

Comparison of the Efficiency of Solar Collectors in Terms of the Working Medium—Review of Selected Technical Solutions [†]

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Abstract: In Poland, the most commonly used solar fluid in heating installations with solar collectors are 35–50% water propylene glycol solutions or ethyl. These mixtures (with ennobling additives) effectively protect the solar installation against the effects of freezing of the working medium at low outside temperatures prevailing in winter. These solutions, compared to water, are characterized by higher viscosity and lower values of the specific heat in the range of typical working temperatures of the working fluid in the solar circuit, have a higher price per unit volume, and may cause poisoning due to accidental ingestion. It is possible in solar installations operating also in winter use of water only, without the addition of glycols, but then equipment is necessary the automatic control system controlling the installation with the protection function of anti-freeze. The aim of this study is to review selected examples of solar installations in which water was used as the solar fluid, proving the disadvantage of using glycol.



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1. Introduction

In 2007, a search was performed in Italy with flat collectors (gross area 5.16 m²) and one pipe collector (3.9 m²) on the roof of the University of Padova. The flat collectors were equipped with a copper absorbent coated with a selective coating, and tidal flow arrays arranged in parallel. The tube collector consisted of 21 with a parabolic mirror. It turned out that the flat plate collector is more sensitive to the difference between the temperature of the heat transfer pointer in the collector and the ambient temperature [1,2].

S. Pater et al. discussed the anti-freeze function in a solar installation with vacuum tube collectors, in which water was used as a solar fluid. The period of time in which this feature was used has been analyzed in detail. Working solar collectors under real conditions for hot utility water preparation and back-up central heating in a residential and service building are part of the multivalent hybrid installation, where additional heat generation is produced from three different heating devices. Energy efficiency was also determined by solar collectors. According to the authors of the *Energy*, the operation of the solar water installation in December, January, and February may be unprofitable. However, disabling the installation is not recommended due to practical issues and unpredictable conditions atmospheric, which is confirmed by December 2013 and 2014. The conducted research confirmed that the use of water as a factor circulation in solar installations in Polish conditions is justified in practical and energetic terms. However, it is related to the use of the appropriate controller or control system of the operation of such an installation. In time of the conducted research, the installation worked without failure [3].

2. Characteristics of Selected Solar Fluids

An important element of every solar heating installation is the circulating medium, whose primary function is to receive the heat generated by solar collector and then trans-

ferring it to the heat receiver, e.g., a domestic hot water (DHW) tank. In the temperate climatic zone, in which Poland is located, the most commonly used solar fluids are 35–50% aqueous propylene or ethyl glycol solutions.

It can be used in solar installations that are used all year round in deionized water, without the addition of glycols, as a circulating medium. However, such installations should be equipped with a control system with an anti-freeze protection function. The collector efficiency (1) is the ratio of energy received by the working medium to the amount of solar radiation energy reaching the collector. The efficiency of the collector decreases with the increase of the temperature difference between the working medium and the environment.

$$\eta = Q_c / E_s \quad (1)$$

η —collector efficiency,

Q_c —useful energy (yield absorbed radiation) (W/m^2),

E_s —solar radiation intensity (W/m^2).

The CPC (compound parabolic concentrator) vacuum tube collector (Figure 1) is a highly efficient collector even in diffuse lighting conditions. To maximize the efficiency of the collector, on the back of each vacuum tube there is a highly reflective, weather-resistant CPC. The optimized geometry of the mirror guarantees the absorption of direct sunlight and stray light even at the most unfavorable angle. This significantly increases the energy yield of the solar collector. The unfavorable angle of radiation results from oblique insolation, e.g., the house is not oriented exactly south, but more east or west, and also due to morning or evening sun or solar radiation scattered by clouds [4].



Figure 1. CPC evacuated-tube collector (own photography).

Water glycol solutions compared to water:

- Have a price several times higher;

- Two to five times higher dynamic viscosity and lower specific heat value in the range of typical operating temperatures of the liquid working in the solar circuit;
- May cause poisoning as a result of accidental ingestion;
- More frequent refrigerant replacement;
- Problems with the disposal of glycol;
- They are thermally degraded to tarry compounds which they can settle on the internal surfaces of pipelines, or heat exchangers [5].

3. Summary and Conclusions

Solar collectors are often and willingly used to support the heating of domestic hot water, heating of swimming pools, or even rooms. Knowledge of the thermal characteristics of the solar collector is necessary for the proper selection of this device depending on the application, type of installation, climatic conditions at the place of installation and the level of the required temperature that we want to achieve. The selection of the appropriate working medium for the installation also results in better efficiency and life of the system.

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