Modeling and Analysis of a Direct Expansion Geothermal Heat Pump (DX): PART II-Modeling of Water-Refrigerant Exchanger

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Abstract

This study is part of a larger project to enhance and develop a new type of heat pump geothermal direct expansion (DX) and to evaluate the performance of such a system with potential fluids (R404A and R407C) for the replacement of R22 refrigerant. A geothermal direct expansion (DX) is a heat pump (Figure 1) with the particularity that one component is buried directly on the ground playing the role of condenser / evaporator according to the mode of operation contrary to the traditional secondary loop. In the first part (pending publication), the numerical model of ground heat exchanger is presented. In this section, we simulate the second heat exchanger system in one dimension characterized by two coaxial tubes (Figure 2) with ribbed inner tube using the equations of conservation of mass, conservation of momentum and energy. The COMSOL PDE interface is used to simulate the monophasic and biphasic flow of refrigerant R22 (Chlorodifluoromethane). Heat transfer in water and inner wall of the exchanger are modeled with two Heat Transfer interfaces (solid, fluid). In this study, the transfer coefficient in single phase flow is calculated with the correlations of GARIMELLA and CHRISTENSEN(1995a,1995b).The two-phase transfer are evaluated with of KOYAMA et al.,(1990) and TAKAMATSU et al.(1990) correlations. Concerning water the transfer coefficient is calculated with the correlation proposed in the thesis of DEMBA (2007). The developed numerical model was used to simulate the phases of superheating, condensing and subcooling in the condenser (Figure 2). Vapor quality (Figure 3), and pressure (Figure 4) of the refrigerant temperature and the water are also simulated. To validate this numerical model a comparison between numerical and experimental results was performed. The numerical model of water-refrigerant heat exchanger is developed by solving the conservation equations of mass, conservation of momentum and energy in one dimension for the coolant. The validated numeric model obtained will be coupled with the ground heat exchanger for developing the global numerical model of heat pump geothermal direct expansion (Figure 1).

Reference

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Figures used in the abstract

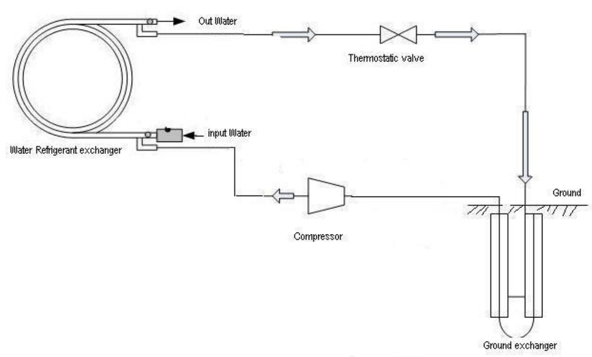

Figure 1: Geothermal heat pump.

Figure 2: Water-Refrigerant exchanger.

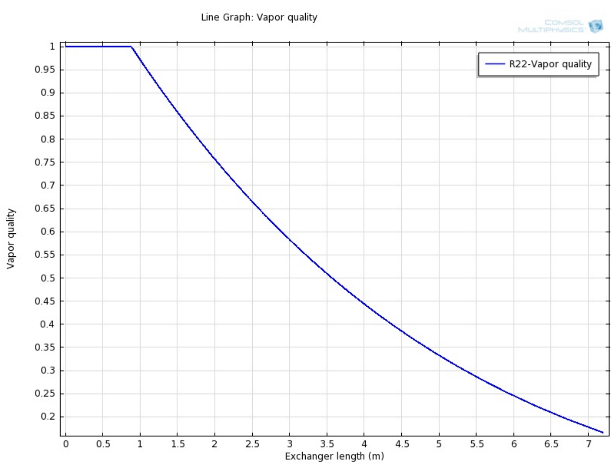

Figure 3: Vapor quality in Exchanger.

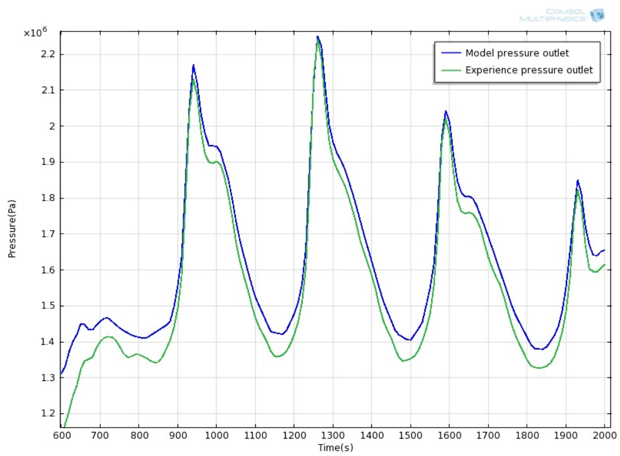

Figure 4: Comparison between numerical model and experiment.