Enhancing CSG well production through BHP control

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Problem definition

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.

The CSG industry is currently using simulators containing models which were originally developed for conventional wells (co-current flow in pipe) for their CSG developments (which are counter-current flow in annuli).

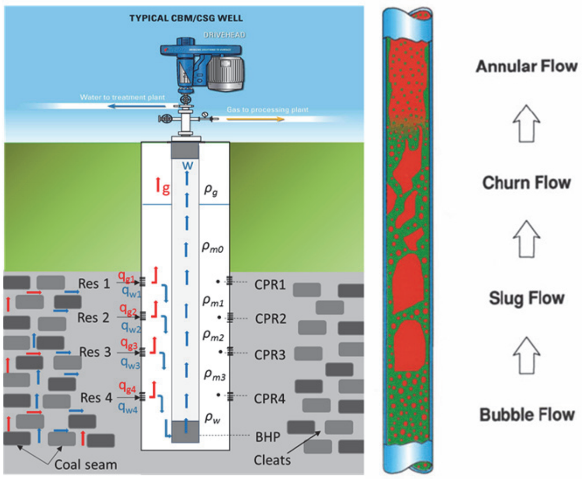


Figure 1: Two-phase flow regimes across a well-bore

Methodology

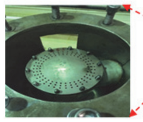
The University of Queensland Well Simulation Flow Facilities were designed to replicate the production zone of a typical pumped CSG well in Queensland, Australia, as closely as possible:

- 7-in casing and 2¾-in tubing.
- Air and water used for safety.

Experimental results are used to:

- Validate models developed within the research team.
- Investigate flow regimes (bubble, slug, churn, and annular) and their associated holdups and pressure profiles.
- Determine the conditions for onset of counter-current flow limitation (gas carryover and "slugging").
- Conduct pressure signal analysis to identify flow regimes

Parameter	7" well
Rig height	30'
Annulus height	24'
Max. air flow	380 Mscf/d
Max. water flow	10,000 bbl/d



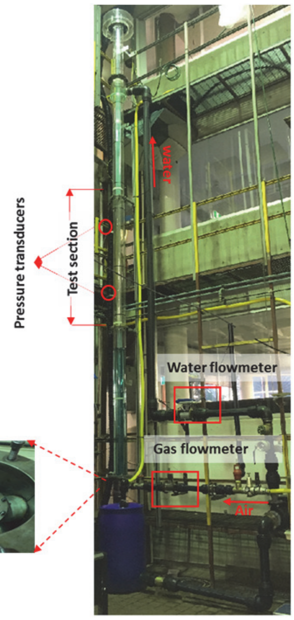


Figure 2: Experimental setup of counter-current two-phase flow in an annulus

Development of flow regimes in CSG wells

Two-phase flow properties are intrinsically linked to the flow regimes that develop. The conditions at which flow regimes exist are typically predicted using superficial velocities (production rates). This is an imperfect but simplistic approach.

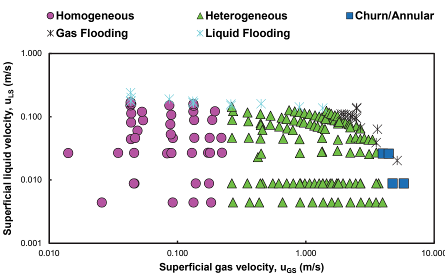


Figure 3: Flow regimes identified in a replica well

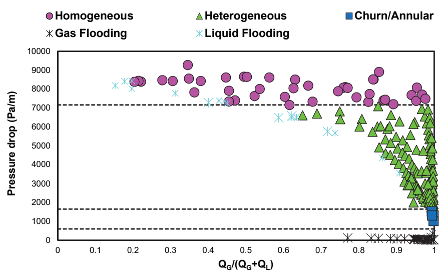


Figure 4: Flow regimes and associated pressure drops

CCFL: onset of gas carryover & free flow

At extremely high gas or liquid flow rates, some fraction of co-current flow develops.

Gas carryover is of particular interest in CSG dewatering operations.

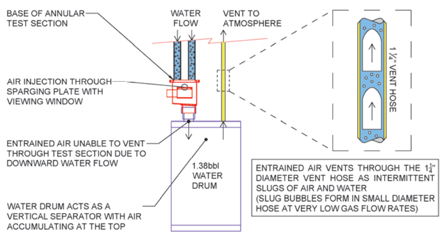


Figure 5: Experimental detection of gas carryover

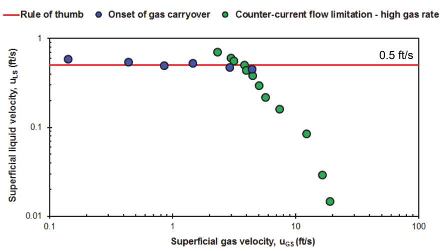


Figure 6: Onset of CCFL in a CSG well (Wu, et al 2018)

Our results validate the 0.5ft/s industry rule of thumb which is equivalent to 1560-bbl/d in a 7-in casing and 2¾-in tubing completion.

Pressure signal analysis to identify flow regimes

Fluctuations in pressure are predominantly due to changes in holdup. Therefore analysis of the pressure signals can reveal detailed information on the two-phase flow.

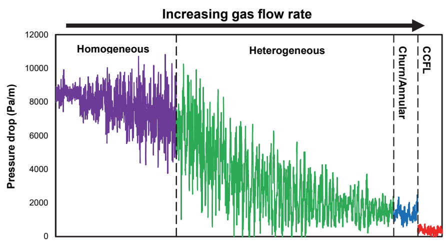


Figure 7: Pressure signals reveal flow regime transitions

Fast Fourier Transformation (FFT) presents the signals in the frequency domain – useful for identifying physical phenomena in flow regimes.

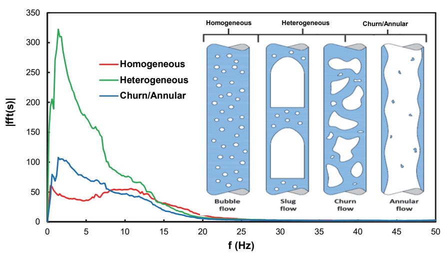


Figure 8: FFT pressure signals characterising flow regimes

Acknowledgements

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