Modeling and Analysis of a Direct Expansion Geothermal Heat Pump (DX): Part I-Modeling of Ground Heat Exchanger

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Introduction: Geothermal heat pump technology is actually one of the most interesting processes to provide heat and cold to building.In this study, a model of the ground exchanger as a evaporator of a direct expansion heat pump is going to be presented in 1 dimension. The model represents the phase change of the refrigerant, here Chlorodifluoromethane R22.

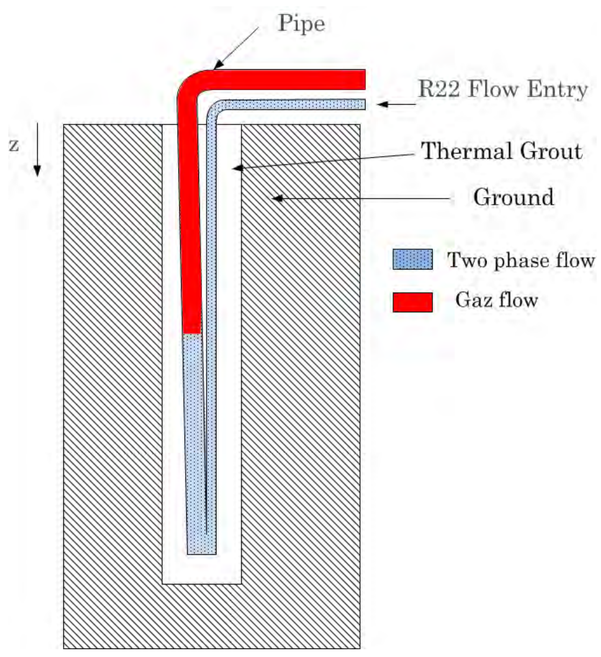

Figure 1. Ground Heat Exchanger

Theory: The PDE and the heat transfer interface is used to solve the governing continuity, momentum and energy equations for the R22 flow and the heat exchange between pipe and grout. Hr is calculated with the Gnielenski[1] correlation for one phase flow and Chen[2] correlation for two phase flow.

$$\frac{\partial \rho_m A}{\partial t} + \frac{\partial \dot{m}}{\partial z} = 0$$

$$\frac{\partial \dot{m}}{\partial t} + \frac{\partial \dot{m} v}{\partial z} + \frac{\partial P_m A}{\partial z} = -\tau \times Pr - \rho \times A \times g \times \sin\theta$$

$$\frac{\partial \rho_m A h_m}{\partial t} + \frac{\partial \dot{m} h_m}{\partial z} = \frac{\partial P_m A}{\partial t} + Hr \times Pr \times (T_p - T)$$

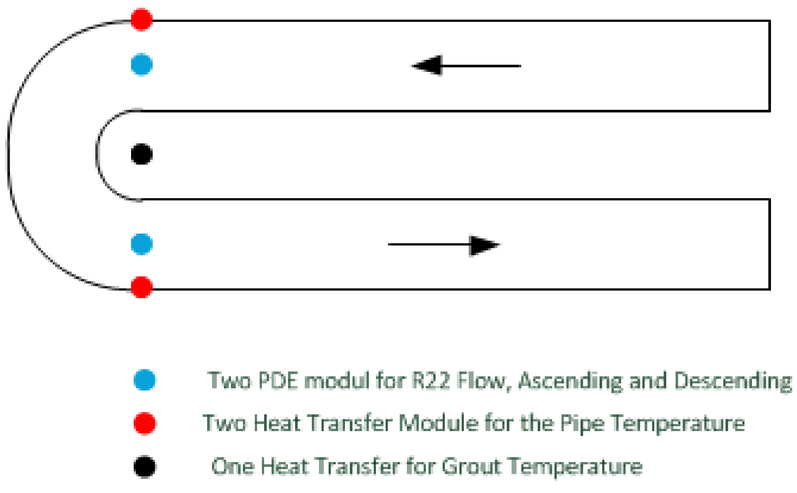

Figure 2. COMSOL MODEL

Comparison between experimentation and model:

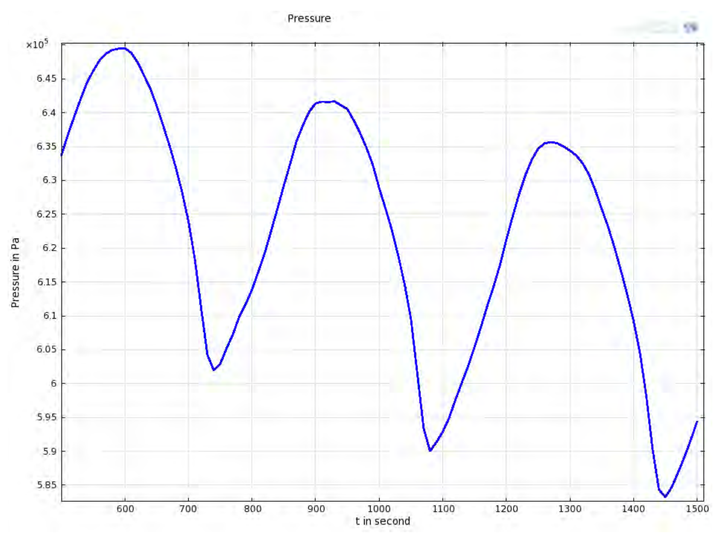

Figure 3. Pressure at the entry of the ground heat exchanger

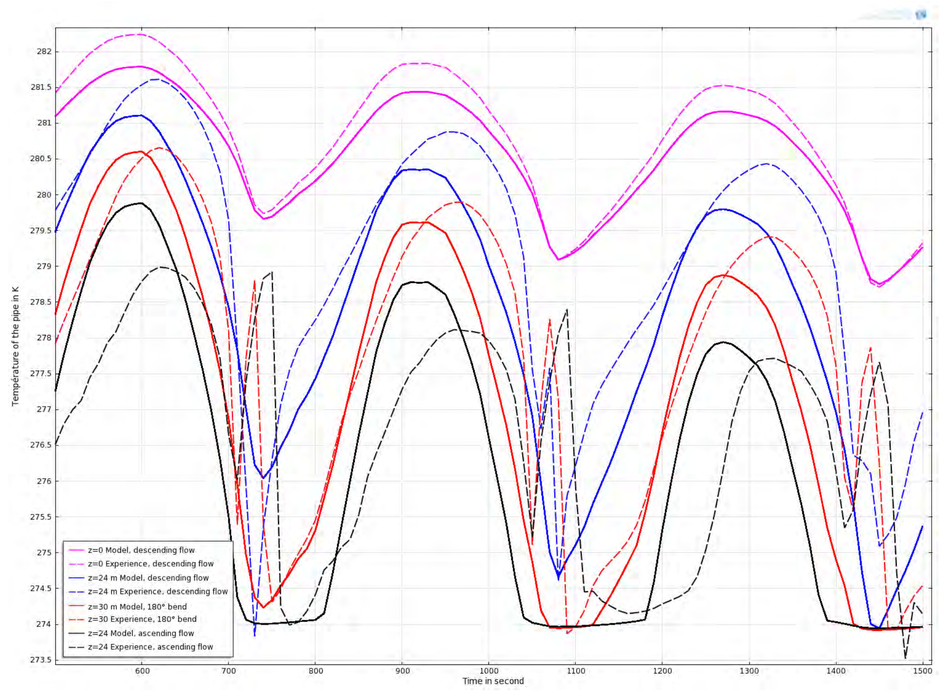

Figure 4. Comparison between Temperature of the pipe experimental and the model

Conclusions: The model is valided. The heat exchange and the pressure drop is representative of the reality. We can see that a difference occur when the pressure increasing, this is because the model don't take account the change of the mass fluid flow. A more complete study is the next step to improve this result.

References:

1. Gnielinski, V., New equations for heat and mass transfer in the turbulent flow in pipes and channels. Forschung im Ingenieurwesen, vol. 41, no 1, p. 8, (1975)
2. Chen JC, Correlation for Boiling Heat Transfer to Saturated Fluids in Convective Flow, Industrial & Engineering Chemistry Process Design and Developmentl, 5, 233 (1966)

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