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Solar Regulator Collectors For Open Absorption Systems

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ABSTRACT:
New circuit solutions for alternative conditioning and refrigeration systems based on an open absorption cycle and direct regeneration of absorbent have been developed. The use of polymeric materials in the construction of the solar collector SK (a new type SK-P and the solar collector-regenerator SK-R) significantly (2.5 times) reduces its weight, cost (several times compared to domestic SK traditional designs), with the actual maintaining performance and reliability. Replacing glass with a polymer plate as a transparent coating increases its strength and significantly reduces the weight of SC, practically without leading to a decrease in the thermal characteristics of the product. The thermal characteristics of the new polymer collector are quite consistent with the characteristics of traditional collectors with non-ferrous metal absorbers. Assessment of the environmental impact of the product on the environment showed great advantages of using the new polymer SC in comparison with traditional types of metal SC.

Keywords: *solar polymer collector, collector-regenerator, open absorption cycle, environmental indicators.*

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I. INTRODUCTION

The use of an open absorption cycle provides new opportunities for creating a promising generation of refrigeration and air conditioning systems. Here we can use solar energy as a heating source. The source of the latter in a practical sense can be a solar system with flat solar collectors [4-6]. Thanks to the studies carried out in recent years [2-5], it became possible to create a polymer type of a solar collector - an absorbent regenerator (SK-R), which provides a new life for alternative systems, given that the main cost and weight of these systems falls on the solar regeneration system absorbent.

II. SCHEME SOLUTIONS AND HARDWARE.

Figure (1) shows the options for the developed schemes of alternative systems (attached to the task of air conditioning AACS) based on an open absorption cycle direct (A) and indirect (B) solar absorption regeneration. The scheme includes two main parts: preliminary dehumidification of air in the absorber-dryer and subsequent evaporative cooling in the evaporative cooler of the indirect type of IEC. In the drainage part, the heat necessary for the regeneration of the absorbent is provided by a solar system with flat solar air collectors 2, and the cooling of the absorber is provided, as a rule, by a fan tower 4.

The air flow, when dried in the absorber 1, reduces the moisture content(x_g) and dew point temperature t_{dp}, which provides a significant cooling potential in the evaporative cooler. As an evaporative cooler, an apparatus for indirect evaporative cooling of (IEC) developed in Odessa State academy of refrigeration (OSAR) is used [5,6]. The IEC cooler is solved according to a combined scheme in the form of a multi-channel nozzle with alternating “wet” (auxiliary air stream and water film recirculating through the apparatus interact) and “dry” channels (main air stream cooled with constant moisture content). The amount of evaporated water in the recirculation water circuit is compensated by replenishment with fresh water 10. As a result of evaporative cooling of the water in the “wet” channels, contactless cooling of the main air flow in the “dry” channels of the IEC through a thin heat-conducting wall separating these channels is provided. . The natural limit of evaporative cooling in a single-stage IEC is the temperature of the air through a wet thermometer at the entrance to the IEC (this is either outside air or its mixture with recirculating air flow leaving the room).

The main issue is ensuring the continuity of the absorption cycle, which is achieved in the process of solar regeneration of the absorbent. The solar system in several versions is used as an external heating source during the regeneration of absorbent material (Figure 1). The main idea of this study is to study the possibility of using polymeric materials (PM) in the construction of a solar collector-regenerator (SC-R). The issue of the use of polymers in SC has long been studied by a number of world research centres and manufacturers [3, 4].

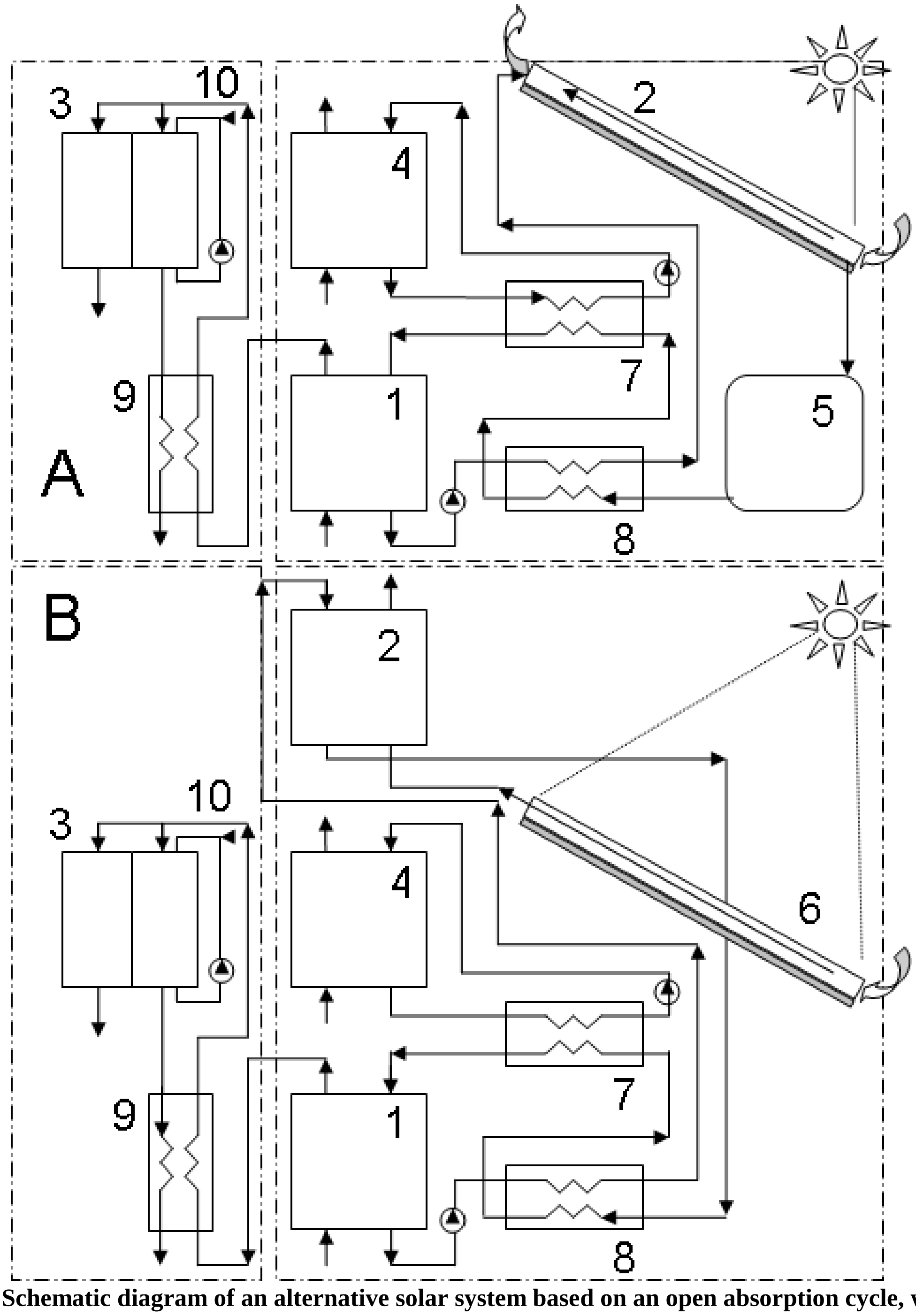

Figure 1. Schematic diagram of an alternative solar system based on an open absorption cycle, with direct (A) and indirect (B) regeneration of the absorbent, using an SC-R air solar collector-regenerator. Designations: 1 - absorber; 2 - desorber (regenerator); 3 - evaporative cooler of indirect IEC or direct DEC type; 4 - cooling tower; 5 - tank; 6 - air solar collector; 7, 8, 9 - heat exchangers; 10 - recirculation water circuit of the evaporative cooler.

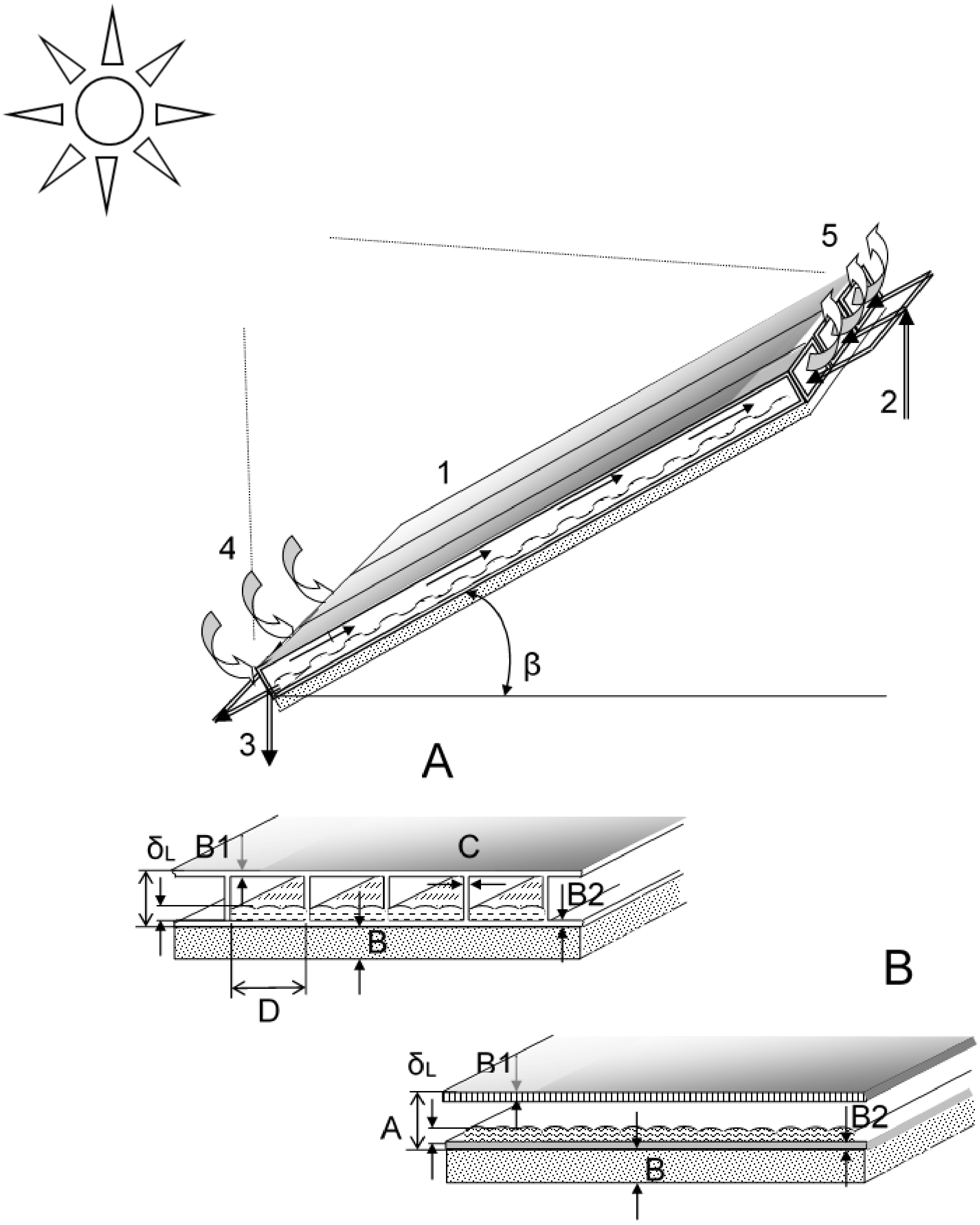

Figure 2. Solar collector - regenerator (direct type stripper) based on the SC-P polymer solar collector and flow pattern in SC-R channels (basic design options for SC-R).
Designations: 1 - solar collector - regenerator; 2, 3 - input and output of the absorbent solution; 4, 5 - air inlet and outlet.

In the diagram according to Figure 1B, a system with flat air solar collectors 6 is used to absorb the regeneration of the absorbent, providing heating and subsequent movement of the regenerative air flow through the stripper 2. The previously developed water-based SC-P made of polymeric materials can also serve as a basis for creating such air-cooled solar collectors. recommended in hot water systems. In terms of its characteristics, such an SC practically does not concede to traditional types of SC, the heat sink of which is made on the basis of the tube register from copper or aluminium tubes. Polymer SC is much cheaper than traditional metal, where non-ferrous metals are used, and this fact is essential for the developed alternative systems, where significant areas of solar energy receivers are required. The disadvantage of such an absorbent regeneration system is the relatively low pressure of the air flow generated by solar heating, which, as shown by preliminary calculations, may not allow air to pass through the nozzle layer of stripper 2. For this reason, the main priority in this study was given to the polymer solar collector-regenerator SC-R (Figure 2), in the form of a stripper of direct (immediate) type.

An analysis was made of polymeric materials (PM) that can be used in SC designs. The most promising material, as shown by studies by Danish scientists [3], is polycarbonate (PC). A honeycomb polycarbonate plate is two parallel sheets with transverse partitions in a single, unified structure. Operating temperature range for polycarbonate: from -40 to +120 ˚C, which allows its use in "open" spaces. The maximum thermal expansion (at $\Delta T = 80^{\circ}C$) is 2.5 mm / m. The light transmittance of PM is of great importance when choosing them for use as a transparent coating of SC. Polycarbonate panels have a light transmission of 70 - 82%, depending on their thickness. The panels with a thickness of 4 mm with the highest light transmission were chosen as a transparent coating of SC in the SC-R variant of design B (Figure 2). With prolonged exposure to solar radiation, the resistance of the material to ultraviolet radiation (UV) is important. Modern PC panels are made with a special coating to prevent UV radiation from entering the panel.

PC is resistant to many chemicals, including high concentration mineral acids, many organic acids, neutral and acidic salt solutions, many fats, paraffin's, saturated aliphatic and cycloaliphatic, except methyl alcohol. PC is destroyed by an aqueous or alcoholic solution of alkalis, ammonia or its solutions and amines. The degree of sensitivity to the effects of chemicals depends on factors such as concentration, temperature, duration of contact with the panel surface, pressure, as well as stresses in the panel. Cellular panels made of PCs are characterized by high mechanical characteristics, such as hardness and resistance to impact under prolonged maintenance in the open air. The outer surface of the panel is covered with a layer that protects against ultraviolet radiation. This layer absorbs the ultraviolet part of the solar spectrum and provides consistent mechanical and optical properties for many years. Tests in the open air, which were carried out for 7 years in the USA, in the states of Arizona and Florida, as well as in Germany, showed high impact resistance and preservation of the original optical properties. Compared to other glazing's of the same thickness, the heat loss through the honeycomb panels from the PC is much lower and the thermal insulation is much better, which determines fuel and energy savings.

III. EXPERIMENTAL STUDY OF POLYMER PLANE SOLAR COLLECTORS.

In the period from 1999 to 2004, comparative tests of various types of developed polymer SC-P were carried out. To experimentally study (test full-scale samples) the thermal characteristics of the developed SC samples, a stand was created, the scheme of which and the description of the experiment are given in [4]. Tests at the bench were comparative in nature and made it possible to identify the real characteristics of the compared SCs, regardless of weather conditions.

Tests and calculations showed that the thermal characteristics of traditional SCs with a heat sink from copper or aluminium pipes are slightly higher than the characteristics of polymer SCs (on average, the difference in temperature of water in the heat storage tank for compared SCs was 7-14%). This is due to the lower light transmittance of polycarbonate compared to glass. In addition, polymer SC has a higher loss coefficient and a lower coefficient of thermal conductivity of polycarbonate in comparison with aluminium.

Two types of polymer SCs were made, characterized by the location of the light-absorbing coating on the surface of the absorber: in one SC it was applied on top of the absorber plate, and in the other in its lower part. Typically, this problem does not arise for traditional types of SCs and is characteristic only in the case of polymer SCs. In the first embodiment, solar radiation passing through a transparent coating was absorbed by the upper side of the absorber and transferred to the coolant, mainly due to thermal conductivity. In the second embodiment, solar radiation after a transparent coating passed through the upper side of the absorber, partially absorbed, passed through a transparent heat carrier and was absorbed by the lower side of the absorber. Tests have shown that the place of coating does not have a special effect on the integral daily heat production of SC (discrepancy of the results is about 5%). Earlier, we analysed the environmental advantages of using polymeric SC in comparison with an aluminium analogy [5-6]. An assessment of the impact of the full "life cycle of the product" on the environment (LCA - Life Cycle Assessment) - Figure 4. Four main steps were analysed: extraction and processing of raw materials, production of the product, its operation and waste treatment. The study took into account nine types of environmental impact: global warming potential, depletion of the ozone layer, emissions of acid-containing oxides, pollution of the water basin, emissions of heavy metals, winter smog, summer smog, depletion of energy resources and emissions of solid waste. Of great importance in the assessment is the percentage of materials in the product that can be recycled after the end of its operation period. The total impact of the collectors on the environment (under the "Eco-indicator 95" program) was 76.2 and 46.8 units, respectively (mPt).

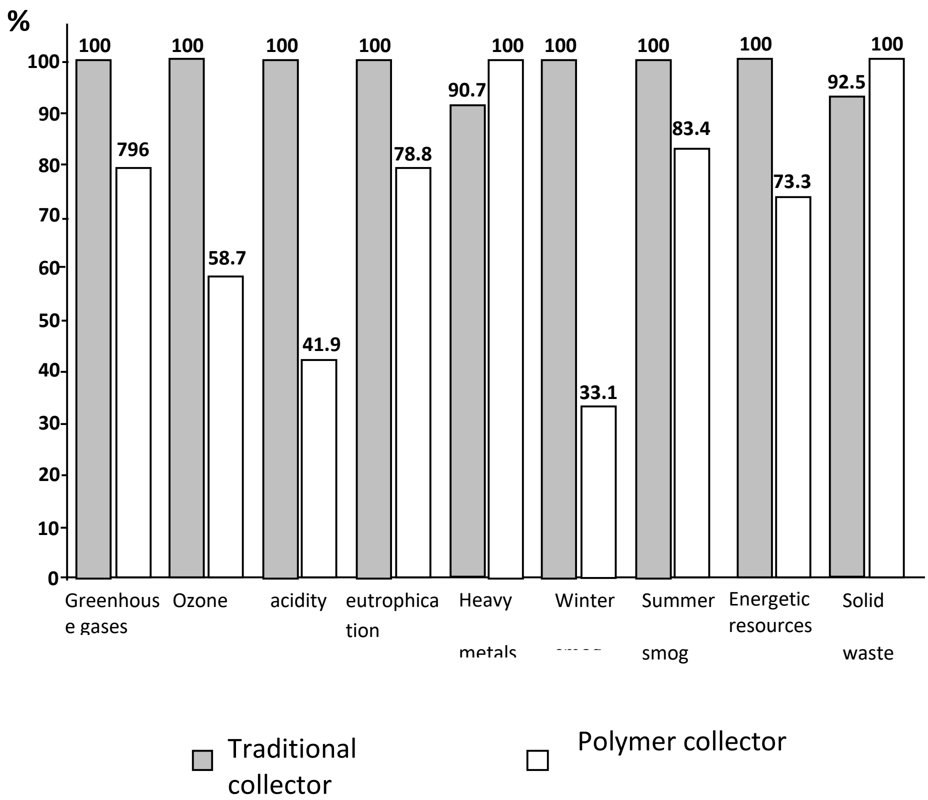

Figure 4. Comparative environmental impact of a conventional and polymer solar collector (SC-P and SC-R) when calculated per 1 GJ of heat produced by the system

IV. CONCLUSIONS:

• New circuit solutions for alternative conditioning and refrigeration systems based on the open absorption cycle and direct regeneration of the absorbent have been developed.
• The use of polymeric materials in the construction of SC (a new type of SC-P and solar collector-regenerator SC-R) significantly (2.5 times) reduces its weight, cost (several times compared with domestic SC of traditional design), while actually maintaining performance and reliability. Replacing glass with a polymer plate as a transparent coating increases its strength and significantly reduces the weight of SC, practically without leading to a decrease in the thermal characteristics of the product.
• The developed polymer SC-R is efficient and can be used to create alternative systems. Non-ferrous metals can be almost completely eliminated in its design.
• The performance characteristics of the new polymer collector in terms of thermal efficiency are fully consistent with the characteristics of traditional collectors with non-ferrous metal absorbers.
• Assessment of the environmental impact of the product on the environment has shown great advantages of using the new polymer SC in comparison with traditional types of metal SC.

NOMENCLATURE
AACS- Alternative air conditioning system.
DEC, IEC – direct and indirect evaporative cooler.
OSAR- Odessa state academy of refrigeration.
SC- solar collector.
SC-R – Solar collector regenerators.
SC-P – polymer solar collector.
PM- polymer materials
PC- polycarbonate.

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