A SOLAR COOLING/HEATING SYSTEM FOR A LABORATORY BUILDING

Georgios A. Florides, Soteris A. Kalogirou

Department of Mechanical Engineering and Materials Sciences and Engineering, Cyprus University of Technology, P.O. Box 50329, Limassol 3603, Cyprus, Emails: georgios.florides@cut.ac.cy, soteris.kalogirou@cut.ac.cy

Abstract

This paper presents the original design concept of a solar cooling/heating system which will be installed in the mechanical engineering laboratories of the Cyprus University of Technology. The system will consist of a LiBr-water absorption unit, a stationary solar collector system, storage tanks, cooling towers and the necessary control and distribution system. As the area where the laboratories are situated has a lot of ground water at a shallow depth, an attempt will be made to relieve part of the condenser load using the ground water as a means of heat dissipation.

Absorption machines are thermally activated and they do not require high input shaft power. Therefore, where power is unavailable or expensive, or where there is waste, geothermal or solar heat available, absorption machines could provide reliable and quiet cooling. Absorption systems are similar to vapor-compression air conditioning systems but differ in the pressurization stage. In general an absorbent, on the low-pressure side, absorbs an evaporating refrigerant. The most usual combinations of fluids include lithium bromide-water (LiBr-H_2O) where water vapor is the refrigerant and ammonia-water (NH_3-H_2O) systems where ammonia is the refrigerant.

The NH_3-H_2O system is more complicated than the LiBr-H_2O system, since it needs a rectifying column that assures that no water vapor enters the evaporator where it could freeze. The NH_3-H_2O system requires generator temperatures in the range of 125 to 170°C with air-cooled absorber and condenser and 95 to 120°C when water-cooling is used. LiBr–H_2O systems are also friendlier to the environment as they work at sub-atmospheric pressures and when there is a leakage no contamination occurs. For these reasons the LiBr-H_2O system is preferred in this design.

Lithium bromide-water chillers are available in two types, the single and the double effect. The single effect absorption chiller is mainly used for building cooling loads, where chilled water is required at 6-7°C. The coefficient of performance (COP), which is defined as the ratio of the cooling effect to the heat input, varies to a small extent (0.65-0.75) with the heat source and the cooling water temperatures (Florides *et al*., 2002a). Single effect chillers can operate with a hot water temperature ranging from about 80°C to 120°C when water is pressurized, whereas for the double effect much higher temperatures are required. For this reason the single effect unit is preferred since the lower temperatures are easily obtained with stationary solar collectors.

It should be noted that the refrigerant in the water-lithium bromide system is water and the LiBr acts as the absorbent, which absorbs the water vapor thus making pumping from the absorber to the generator easier and economic. A single-effect, two shell, LiBr -water chiller is illustrated in *Figure 1*, where typical temperatures are shown. At point (1) the solution is rich in refrigerant and a pump forces the liquid through a heat exchanger to the generator (3). The temperature of the solution in the heat exchanger is increased. In the generator thermal energy is added and refrigerant boils off the solution. The refrigerant vapour (7) flows to the condenser, where heat is rejected as the refrigerant condenses. The condensed liquid (8) flows through a flow restrictor to the evaporator (9). In the evaporator, the heat from the load evaporates the refrigerant, which flows back to the absorber (10). A small portion of the refrigerant leaves the evaporator as liquid spillover (11). At the generator exit (4), the steam consists of absorbent-refrigerant solution, which is cooled in the heat exchanger. From points (6) to (1), the solution absorbs refrigerant vapour from the evaporator and rejects heat through a heat exchanger.

The complete solar system that will be used in the laboratories is shown schematically in *Figure 2*. The design temperature of the system will be 70 to 90°C so as to avoid having a pressurized storage. The solar collectors to be used are of the evacuated tube type, which have a good efficiency at this working temperature. The total area of the laboratories is 1400 m^2. The building is an existing one that will be renovated and has limestone walls, 50cm in thickness. The roof will be reconstructed and covered with 15cm insulating material and the existing doors and windows will be replaced with double glazed ones. The maximum cooling load of the laboratories is of the order of 250 kW. A total of 12,000 liters storage cylinders will be used. Such a system was evaluated in the past (Florides *et al.*, 2002b) and found to have a low total equivalent warming impact (TEWI).

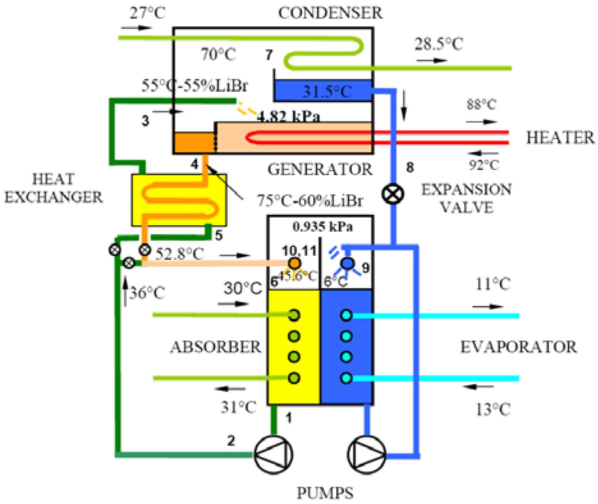

Figure 1 *- Schematic diagram of the LiBr-water absorption unit*

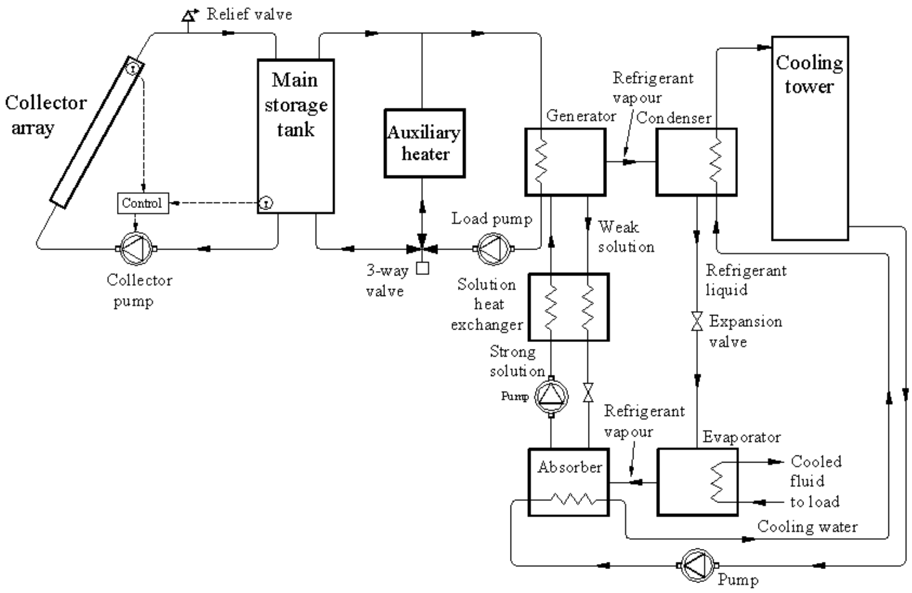

Figure 2 *- Schematic diagram of the complete solar cooling system*

The scope of this solar application is to evaluate the technology in the Cyprus environment and for this reason the system will be fully monitored for a number of years. This will lead to conclusions whether the Department of Energy will partly subsidize these types of systems in the future and at what extent. Electronic display boards will also be installed showing at any time the working condition of the various parts of the system and their contribution to the load. This will be done for the purpose of demonstrating to the general public the benefits of this solar application.

References

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