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高压气体微管流动机理

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Flow mechanism of high pressure gas in micro-tubes

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摘要

为了研究微管实验真实的流动情况,将3种管径(10μm、5μm和2μm)的熔融石英微圆管分别以串联、并联的方式,接入自主研发的高压微管夹持器,研究了气体在微管流动过程中的压力分布规律和流量变化特征。实验结果表明:5根相同管径(10μm)微管串联时,入口压力越高,气体压缩效应越显著,压力分布更趋于呈非线性,同时微管末端动能损失和节流效应越明显,这进一步解释了高压条件下气体微管流动偏离经典Hagen-Poiseuille理论的原因,为高压条件下新型气体流量方程的建立提供了理论依据;3根不同管径的微管并联时,管径大的微管是气体主要流动通道,管径小的微管气体几乎不流动,但提高注入压力可使中等管径的导流能力适度增加,同时结合不等径毛管束模型与气体流量方程,可以解释和验证低渗透多孔介质渗流特性机理。

关键词 : 微管, 高压, 串联, 并联, 不等径毛管束模型

Abstract:

To study the actual flow situations in micro-tube experiment, molten quartz micro-tubes with the diameter of 10 μm, 5 μm and 2 μm were connected in series and in parallel to the independently-developed high pressure micro-tube holder, so as to further explore the pressure distribution laws and flow changing characteristics of gas in micro tube flow. The experimental results show that when the five micro tubes with the same diameter (10 μm) are connected in series, the higher inlet pressure will lead to the more significant gas compression effect; the pressure distribution tends to become more nonlinear; the kinetic energy loss and throttling effect at micro-tube end will be more significant. This further explains the reason why micro-tube gas flow deviates from the classic Hagen-Poiseuille theory under high pressure conditions, providing theoretical basis for establishing new gas flow equation under high pressure. When three micro-tubes with different diameters are connected in parallel, the micro-tube with larger diameter is the main channel of gas flow, while the gas hardly flows in the micro-tube with smaller diameter. However, the rise in flow pressure can lead to an appropriate increase in the flow conductivity of micro-tube with moderate diameter. Meanwhile, both capillary bundle model with different diameters and gas flow equation are combined to predict and verify the seepage mechanism of low-permeability porous media.

Key words: micro-tubes high pressure in series in parallel capillary bundle model with different diameters

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