Mechanical Engineering Master's Defense

Compressible flow through a porous medium: choking at pore scale and its implications

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abstract

Production from a high pressure gas well at a high production-rate encounters the risk of operating near the choking condition for a compressible flow in porous media. The unbounded gas pressure gradient near the point of choking, which is located near the wellbore, generates an effective tensile stress on the porous rock frame. This tensile stress almost always exceeds the tensile strength of the rock and it causes a tensile failure of the rock, leading to wellbore instability. In a porous rock, not all pores are choked at the same flow rate, and when just one pore is choked, the flow through the entire porous medium should be considered choked as the gas pressure gradient at the point of choking becomes singular. This thesis investigates the choking condition for compressible gas flow in a single microscopic pore. Quasi-one-dimensional analysis and axisymmetric numerical simulations of compressible gas flow in a pore scale varicose tube with a number of bumps are carried out, and the local Mach number and pressure along the tube are computed for the flow near choking condition. The effects of tube length, inlet-to-outlet pressure ratio, the number of bumps and the amplitude of the bumps on the choking condition are obtained. These critical values provide guidance for avoiding the choking condition in practice.

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