Effectiveness of Polymer Materials in Solar Cooling System

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Abstract

Renewable energy technology research and development has increased substantially in recent years. Solar cooling system energy is a significant part of this and can provide high efficiency energy conversion. This paper focuses on the development of new schematics of alternative conditioning and refrigeration systems based on open-cycle absorption and direct regeneration of the absorbent. Polymeric materials - multi-polymer plates made of polycarbonate, including an absorber of the collector-air regenerator and an evaporative cooler has been used in this study. The heat-mass transfer (HMT) systems are numerous and occupy together with the solar heat collector, as the basis of weight, size and cost of systems. This approach allows increasing their practical feasibility and has been presented in this work.

Keywords: *The solar polymer header - regenerator, ablative chiller, absorber open absorbing cycle, absorbent.*

Symbols

AACS: alternative air conditioning system
SC: Solar collector
SC-R: Solar collector –regenerator
SC-P: polymeric solar collector
HMT: heat-mass transfer
DES: Direct evaporator cooler
PM: polymeric materials
OSAR: Odessa sate academe of refrigeration
HME: Heat-mass exchanger

1. Introduction

In today's world every year, there is growing interest in the use of absorption-type refrigeration systems. Such systems compare favorably with compression setting of environmental cleanliness and low power consumption. The most actively study pertains to using closed system under pressure. The potential for open systems is explored out in this study. The existing schemes are at the stage of conceptual development. Open type cycle absorption provides new opportunities to create long-term generation of refrigeration systems. The cycle is efficient at low temperature. The differences, in general, are environmentally friendly and characterized by low energy consumption [1-5]. The heating source ensures the regeneration of the absorbent and the continuity of the cycle, to use solar energy. The source of which in a practical sense can be solar system with flat solar collectors.

2. The Main Part

Earlier OSAR [1-8] have been performed for studying such systems. This allows it to identify the main issues that are specific to them. In particular, it requires considerable surface as the solar system, ensures the regeneration of the absorbent and heat and mass transfer devices that make up the system, which leads to increase size, weight and cost. The formulation is initiated for widespread use of polymeric materials (PM) in the design of equipment as a heat –mass transfer (HMT) alternative systems. The HMT systems are numerous and occupy together with the solar heat collector, the basis weight, size and cost of systems. This approach allows increasing practical feasibility as shown in preliminary studies. These systems are substantially environmentally attractive aspect [7, 8]. Figure 1 shows the schemes of alternative systems (attached to the problem of air conditioning (AACS) and objectives of the cooling medium) based on the open-loop and direct absorption of solar regeneration of the absorbent. Schemes include two main parts: i.e. a preliminary air drying and subsequent evaporative cooling evaporative cooler in direct-type (Figure 1A uses a direct evaporative cooler air (DEC) (3), and Figure 1B - cooler). In the drying of the heat required for the regeneration of the absorbent is provided at least partially with a flat solar air collector 2, cooling the absorber is provided, usually the cooling tower fan 4. The main elements of the scheme include reduced absorber 1 (dehumidifier), stripper (solar regenerator) 2, designed for solar regeneration of the absorbent; evaporative cooler 3 direct-type system and regenerative heat exchangers 7-8, The need for which is dictated by the small disposable temperature differences. Airflow (fresh outdoor air), in drying the absorber 1, reduces the moisture content and temperature of the dew point which provides significant cooling capacity evaporative cooler.

The circuit switched cooling fan cooling tower 4 absorbent entering the absorber. The absorption of moisture from the air to be dried in the absorber generates heat. Cooling absorber may be as shown in Figure 1B, leaving the tower with "product" loop cooling air flow as it is cold enough. In this case, or "unload" a drying tower circuit, adding part of the recycle stream of air at its inlet, or to do without this tower, the entire recycle directing airflow into the heat exchanger 7 (in which case it is converted into an air-liquid heat exchanger). Selection of the final version of the circuit cooling of the absorber depends on the calculation mode setting as determined on the basis of a feasibility study. Undoubtedly, the approach to isothermal absorption increases the efficiency of the entire circuit as a whole.

In an evaporative cooler as used and developed in OSAR [1, 2], the machine directs evaporative cooling DEC (Figure 2). This film is cross-flow heat and mass transfer device type. The amount of evaporated water in the recirculation water circuit DEC offset-fed with fresh water. In the DEC as a result off evaporative cooling process of changing the state of the air flow and the redistribution isenthalpic "dry" and "wet" components of the enthalpy of the air. Temperature of the recirculation water through a nozzle apparatus remains unchanged and equals to the cycle of wet-bulb temperature of dry air in the absorber at the unit inlet DEC.

After evaporative cooler is arranged such as the ventilation and for recirculation circuits in the latter case, the portion of the airflow entering the PIP is air leaving the conditioned space. Of particular interest for refrigeration and air conditioning is a diagram in Figure 1B, where the evaporative cooling tower is used 4. The air-dried in the absorber 1 and having a low dew point temperature is supplied to the cooling tower, which is provided by the deep cooling water, which can be used in ventilated heat exchangers, coolers (11) to be attached directly to the air-conditioned rooms (13). The cooling unit, in this case, may be located outside the conditioned space and the building. The cooling tower is also cross-flow type of film that is structurally similar to the DEC. The main issue is to ensure the continuity of the cycle, which is achieved in the process of regeneration of the absorbent. As the external heating source are used for regeneration of the absorbent solar system. The diagram used in this study is developed by using a polymer solar collector-regenerator SC-R (2) as a stripper (regenerator) direct (direct) type.

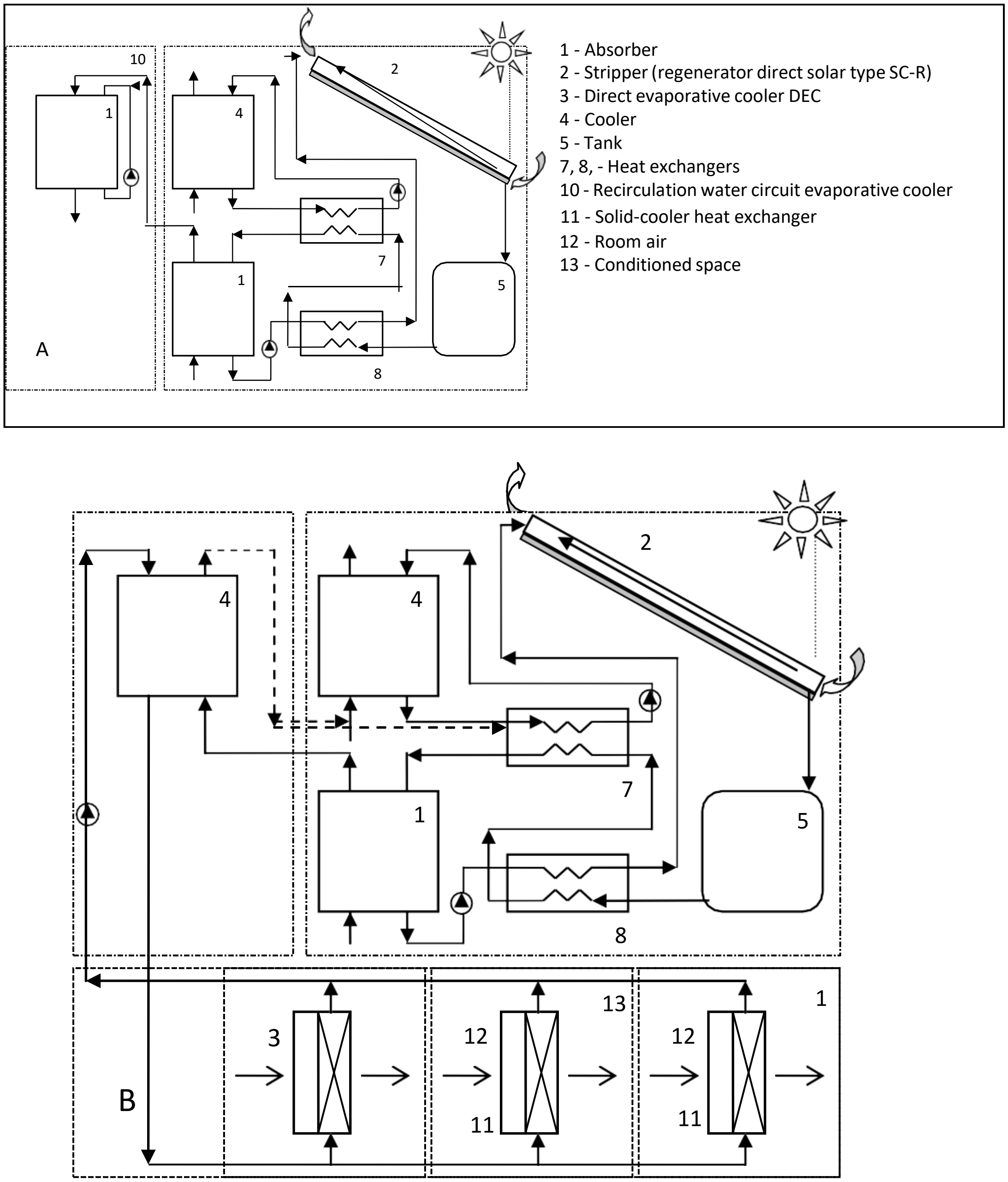

Figure 1. Schematic diagrams of alternative solar direct regenerating the absorbent using a direct evaporative cooler DEC (A) and the tower (B) to supply chilled water to the heat exchangers, coolers. .

This greatly simplifies installation and reduces the overall energy consumption for the "pumping" of air flow through the regenerator. The basis for the creation of such aircraft SC-R is a previously developed water-SC made of polymeric materials, a well-proven in hot water. According to its characteristics such polymeric solar collector (SC-P), as shown in experimental studies, almost are as good as traditional types of solar collector. The heat sink is made on the basis of the register of copper pipe or aluminum tubing. Polymeric solar collector is significantly cheaper than traditional metal, in which non-ferrous metals has been used. This fact is extremely important to develop alternative systems that require large areas receiving solar energy. Developed several modifications of polymer SC uses an area of the heat sink 1.1 and 2.0 m^2 [5], One modification collector SC-P 1.1 provides 80 liters of water heated to 60-65C^o in July in Odessa.

This is acceptable for the process of regeneration of the absorbent, at least in part AACS problems. Heat receptive panel solar-regenerator SC-R is made of a polymeric multi-plate. The inclined channels SC-R (position 2 in Figure 1) drain the film. The regenerated absorbent is heated by solar energy and releases excess moisture to the air flow moving above the counter on the same channels. The main feature of HME developed for alternative systems (Figure 2) is the application as structural materials and, multi-polymer plates made of polycarbonate. This path does significantly reduce metal system as a whole. Its cost is low and it reduces damage to the environment in the production and operation of its components [8]. In these systems are made of polymeric materials: a cooling tower, a direct evaporative cooler, solar collector - a regenerator, and the basis of all of these devices is a multi-channel polymer plate of polycarbonate.

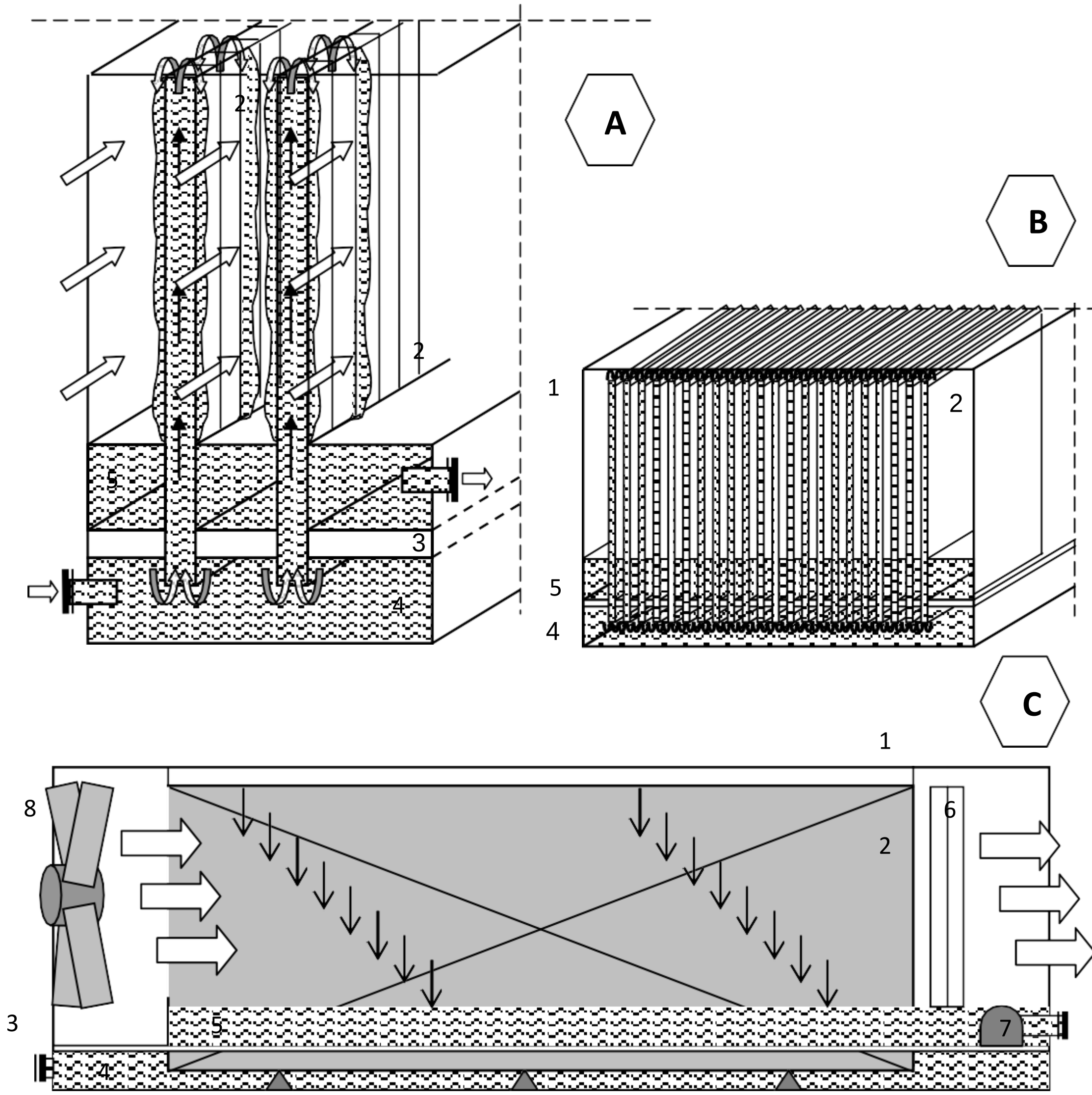

Figure 2. Cross-flow heat and mass transfer device based on polymeric multilayer sheets of polycarbonate for alternative systems. Direct evaporative cooling water (cooling tower), or air unit DEC. Legend: 1 - body, 2 - HME packing elements of a polymer material, 3 - support-distribution grid, 4 - container for liquid entering the HME, 5 - tank of liquid coming out of the HME, 6 - condensed moisture separator 7 - filter pump 8 - the fan.

Absorber, evaporative cooler and cooling tower are structurally completely identical (Figure 2). By packing elements within the channels (polycarbonate plates), the liquid (absorbent solution, or water) rises under a certain pressure in the distribution container up film overflows and flows along the outer surfaces of the nozzle. Bottom liquid is collected in the storage container. It is then sent for regeneration (absorber). It is recycled (evaporative cooler), or intermediates used in other processes (cooling tower). The air in these devices is blown along the packing elements (multi-plate) in the "bulkhead" space, the cross-flow contact with the liquid film flowing on the outer surfaces of the elements. Previous studies [1,2] show that the cross flow diagram HME is most convenient for such systems from the point of view of stability of film flow and the convenience. HME multiple joint assembly is in a single block. According to the technological processes in the absorber air dried absorbent and the remaining devices are cooled air flow and water film by evaporative cooling. The absorbents in open systems commonly used aqueous solutions of calcium chloride, lithium chloride, lithium bromide, such as multi-component solutions based on these materials. In previous studies [7, 8] uses the best absorbency aqueous lithium bromide. The additives used are $LiNO_3$, $ZnCl_2$, $CaBr_2$, LiI, and other components.

Consider the efficiency of working substances, applied to open cycles, solar absorption regeneration of the absorbent. In Figure 3A analyzed solutions are indicated: H_2O + LiBr - LiBr; H_2O + LiBr + $LiNO_3$ - LiBr +; $H2_O$ + LiBr + $ZnCl_2$ + $CaBr_2$ - LiBr + +. Given the vapor pressure of water solutions of LiCl and LiBr on two typical for open-cycle absorption isotherms: 303.15 K (absorption) and 333.15 K (desorption). For the same pressure to the isotherms 303.15 LiBr solutions and LiBr + are further away from the crystallization solution than LiCl. Therefore, their use is preferred from the viewpoint of reliable operation of the equipment under the same driving forces of absorption. The fact that under identical conditions of solution LiBr + requires lower desorption temperature. It is essential when using a solar collector - regenerator SC-R (direct-type stripping).

The advantage of this solution is also low corrosively. Some typical calculated results are shown in Figure 3B as a function of air changes in the moisture content of the absorber and the desired temperature of desorption of the reduced concentration of the solution LiBr +(ξ *= ξ / ξ_s), where ξ_s is the concentration of the solution in the crystallization line. The calculations are carried out at ambient temperature 30 C°and moisture content of 13.5 g / kg. It shows the basic possibility of an open-cycle absorption in AACS direct (immediate) regeneration of the absorbent.

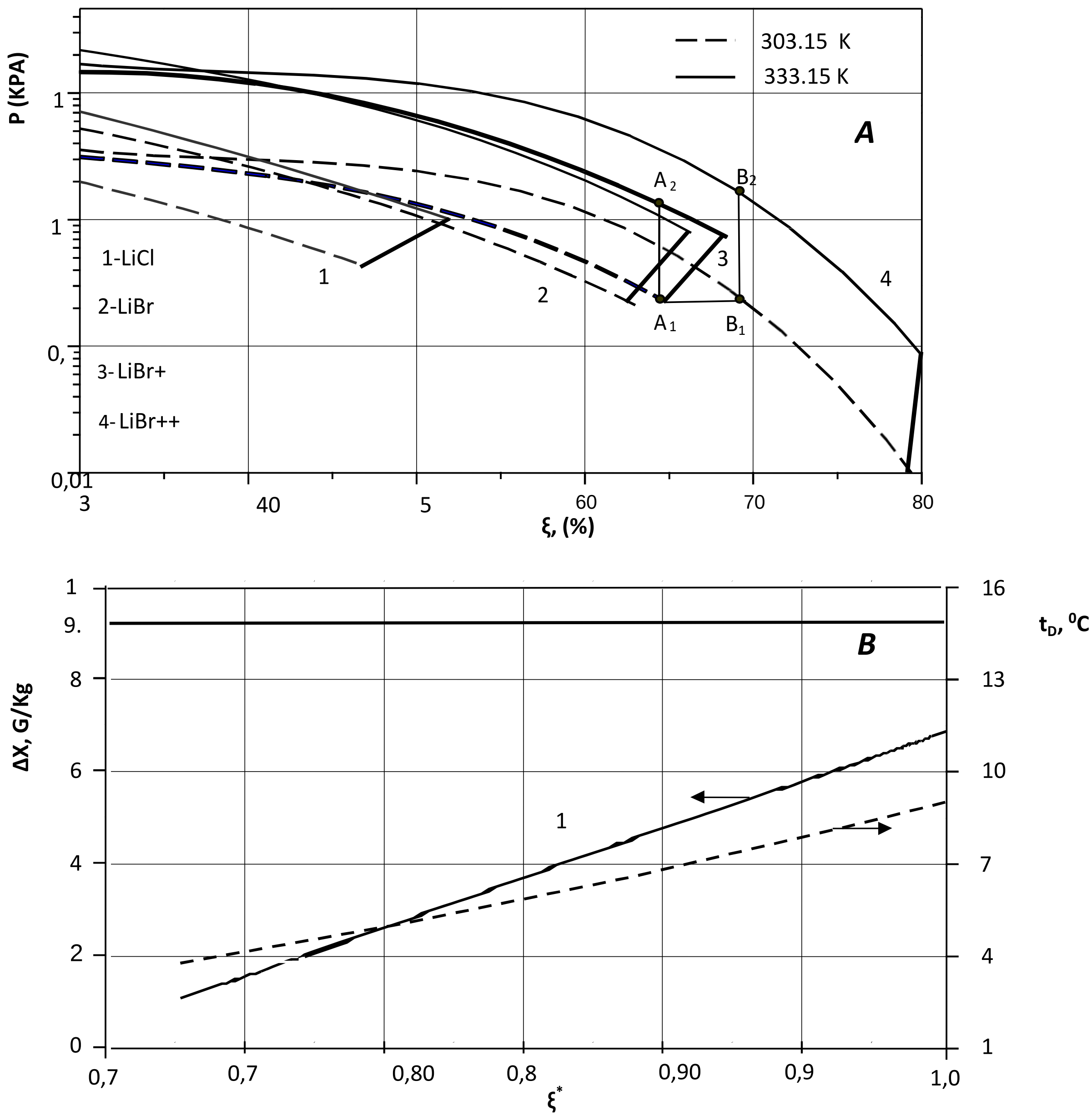

Figure 3. By the choice of absorbent and pre-calculated results. **A**. The vapor pressure above the surface of the absorbent. Legend**:** Line crystallization A_1 - A_2 and B_1 - B_2 - conventional processes of absorption and desorption, 1 - 4 - absorbent solutions. **B**. The time variation in the air moisture absorber (Δx) and the desorption temperature (t_D) the reduced concentration of the solution LiBr +. Payment terms: the temperature of the air entering the absorber 300C, the moisture content of air to be dried 13.5 g / kg.

Previously, analysis is made for the environmental benefits by the use of polymer SC as compared to traditional analogue with a metal heat receiving [7,8]. By evaluating the influence of "product life cycle" on the environment (the program LCA - Life Cycle Assessment), analyzes the environmental impact of the extraction and processing of raw materials, the production of a product, use and handling of waste. to account the nine types of environmental impacts: global warming potential, ozone depletion, acid-oxide emissions, water pollution, emissions of heavy metals, winter smog, summer smog, the depletion of resources, energy and solid waste emissions. Of great importance in the evaluation is the percentage content of the materials in the product which recycled after its period of operation and returned to the overall production cycle. The full impact of reservoirs on the environment (program "Eco-indicator 95") was 76.2 and 46.8 units (mPt). Calculations show that the time to return the spent energy production was 8.3 and 3.8 years for the traditional collector SC-A and SC-P polymer, respectively. Accounting for environmental effects and can significantly reduce the payback time items (for SC this was 3.5 and 1.9 years, respectively, the integration of environmental indicators). It is expected that when the results of this analysis are applied to the air collector-regenerator SC-R (re boiler straight-type) it will close. A similar analysis when performed with respect to the whole AACS [8] shows promise of such developments and also from an environmental view point.

3. Conclusions

The new schematics of alternative conditioning and refrigeration systems based on open-cycle absorption and direct regeneration of the absorbent are presented in this paper. Based on the compact heat-mass exchanger equipment for alternative systems based on the use of polymeric materials - multi-polymer plates made of polycarbonate, including an absorber of the collector-air regenerator and evaporative coolers. The environmental benefits of the practical use of polymeric materials in creating heat- mass exchanger equipment for alternative refrigeration systems, to the bulk and weight is presented in this work.

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