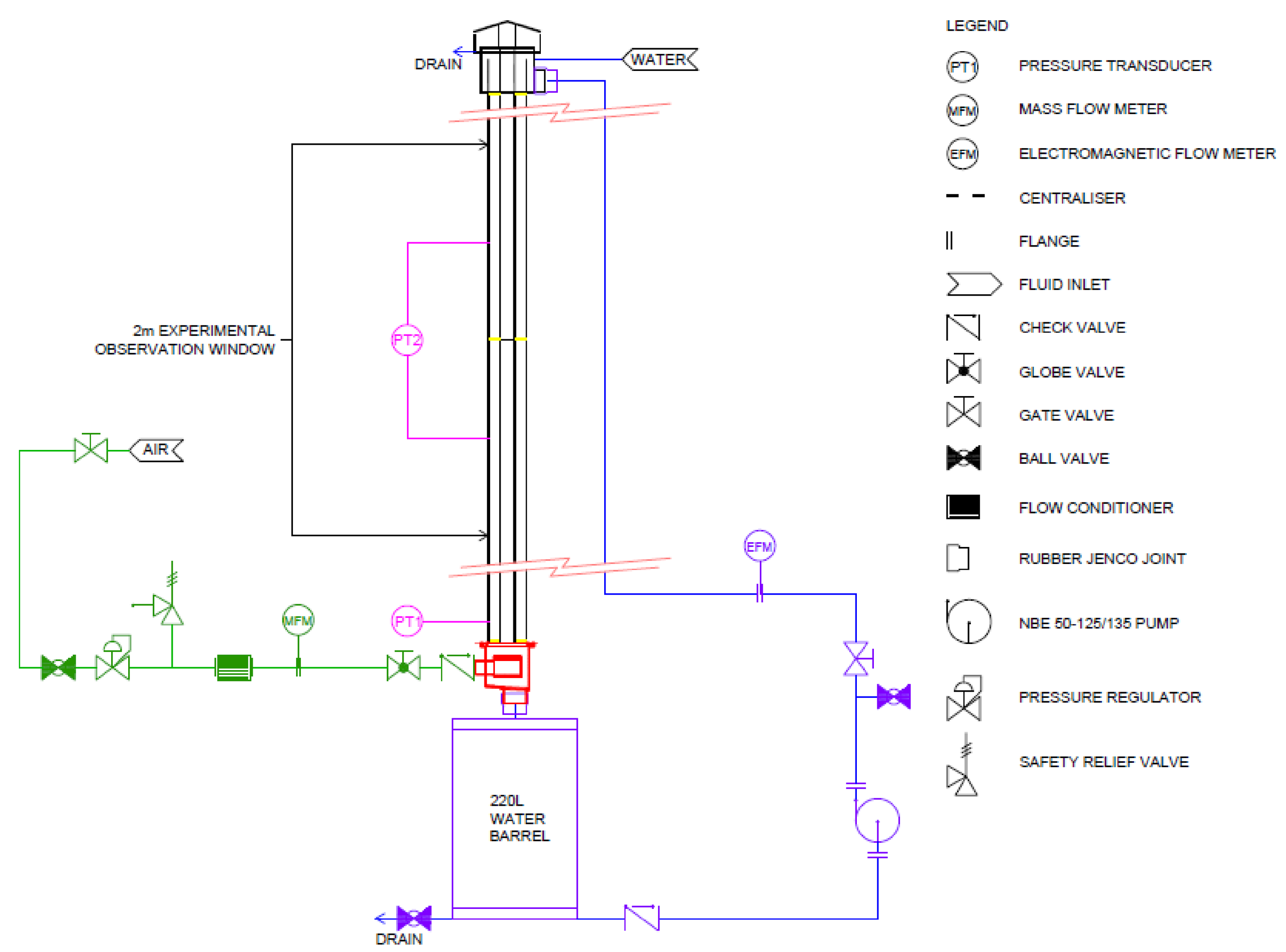



**Figure 3. Schematic of the experimental rig**

## Results

Experimental results and corresponding flow rates are monitored in real time and recorded as logs.

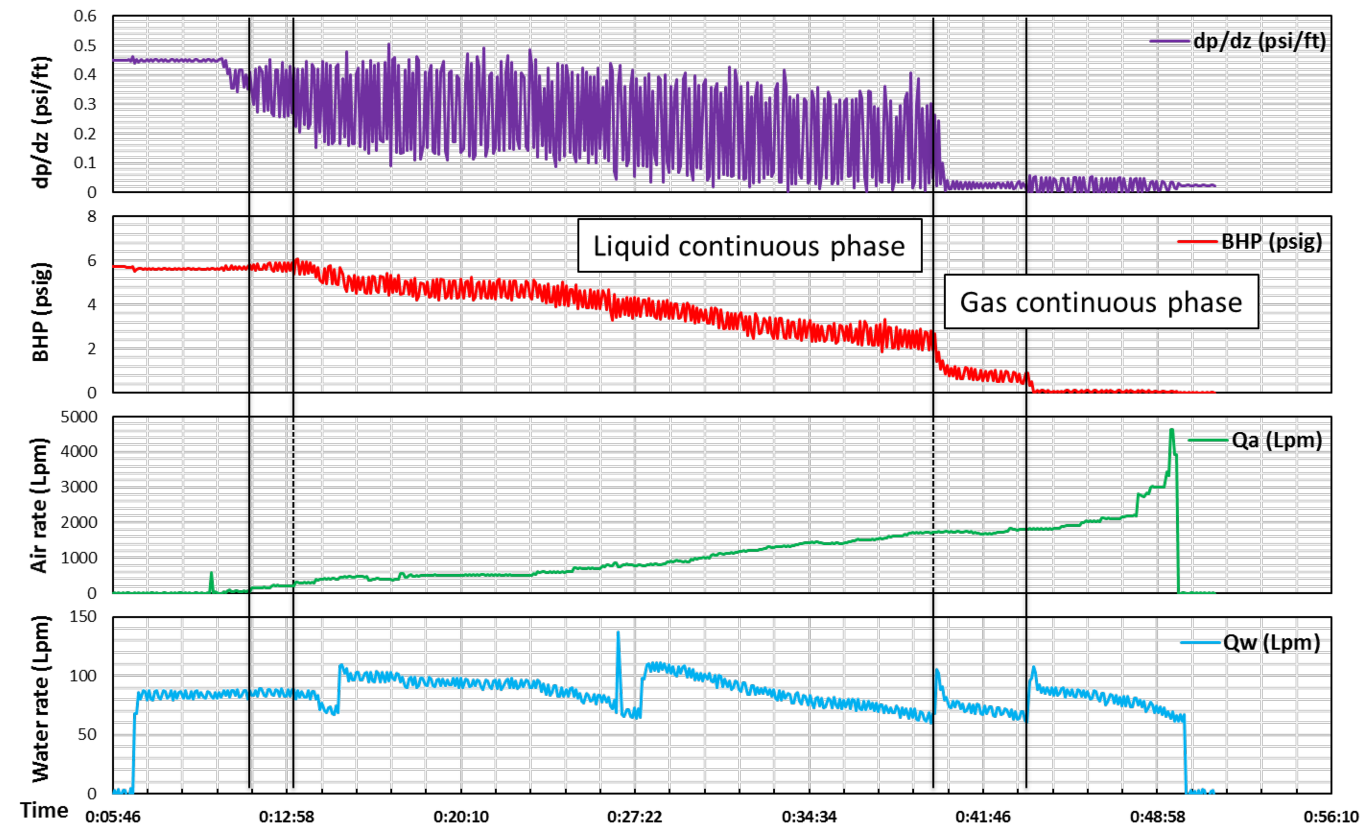



**Figure 4. Pressure and flow rate log data**

A transition to the annular flow regime, gas continuous phase, was observed when water flow rate was increased. Shifting from a liquid continuous phase to a gas continuous phase has the most significant impact on the pressure data.

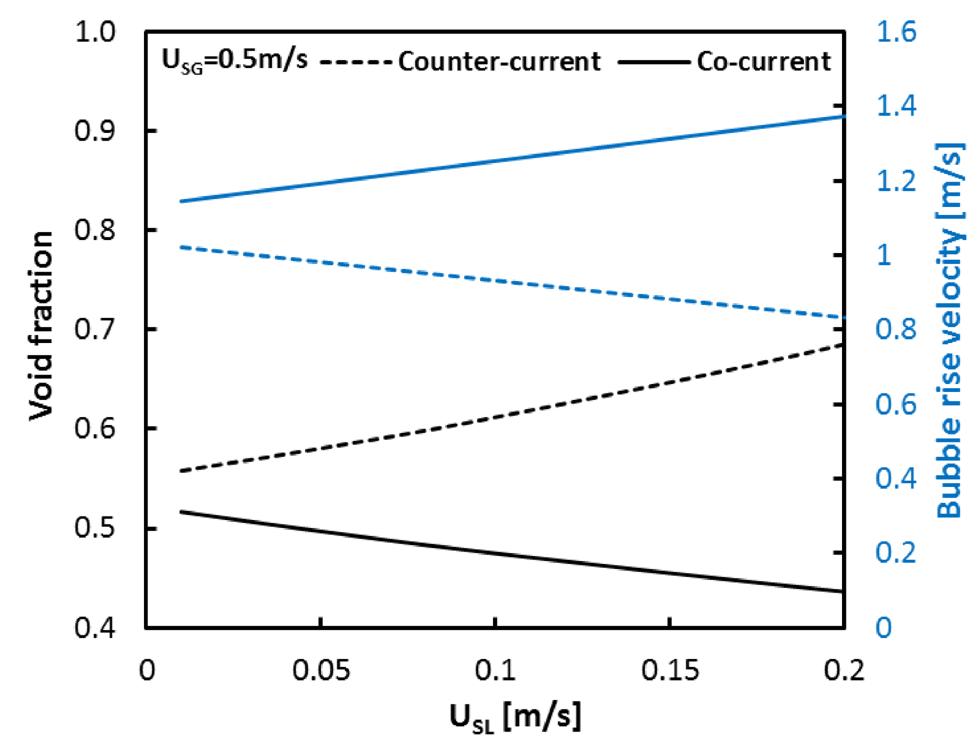



**Figure 5. Modelling results for liquid rate vs. void fraction**

Models have shown that in counter-current two-phase flows, water flow contributes to increased void fraction by decreasing bubble rise velocity and increasing gas retention time. Void fraction, or hold-up, is a key criteria in the description of flow regimes.

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