Proceedings of the Canadian Society for Mechanical Engineering International Congress
32nd Annual Conference of the Computational Fluid Dynamics Society of Canada
Canadian Society of Rheology Symposium
CSME-CFDSC-CSR 2025
May 25–28, 2025, Montréal, Québec, Canada

A COMPREHENSIVE COMPUTER MODEL FOR THERMAL FLOWS OF MOIST AIR THROUGH POROUS MEDIA

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ABSTRACT

Accurately simulating the flow and thermal behaviors of moist air in porous media is essential for many natural processes and industrial applications. One particular example is that the Creighton and Kidd Creek Mines (Sudbury, Canada) use the fragmented rock as a cooling or heating source to regulate the temperature and humidity of the air for underground mine ventilation. To model such systems, an integrated model is established to incorporate fluid flow, heat transfer, mass transport, and phase change in a porous material. The model adopts a two-temperature representation, which allows us to account for convective heat transfer due to air flow, the thermal conduction between air and rock due to the temperature difference, as well as the latent heat effect during phase change. The multiple-relaxation-time (MRT) lattice Boltzmann method (LBM) is selected to solve the governing equations. In specific, the D3Q19 lattice model is used for the porous flow with the Darcy and Forchheimer forces considered, and the D3Q7 model is utilized for the solid and fluid temperatures as well as the vapor concentration transport process. Furthermore, the vapor-liquid phase change process is included based on the vapor concentration and temperature, and the associated heat and mass transfer are implemented as source terms in the corresponding governing equations.

In this presentation, more details of the theoretical model and numerical techniques will be presented. Several validation tests will be discussed, where simulation results are compared to analytical solutions to demonstrate the correctness and accuracy of our programs. Example simulations will also be described for the potential applications of our model in future studies.