
Contribution ID: **230** Type: **Oral Presentation**

# Slip correction theory and transient solution of the pressure oscillation method

*Monday, 13 May 2024 11:55 (15 minutes)*

The pressure oscillation method is a widely employed technique for measuring the permeability of time-varying and tight porous media. The previous analytical solution for permeability calculation neglects the unsteady-state condition of the slip effect, and the application of the Klinkenberg correction lacks theoretical support. Existing permeability calculations rely on the periodic part, and the utilization of the transient part needs further development. In addition, parameter regulation in experiments incurs trial-and-error costs, and the reasonable prediction of parameter setting is necessary. In this study, the analytical solution of the pressure oscillation process considering the slip boundary is derived based on the capillary model and perturbation expansion. The correspondence between the Klinkenberg correction relation and the Knudsen number is clarified, which provides a theoretical basis for applying Klinkenberg correction to the pressure oscillation method. A new data processing method is proposed for permeability calculation based on the transient solution, and the scope of application of the Klinkenberg correction for the new method is given. Experiments of the pressure oscillation method and pulse decay method are carried out to validate the theoretical model and data processing method. Through comparison of the permeability measurement results, the transient solution is consistent with the periodic solution, and the unification of the quasi-steady-state and unsteady-state methods under pressure oscillation conditions is achieved. In contrast to the pulse decay method, the pressure oscillation technique exhibits advantages in terms of measurement duration. Under conditions of higher permeability, a tenfold increase in measurement speed can be attained, while under lower permeability conditions, there is a minimum threefold improvement. Through the inverse solution process for permeability calculation, this study analyzed the main factors influencing measurements in the pressure oscillation method. The reason for the inaccuracy of porosity measurement is that porosity is extremely sensitive to the amplitude ratio and the phase difference, and the measurement error is magnified several times. The contour of the amplitude ratio response based on the dimensionless number is established to provide a reference for the selection of experimental parameters for practical engineering applications.

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**Primary author:** ZHANG, Mingbao (Tsinghua University)

**Co-authors:** Prof. WANG, Moran (Tsinghua University); Mr TIAN, Zhiguo (Tsinghua University)

**Presenter:** ZHANG, Mingbao (Tsinghua University)

**Session Classification:** MS13

**Track Classification:** (MS13) Fluids in Nanoporous Media