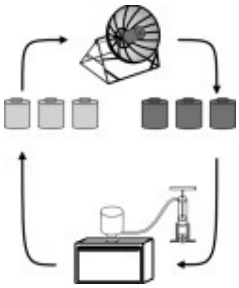
Refrigerating with the sun

Refrigerator with a Solar Operating System



Picture: Complete Refrigeration System

In developing countries, there is an acute need for refrigerating foodstuffs and medicines. However, normal refrigerators familiar to us are luxury items for these countries. In order for them to work, they need electrical energy, often only available in large city centers, which are either difficult to access or simply impossible

However, the sun is shining everywhere and offers warmth in excess, especially in southern countries. With the assistance of a cooling aggregate and a parabolic solar collector, the warmth of the sun can be transformed into cold.

In this particular form, the solar-powered refrigerator is a world's first and is being developed for production stage by EG Solar in association with the firm ZEO-TECH of Munich. The project was promoted by the Bavarian Ministry of Economic Affairs. The solar-powered refrigerator consists of a cooler box with a built-in evaporator and uses water as the cooling agent. In addition to this, all that is needed is a manually operated vacuum pump and one or more canisters containing the non-toxic mineral zeolite (a naturally occurring mineral) and an SK 14 parabolic dish.

To produce the desired cooling effect, one of the zeolite containers is connected up to the evaporator. Air is extracted from the system with the aid of the vacuum pump. The vacuum created by the pump causes the

boiling point of the water to drop so rapidly that the water boils at room-temperature. The energy needed to bring this about is drawn from the water itself, such that it cools to freezing point. The cooler box will then remain at a temperature from 0 to 6℃ for 72 hours.

Once the zeolite (which has adsorbed the very high-energy steam) is saturated, the zeolite canister is disconnected from the evaporator and replaced by a canister of non-saturated regenerated zeolite. A few pumps to remove the air from the system once again and the refrigeration process continues. The saturated zeolite is then dried with the aid of the SK 14. And the mineral can be endlessly recycled in this way.

The advantages of the solar-power refrigerator: cordless refrigeration (which means that the cooler box can also be used to transport medicines), the use of simple and non-toxic materials, and the possibility to produce a refrigerator locally and extremely easy, and for far less expenses than the conventional type.

Physical-Chemical Description:

Zeolite

The solar refrigerator works on the basis of adsorbing water through zeolite. Zeolite is
chemically similar to sand, however it is not made of compact molecules, but rather possesses a crystal structure with a very large interior surface. In nature, there are about 40 different types of zeolite. These mostly come from volcanic activity and contain large amounts of impurities, and are therefore inappropriate for technical cooling purposes. The chemical industry develops different types of zeolite artificially. The synthetic zeolite is mostly used as a phosphate substitute in washing detergent or for example, as a dry substance in double-paned glass windows. The application of large amounts of zeolite in washing detergent has led to countless studies concerning its environmental compatibility. Through this it has been proven that zeolite has no environmentally damaging properties and has no toxic effects.

Basis for the Refrigeration Technique with Zeolite

Essential for the use of zeolite, is its very large inner surface, reaching from 800-1200 m^2/g. A strong electrostatic strength occurs within this

empty area. As a result polarized molecules, water for example, are strongly pulled and through heat loss are bound to the crystal structure (adsorption). Should this process occur in an air-free container, the pulling of vapor occurs with such severe strength, that the resulting high evaporative cold causes the rest of water cool and freeze into ice. This process can occur for only so long, until the zeolite is saturated with water. Depending upon the type, zeolite can take in up to 25% of its own weight in water.
For further applications, the zeolite must first be dried again, but thereby retaining its complete effectiveness. This regeneration occurs through heating it at a high temperature. This causes the water to be taken out of the zeolite in the form of water vapor (desorption). The heat can come from electric energy, combustible fossil-fuels, or – which is especially practical – from solar energy. After a cool-down phase, the next adsorption process can begin. Because the zeolite is never used up, one can carry out as many cycles as one wishes.

Solar Refrigeration System

The solar powered refrigeration system consists of a cooling container with a lid, which has an integrated evaporator, in which water is located as the cooling medium. Additionally, one or more zeolite canisters are necessary, a hand vacuum pump, and a parabolic solar collector. In order to dry the zeolite appropriately, temperatures must reach 250°C. It is necessary to have a system which can concentrate the heat, flat solar collectors can not reach this temperature. With the described refrigeration system, one of the EG Solar e.V. parabolic collectors are used, which are normally used for solar cooking. Up until now, these solar collectors have been spread throughout the world, above all in developing countries in order to offer people in these countries an alternative fuel to firewood or kerosene. In addition to preparing meals, the cooker is also suitable to sterilise medical instruments or to boil water. Up until now, more than 10,000 such parabolic collectors have been build. The collector has a diameter of 1.4 meters and is made of highly polished and coated aluminium sheets, and is therefore appropriate for differing climates. The mount is rotatable and sits upon a flat steel frame, so that the entire collector can be moved through turning the frame and angle of the mirror in order to optimally follow the path of the sun. With a received radiation at 1000 W/m², the collector has a capacity to produce around 800 Watt.

Desorption:

To dry the zeolite, a zeolite canister with around 4 kg of zeolite is set upon the point of concentration within the parabolic collector. After 4 hours and reaching a maximum temperature from circa 350° C, the zeolite has been regenerated.

Adsorption

For refrigeration, the zeolite container with dry zeolite is connected to the level evaporator, which is filled with water. At the conclusion, a hand operated vacuum pump removes the air from the system. After connecting the zeolite container, the water begins to strongly vaporize, resulting from the area reaching a low enough pressure. Through the previously explained refrigeration activity, the water is cooled in the evaporator and freezes. From the ice that is created, further water molecules continue to evaporate (sublimation), which causes the ice to continue freezing. With one zeolite canister, the cooler box with 55 liters of usable space, can be cooled at 22° C room temperature and can stay at an average temperature between 0-6° C for about three days. After this time, the evaporator again has to be filled with water and a generated zeolite canister attached, and once again the air from the system must be pumped out. In order to refrigerate for longer periods of time and bridge the gap during times of bad weather, several regenerated zeolite canisters must be kept ready in stock.

Summary

The described prototype of a solar adsorption refrigerator offers a promising possibility for refrigeration in developing countries. The great advantage of this system is:

- Electricity-free operation with solar energy.
- Neither during the production, during the use, or during later disposal are any environmental problems caused, because the system of water/zeolite are environmentally neutral.
- The price is low in comparison to refrigerators which operate with photovoltaics.
- Suitable for mobile implementation.
- The solar collector can also be used to cook, sterilize, etc.