Mathematical modelling of the slug flow regime in CSG wells

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School of Chemical Engineering UQ-CSG Project Title: Mathematical modelling of counter-current two-phase flow in CSG wells

Research Aims

History matching of production data such as bottom hole pressure (BHP) is a common practice in oil & gas industry to predict wells' deliverability. The available models in CSG industry simulators were originally designed for conventional oil & gas (Co-current two-phase flows).

This project aims to develop new models for predicting the pressure profile of counter-current two-phase flows in CSG wells.

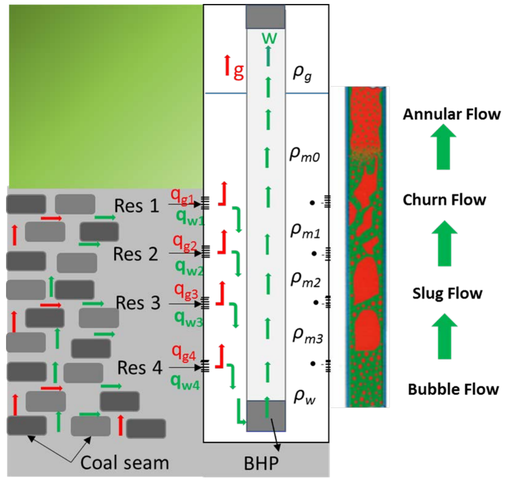


Fig 1. Schematic of a CSG well

Flow maps

Depending on fluid properties, flow parameters and conduit characteristics, distinct flow patterns may develop in liquid-gas flows.

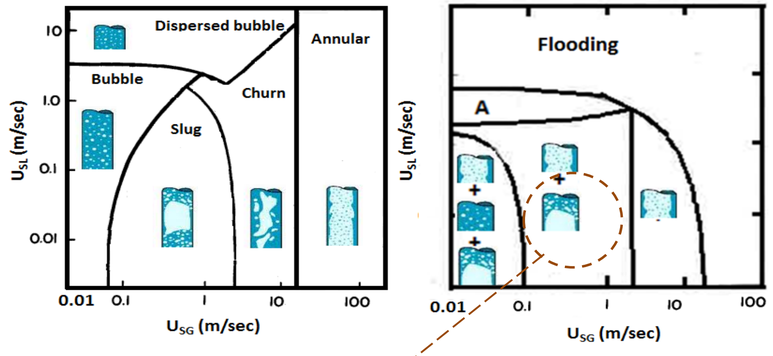
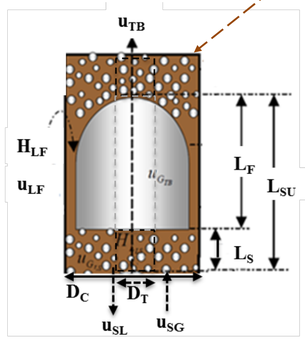


Fig 2. Flow maps for co-current (left) and counter-current (right) two-phase flows in pipes



u_{TB} : Bubble translational velocity
u_{SL} : Liquid superficial velocity
u_{SG} : Gas superficial velocity
$u_{G_{TB}}$: Gas velocity in Taylor bubble
u_{L_F} : Liquid velocity in the film
u_{G_S} : Gas velocity in the slug
u_{L_S} : Liquid velocity in the slug
H_{L_F} : Liquid holdup in the film
H_{L_S} : Liquid holdup in the slug
L_F : Length of the Taylor bubble
L_S : Length of the liquid slug
L_{SU} : Length of the slug unit

Fig 3. Schematic of slug unit and hydrodynamic parameters

Modelling results

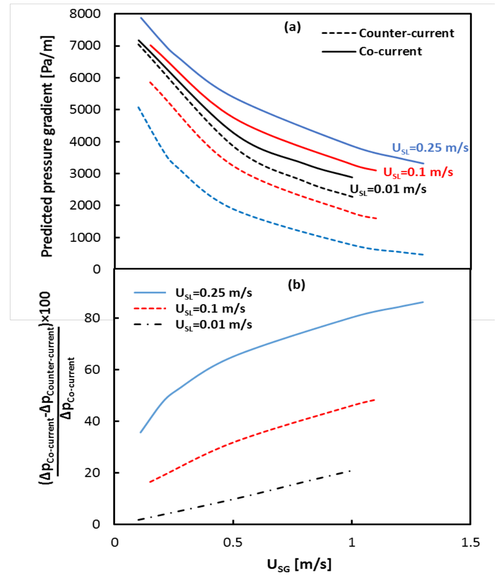


Fig 4. (a) Predicted total pressure gradient for methane-water slug flows and (b) relative deviation of the total pressure gradient of counter-current flows in an annulus (D_T=7 in and D_C =2 7/8 in).

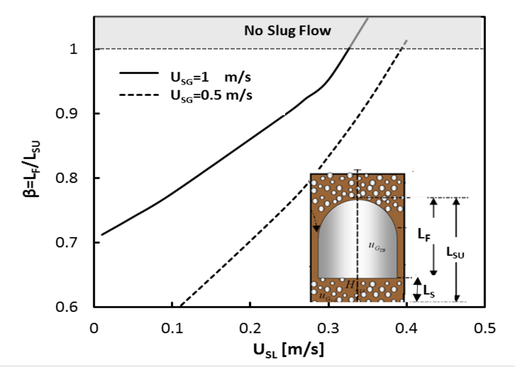


Fig 5. Predicted relative length of the Taylor bubble with respect to the length of the slug unit in counter-current flows (β>1 indicates that the slug regime does not exist)

Comparison of the modelling results

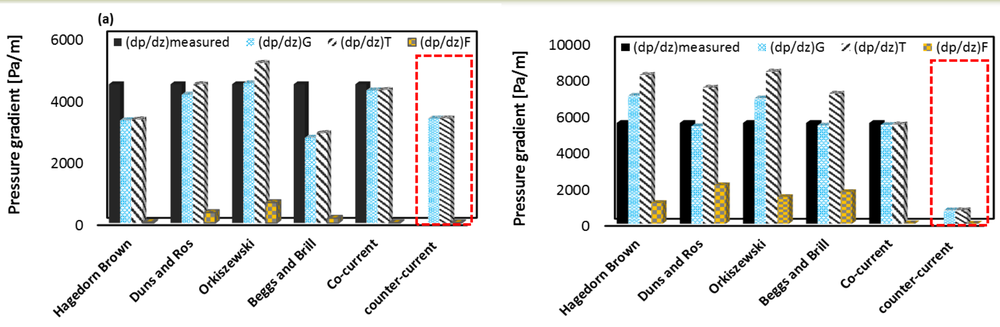


Fig 6. Comparison of the modelling predictions of this work with the available models and measured pressure gradients for (a) u_{SG}=0.4 and u_{SL}=0.04 m/s (b) u_{SG}=0.4 and u_{SL}=0.24 m/s

Conclusion

- Our comparison of the pressure profiles of co-current and counter-current flows in annuli for the slug flow regime indicates that the pressure loss of counter-current flows is appreciably different to that in co-current flows at high gas and liquid flow rates.
- This highlights the need to modify the models that are currently applied in typical commercial well flow simulators to better predict the pressure drop across CSG wells.

Acknowledgements

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