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Entwicklung eines thermophysikalischen Modells zur Blasenabsorption in Minikanalwärmeübertragern

(Development of a thermophysical model for bubble absorption in mini channel heat exchangers)

Nr.617

Motivation

The absorption refrigeration technology, which works primarily by exploiting the absorption properties between two different fluids, is becoming increasingly popular because of its green and clean characteristics. A better understanding of the two-phase flow of the working pairs is required to make the best use of this technology.

Research objectives

In order to understand the two-phase bubble absorption of the water-ammonia mixture, a thermophysical model will be established to describe the physical process. The model should consider not only the mass and heat transfer between the vapor and the liquid phase but also the heat transfer between the liquid solution and the cooling water.

ANSYS Fluent is used here as the CFD software to execute the simulation. Since Fluent does not have the database of water-ammonia two-phase flow, a third-party databank will be loaded here using the UDF (user-defined function).

Assumptions

Bubble absorption is a very complicated physical phenomenon. To finish this project, several assumptions have to be made to simplify the model. Here are some important ones of them:

- The whole system is in a steady state.
- The pressure inside the absorber is constant.
- The change in mechanical energy and kinetic energy of the system can be ignored.
- The surface of the bubble is in thermodynamic equilibrium.

Model structure

The following picture (see Fig. 1) shows the bubble flow in the heat exchanger. The ammonia vapor enters the system at the bottom of the tube. The tube wall is covered with cooling water, which carries away the heat from the system. The boundary between the bubble and the solution is called the interface.

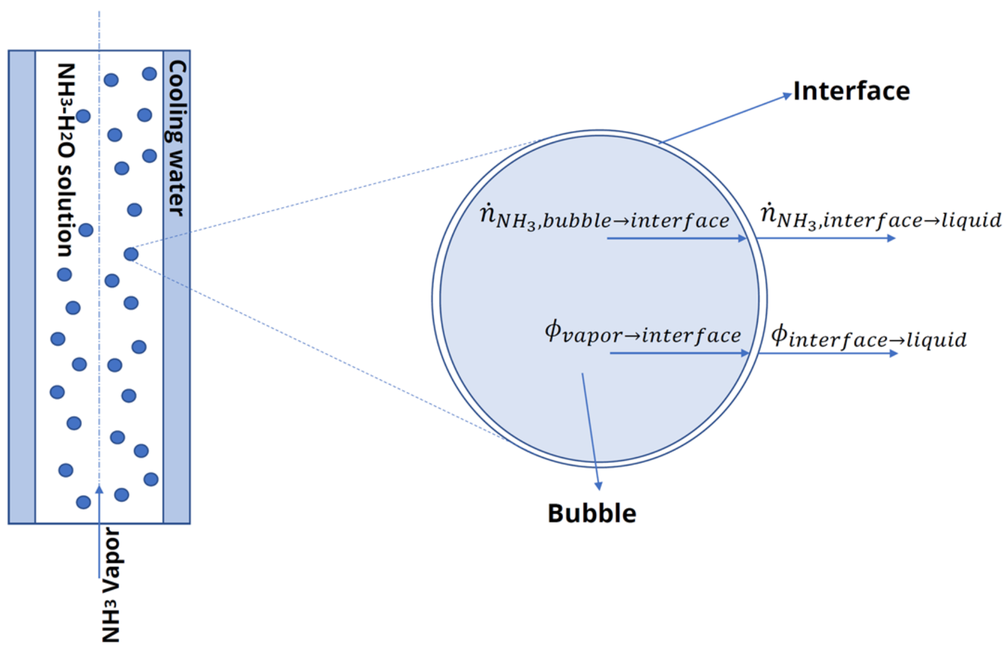

Fig. 1: Model of the bubble flow in the heat exchanger.

Mass transfer

The mass transfer of ammonia from the bubble to the interface can be calculated using Fick´s first law.

The mass transfer from the bubble to the interface and from the interface to the liquid phase can be expressed. According to the principle of mass conservation at the interface, the mass transfer through the interface should also be equal.

Heat transfer

The heat transfer occurs in two central regions. One is between the vapor and the liquid phase, and the other comes from the process between the solution and the cooling water.

The heat transfer between the vapor and the liquid phase consists of two parts, the convective heat transfer due to the temperature gradient and the heat transfer that comes from the enthalpy difference caused by mass transfer.

The following picture (see Fig. 2) shows the heat transfer process from the solution to the cooling water. It can also be expressed by the convective heat transfer equation.

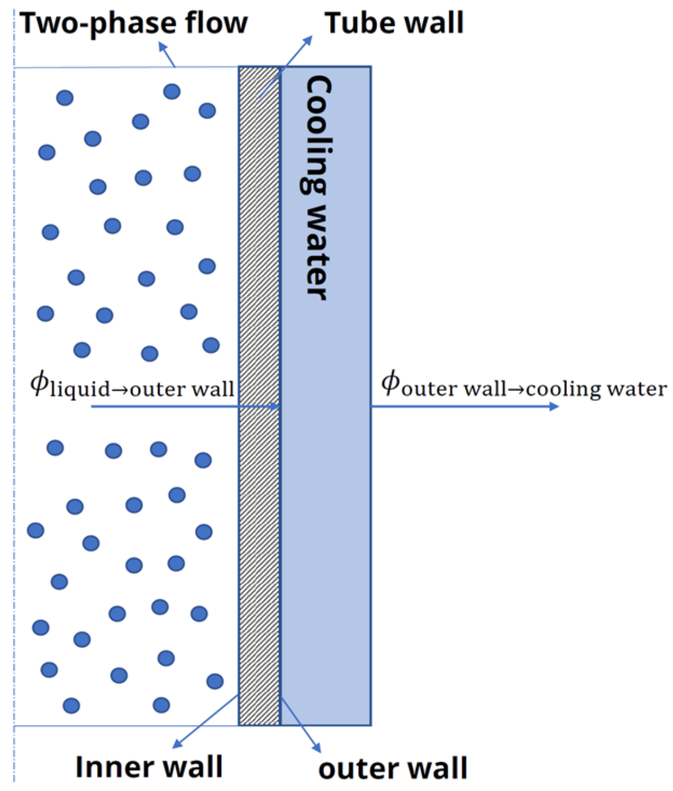

Fig. 2: Heat transfer between the solution and the cooling water through the tube wall.

Fluent and UDF implementation

Fluent is one of the best software in the CFD field today, the bubble absorption in the mini channel heat exchanger will be simulated on Fluent. Since fluent does not have the property data on the two-phase mixture of ammonia and water, some external databases need to be used.

The data was purchased from *KCE ThermoFluidProperties* in C++ form. It is stored as functions in a dynamic link library (DLL) file named *LibAmWa*. Some UDFs were applied here to implement this data bank to the Fluent server, some basic DEFINE macros were also used.

Summary

In this present thesis, a thermophysical model of the bubble flow was developed, and the mass and heat transfer in the system was expressed. The thesis also discussed the method of implementing a third-party database using the UDF.

It is necessary to set up the compilation environment, especially to modify the Windows PATH variables using the makefile. In addition, the fluent should be run in the developer command window to ensure that the third-party file is successfully imported when the UDF is loaded.