

Technical University of Denmark



## Multiphase flow in porous media using CFD

Hemmingsen, Casper Schytte; Walther, Jens Honore

*Publication date:*  
2016

*Document Version*  
Peer reviewed version

[Link back to DTU Orbit](#)

*Citation (APA):*  
Hemmingsen, C. S., & Walther, J. H. (2016). Multiphase flow in porous media using CFD. Abstract from ECCOMAS Congress 2016, Hersonissos, Greece.

## DTU Library

Technical Information Center of Denmark

---

### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

# Multiphase flow in porous media using CFD

Casper Schytte Hemmingsen<sup>1\*</sup>, Jens Honore Walther<sup>1,2</sup>

<sup>1</sup>Technical University of Denmark

ETH Zürich

Nils Koppels Allé, Bygning 404, 2800 Kgs. Lyngby

casche@mek.dtu.dk

We present results from a new Navier-Stokes model for multiphase flow in porous media implemented in Ansys Fluent 16.2 [1]. The model includes the Darcy-Forchheimer source terms in the momentum equations and proper account for relative permeability and capillary pressure in the porous media. This approach is widely used for single phase flow, but not for multiphase flow in porous media. This might be due to the complexity of introducing relative permeability and capillary pressure in the CFD solver. The introduction of relative permeability and capillary pressure may cause numerical instabilities as the saturation of a grid cell approaches the residual saturation, i.e. the relative permeability goes towards zero. This means that the viscous resistance in the Darcy-Forchheimer equation approaches infinity. Furthermore, by coupling the Navier-Stokes equation and Darcy-Forchheimer equation it is possible to model both the non-porous and porous media using the same formulation.

We are testing the Ansys Fluent 16.2 for two-phase flow in porous media using analytical data as reference. For a radial inflow to a vertical well in a homogeneous reservoir, we compare with the analytical solution for the volumetric flow rate into the well

$$q_{\alpha} = 2\pi K_{abs} k_{r\alpha} h (P_{ref} - P_{well}) / (\mu_{\alpha} (\ln(r_{reservoir} / r_{well}) + S))$$

where  $K_{abs}$  is the absolute permeability,  $k_{r\alpha}$  is the phase relative permeability,  $P_{ref}$  is the reservoir pressure,  $P_{well}$  is the well pressure,  $\mu_{\alpha}$  is the phase viscosity,  $r_{reservoir}$  is the reservoir radius,  $r_{well}$  is the well radius and  $S$  is a skin factor for near-well damage. The relative permeability is modeled for the oil and water system with the Corey correlation [2]

$$k_{rw} = k_{rw,max} s_{wn}^{n_w} \text{ and } k_{ro} = k_{ro,max} (1 - s_{wn})^{n_o}$$

where  $s_{wn} = (s_w - s_{wi}) / (1 - s_{wi} - s_{or})$  is the normalized saturation, and where  $s_w$  is the water saturation,  $s_{wi}$  is the residual water saturation,  $s_{or}$  is the residual oil saturation,  $k_{rw,max}$  is the water relative permeability at residual oil saturation,  $k_{ro,max}$  is the oil relative permeability at residual water saturation,  $n_w$  is the Corey exponent for the water system, and  $n_o$  is the Corey exponent for the oil system.

The comparison between the CFD and analytical solution is shown in Figure 2 and validates the implementation of the relative permeability. Further validation tests on core plugs and with reservoir simulators will be presented at the conference.

## References

[1] ANSYS Fluent, 16.2, User's Guide, ANSYS Inc.

[2] Corey, A. T., 1954, The interrelation between gas and oil relative permeability, *Prod. Monthly* 19 (1): 38-41

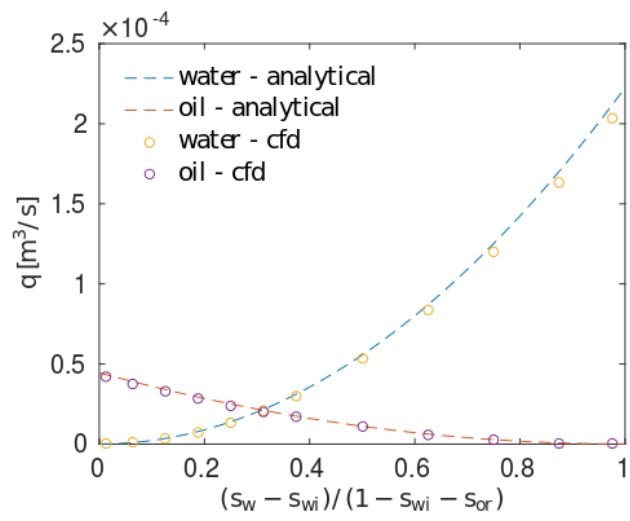


Figure 1: comparison of numerical and analytical multiphase inflow to a vertical well.