CHAPTER VIII

Conclusions

This thesis describes an investigation of a diffusion absorption refrigeration cycle (DAR) in both theoretical and experimental terms. The experimental refrigerator was designed and constructed. It was tested with various generator heat inputs, helium charge pressures, and rectification temperatures. The system could produce cooling capacity up to 200 W with COP up to 0.2. A simple mathematical model is also described. The calculated results were used to compare with the actual values.

A bubble-pump, used for circulation of working solution in the system, was studied separately. The actual system is operated under high pressure and using ammonia and water as working fluid, the pump was tested at atmospheric pressure using water and air. The study showed that pump performance depended on its dimensions i.e. tube diameter, tube length, and head ratio. A pump tube with similar geometries to that used in the experimental refrigerator was tested. Its performance equation was also obtained. Then, the bubble pump equation and the first law of thermodynamics were used to develop a simple mathematical model, which was used as an analysis tool for the experimental DAR.

Tested results of the experimental DAR showed that there was a minimum heat input required to start the system operation. In fact, it was required for onset of pumping effect of the bubble pump. Cooling capacity and COP were found to increase sharply as the generator heat input was increased. However, at a point, the COP approached a maximum value. Further increase of the generator heat input caused reduction of COP. At this point, the cooling capacity was almost constant. It might be limited by mass transfer performances of either the absorber or the evaporator. The actual results were also compared with calculated values. It was found that the absorber-evaporator effectiveness reduced while the actual cooling capacity remaining constant. At effectiveness of one, all the liquid ammonia was assumed to evaporate, and a maximum cooling capacity was obtained.

The optimum helium charge pressure was not found. With low helium charge pressure, the bubble pump performance was high. This might result from changes of specific volume of ammonia vapor with system pressure. For a given generator heat input, liquid solution flow rate through the pump tube was increased with reduced helium charge pressure, which should improve the absorption capability. However, it might degrade the heat transfer performance in the evaporator. At low helium charge pressure, the ammonia partial pressure is high. Thus, it will evaporate at relatively high temperature. This causes reduction of the differential temperature between refrigerant and chilled water. Then, the heat transfer rate will be reduced.

There was no significant effect of the experimental performance due to variations of rectification temperature. The calculated results showed that with lower rectification temperature, the refrigerant produced was less but its purity was increased.

Energy balance obtained from the mathematical model was used as an effective tool to analyze the system performance. It will show how the system can be modified. The most critical components are the evaporator and the absorber. They should be designed so that all liquid ammonia can be completely evaporated (in the evaporator) and absorbed (in the absorber). The bubble pump is also a critical part, as it indicates the mass of refrigerant and solution flow. Too much refrigerant or too much solution flow through the pump tube can be considered as waste because it requires energy to produce. Thus, to obtain a maximum performance, the bubble pump must be designed so that the flow of refrigerant is matched with that of liquid solution.

Heat exchanged at the solution heat exchanger (SHX) was shown to be important in designing of the DAR. The results showed that heat recovered at the SHX was higher than the heat input at the generator and the use of SHX could double the COP. Therefore, the capacity of the SHX should be as large as possible. Use of the SHX also reduced the heat rejected at the absorber and its size.

It may be concluded that, to design a DAR with maximum performance, the first priority should be given to the bubble pump. It must be designed so that, the liquid solution and vapor flows are matched. The second attention is paid to the evaporator and the absorber. They must be designed so that, the liquid ammonia is completely evaporated and absorbed. The solution heat exchanger should be designed with maximum effectiveness. Heat recovery at the rectifier is also important as the rejected heat can be used to preheat the solution entering the generator. Helium charged pressure and rectification temperature must be selected to suit the operating condition.

The DAR is a refrigeration system, which can be considered as a user-friendly system. It is easy for use especially in any areas that no electrical is available. Moreover, it requires little maintenance due to its configuration. According to the prior conclusion remarks, it could be improved to perform better operating performance. However, its operating conditions should be considered carefully to match with the atmosphere of site locations. It has potentials to adapt for using as air conditioner or refrigerator, which operated at higher cooling effect temperature than a freezer. It can also be modified to couple with low-grade heat such as industrial waste heat or even the renewable energy such as solar energy.