

POSSIBILITIES OF USING SOLAR POWERED COOLING SYSTEMS IN AGRICULTURE

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Abstract: A significant part of the electrical energy used for the heating and cooling, produced from fossil based sources. The decrease of fossil based fuels and the price rises forced people turn to other energy sources. Renewable energy sources are shown as a good alternative to fossil energy sources cause of the environmental its potential. Compared to solar energy become prominent by having easy operation and lower installation costs, as one of the alternative energy sources compared with other renewable energy. Solar energy mostly used for heat water and environment. Cause of the lower solar radiation when much-needed period of habitat heating, solar power cannot be used as efficient for heating. In the summer, while the most intense and prolonged period of solar radiation there is no need for heating, instead an arising need for space cooling. In the summer, using solar power for cooling could be a significant saving method. Especially in the sun-rich regions it is possible to take advantage of solar energy for climatization plant and animal production facilities.

In this study, it is aimed to explain using solar cooling systems in agricultural applications and solar cooling technologies.

Keywords: SOLAR POWER, COOLING SYSTEMS,

1. Introduction

One of the conditions for leading a comfortable life for humans, animals and plants, all living creatures in short is being able to fulfill the needs of heating and cooling. The energy used for cooling and heating constitutes a big portion of the total energy consumption. A large portion of the used energy is derived from fossil fuels, and this means greenhouse gas emission like CO₂ and CO, leading to global warming [1]. This means fossil-based energy sources affect the increase in global temperature. As with heating, fossil fuels are also important sources in cooling; but the gradual decrease in fossil fuels is leading humans to other sources of energy. Especially renewable energy sources, with their environmental aspects and potential, are considered to be a good alternative to fossil energy sources.

Solar energy, which is another alternative energy source, when compared to other renewable energies, stands out more due to its easier application and lower setup cost. The greatest areas of application of solar energy has been the heating of water and ambient heating; but the fact that solar radiation is low and cannot be efficiently used in times when ambient heating is most needed, continues to be a problem. Whereas in the summer time, when the solar radiation is at its peak and has the longest duration, there is no need for ambient heating, on the contrary there is a need for cooling. Making use of solar energy for ambient cooling in the summer months appears to be an important savings method.

It is important to make environmental and economic solar powered cooling systems used for ambient cooling become widespread.

2.Solar Powered Cooling Systems

Transfer of heat from a low ambient temperature area to high ambient temperature area does not occur by itself; the machines that provide this transfer based on the "Reversed Carnot Cycle Principle" are called "Cooling Machines". Cooling cycles with vapor compression takes place with 4 main elements (Fig. 1). These are the compressor, condenser, regulating valve, and vaporizer. The refrigerant fluid enters the compressor as vapor and is compressed to the condensers pressure. The fluid comes out of the compressor with high heat, passes through the condensers pipelines while its heat to its ambient area and thus cools and condenses. After the condenser, the fluid enters a capillary tube and here with the effect of reduction, the pressure and temperature of the fluid decreases considerably.

The low-temperature refrigerant fluid later enters the vaporizer, and vaporizes by absorbing heat from the area to be cooled / refrigerated. The cycle is completed with the refrigerant fluid exiting the vaporizer and re-entering the compressor [2].

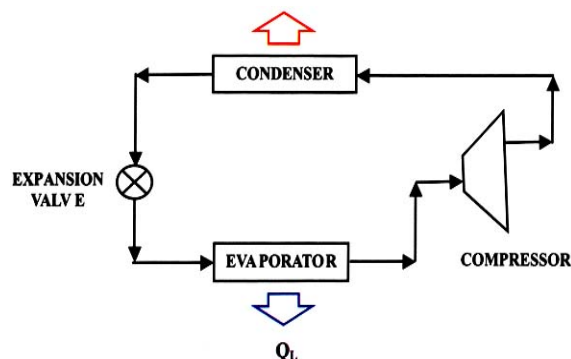


Fig.1 A simple scheme for mechanical refrigeration system.

The efficiency of a cooling machine is expressed with an activity coefficient and shown as COP (Coefficient of Performance). The aim of a cooling machine is to draw heat (QL) from the area to be cooled. In order to achieve this, it has to put in work (Wg), thus the coefficient of performance of a cooling machine can be expressed as follows. According to the law of conservation of energy for machines operating by performing cycles:

$$\text{Since} \quad W_g = Q_H - Q_L$$

The coefficient of performance of a cooling machine can be expressed as:

$$\text{COP} = Q_L / (Q_H - Q_L)$$

Studies on making the use of energy more efficient in the cooling sector is ever-increasing with new designs to replace electrical energy sources of cooling machines with solar powered sources. In order to use the energy coming from the sun for cooling, certain thermodynamic cycles are used. There are many cooling machines with solar powered sources that use the difference formed with these cycles. These cooling system can vary due to small changes and different denominations. Conventional solar panel vapor compression systems, single iterative absorption systems, double iterative absorption systems, adsorption systems, desiccant systems and vapor-jet system are examples of such systems. Especially the solar energy assisted absorption cooling systems are one of the most commonly used (Fig. 2).

The reason this system is so preferred is the low amount of energy the system needs. The fundamental difference between the absorption cooling system and conventional mechanic vapor compression systems in terms of cycles is that absorption system uses an absorber-generator duo instead of a compressor. This way, there is no need for the high electrical input of the compressor. In related studies, the achieved COP (Coefficient of Performance) values range between 0,3 and 1,2. The most important factor in the design of the absorption cooling system is the performance of the solar collector to be used. If liquid temperatures reach 150°C, then double iterative absorption systems that have high COP values can be used; if the liquid temperatures are around 90°C, then single iterative systems with lower COP's can be used [3].

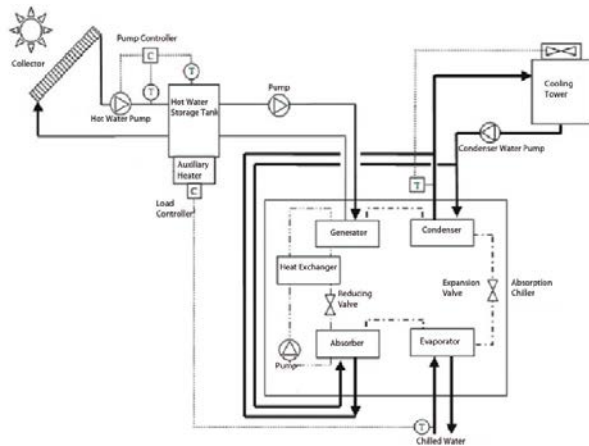


Fig.2 Solar Power Based Absorption Cooling System

In the solar system, the flat plate solar collectors can be used while the supply water temperature is between 60 to 90°C. Supply water temperature can be increased up to 120°C by planar solar collectors with selective surface. While using the stationary vacuum tube collector system, supply temperature will be between 97°C to 73°C. Moreover, with focusing parabolic collectors, temperature can reach 165 °C [4].

3. Applications of Solar Powered Cooling Systems and Their Applicability in Agriculture

There are various applications of solar powered cooling systems around the world. In a factory in Germany, 100 m² of heating collector is used in a single stage desiccant system to cool a 800 m² area. The system reached a lowest cooling temperature of 17°C. The COP value was determined to be 0.5 on average during the desiccant cooling process. In a public library in Spain, an area of 3500 m² was successfully cooled using a heating collector system with a collector area of 155 m². The COP value was determined to be 0.6 on average. In China, 3 vacuum tubed collectors were used to cool a laboratory with a volume of 72 m³. The system's maximum cooling load was around 4,5 kW. The average COP value was found to be 0.95 [5].

In the Rethimno holiday resort south of Greece, an absorption cooling system was setup in 2001 (Fig. 3). The system was capable of both heating and cooling. The cooling capacity of the system was 105 kW, the cooled area having an area of 3000 m². The gross surface area of the planar collectors was 448 m², with the hotels cooling system also being used in the heating of the pools. The system was operated with the cooled water temperature to be within the range of 8-10°C and the cooling efficiency was determined to be 0.60. In cases where the sun was insufficient or there was clouding, a 600 kW capacity gas-fired broiler would provide the system with hot water [6].



Fig.3 In the Rethimno holiday resort in Greece

A system was installed for the cooling of a two-story office in Spain with an area of 10000 m². The system having 1632 m² of gross collector area, the ambient temperature was maintained at 23°C by utilizing a four pipe fan-coiller (Fig. 4). The total cooling load of the building was determined to be 170 kW. The water heated with the installed solar power system was stored in 2 tanks of 30000 liters capacity each. In the winter, when the sun was insufficient, an electrical cooler would kick in. In the summer when the need for heated water would decrease, the absorption cooling system would kick in when the accumulated water temperature reached 80°C and thus the electrical cooler would operate less. The installed system would save 565060 kWh of energy per year [6].



Fig.4 Two-story office in Spain

In a wine cellar in France, a solar power assisted absorption cooling system was installed in 1991 and has been working as planned without any problems since that day (Fig. 5). In this system, it was aimed to store energy with the solar collectors, generate cold water in low temperatures and cool the surrounding air. The surface area of the system's vacuum piped solar collectors are 130 m². The wine cellar, which can store up to three million bottles of wine has a total of 3 levels, with 2 levels being below the ground. The wine cellar has a total area of 3500 m². The system's cooling coefficient was found to be 0.57 according to the readings obtained [7].



Fig.5 The wine cellar in France

Many studies are being conducted around the world regarding the economical use of energy. The integration of newly developed technologies in different industries is very important in terms of increasing the global energy savings. Solar power assisted cooling systems are developing every day and are appealing to many different industries. Agriculture, being one of these industries, uses small capacity cooling systems in many of its sections. Cooling systems are being used in the air-conditioning of special places such as agricultural seed and plant production rooms, hatcheries, and chick production facilities [8].

Cooling of milk storage facilities after milking is important in terms of health. In 2004, with the aim to cool milk, Pilatowsky and colleagues performed a theoretical thermodynamic simulation of an absorption cooling system in one of their studies (Fig. 6). In the study, the necessary heat was provided with a vacuum tube solar collector. The system was designed for Mexico's countryside, and it was concluded that the system was applicable for cooling milk [9].

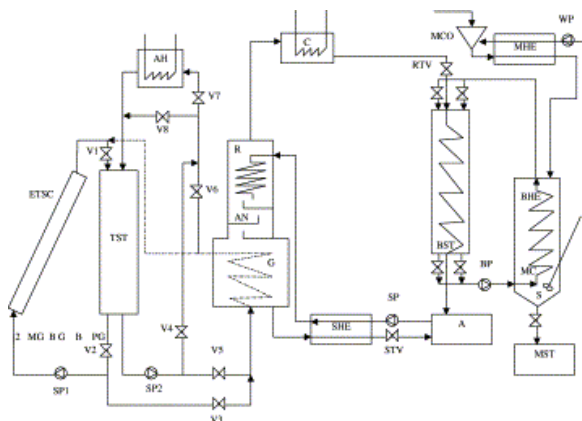


Fig.6 Schematic description of the monomethylamine–water absorption milk cooling system.

Greenhouse temperatures have a negative effect on plant development in regions with high yearly temperature averages. In periods where the ventilation and cooling are insufficient, production has to be halted and thus the producer loses money. Using solar powered cooling systems, greenhouses can be cooled with low operating costs when solar radiation is high. Cooling of building of agricultural enterprises and agricultural product storage areas can also be included in solar power applications.

4. Conclusion

In a world where fossil fuels are gradually decreasing and environmental energy is steadily gaining value, renewable energy sources are an issue that must be put emphasis on. Greenhouses, milk storage tanks, agricultural enterprise buildings and storage areas can be seen as suitable fields of application for solar powered cooling applications.

5. References

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