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Theoretical Foundation for Klinkenberg-corrected Permeability of Microporous Media in Pulse Decay Method

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We provide the theoretical foundation of directly adopting the Klinkenberg plot, the apparent permeabilities versus the reciprocal of the mean pressures, in Pulse Decay Method to eliminate the slippage effect, which is characterized by the Knudsen number and strengthens with the decrease of permeability, by asymptotic perturbation of Navier-Stokes equation in capillaric model in this work. Traditional late-time solution of Pulse Decay Method intrinsically cannot take the slippage effect into account, except for some tedious numerical attempts. We theoretically fill the gap of interpreting the experimental data got by the traditional late-time solution of Pulse Decay Method with consideration of the slippage effect. By considering the nature of the low value of permeability, asymptotic perturbation method is adopted to theoretically solve the governing equation. We show that the Klinkenberg plot can be safely used to interpret the experimental data of Pulse Decay Method for microporous media when the ratio between the pore volume of the microporous media and the upstream or downstream chamber is smaller than 0.1. This implies that when one chamber, upstream or downstream chamber, is totally sealed in experiment, the slippage effect cannot be eliminated for this kind of experimental apparatus. Our own experimental results, by comparing the intrinsic permeabilities got by Pulse Decay Method and steady-state method in different mean pressures for the same sample, verify the correctness of our derivation.

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References

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