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В терминах инварианта рассмотрена топологическая эквивалентность непрерывных функций, заданных на окружности с конечным числом экстремумов. Инвариантом функции, что дает возможность подсчитать число топологически неэквивалентных функций, есть $\Omega(f)$ – разбивка S^1 на дуги S_i, значение функций в их локальных экстремумах, образующих змеи определенного типа.

Критерий, эквивалентность, функция, многообразие, экстремум, последовательность.

In terms of the invariants considered topological equivalence of continuous functions defined on a circle with a finite number of extrema. Invariant function, which enables to calculate the number of topologically different functions, there is $\Omega(f)$ – on the partition S^1 arc S_i, value functions in their local extrema forming snake

Criterion, equivalence, function, diversity, extremum, sequence.

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ANALYSIS SOLAR WATER-HEATING SYSTEMS ON THE BASIS OF EVACUATED TUBE COLLECTORS

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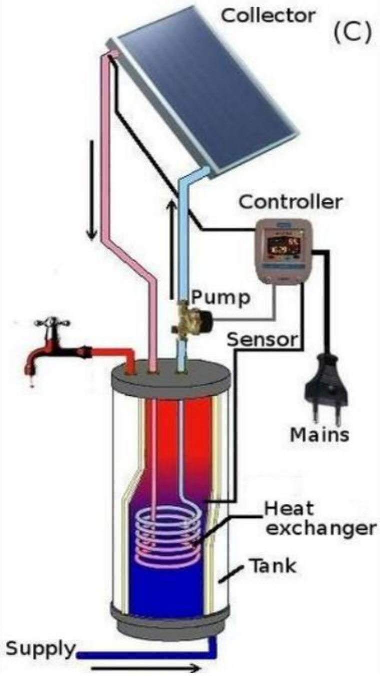
This paper presents main aspects the use of solar systems for heating domestic water on the example standard solar installation constructed as an object of o research in Education and Research Institute of Energetics Automatics and Energy Saving (NULES Ukraine). Obtained charts with the input and output temperature of vacuum solar collector.

Solar energy, hot water systems, collector efficiency, vacuum solar collector.

Solar hot water system comprises several innovations and many mature renewable energy technologies, which have been accepted in most countries for many years. Nowadays, the demand on heat energy has increased, and it is the natural, safe and costless process to collect hot water by solar radiations. There are many applications of the hot water heated by the solar radiations. Where the solar hot water is used in the domestic purposes, it also is used in industrial applications, e.g. used for electricity generation [1].

The effective sunshine occurs only about 5–6 h per day and since heating and hot water loads occur up to 24 h a day. Some type of energy storage system is needed when using the solar energy. Practical experiences in the industry as well as computer simulations and experiments have resulted in rules of thumb for storage sizing. These guidelines provide storage sizes for which the optimized and relatively insensitive to changes within the range indicated [2].

Materials and methods research. Most solar water-heating systems for buildings consist of a solar collector, a storage tank, circuit pump and a control system (pic.1). The most common collector used in solar hot water systems is the flat-plate collector (FPC), but evacuated tube collectors (ETC) are gaining in popularity as their price comes down, and they are more efficient than FPC's at the higher temperature differences expected in winter.

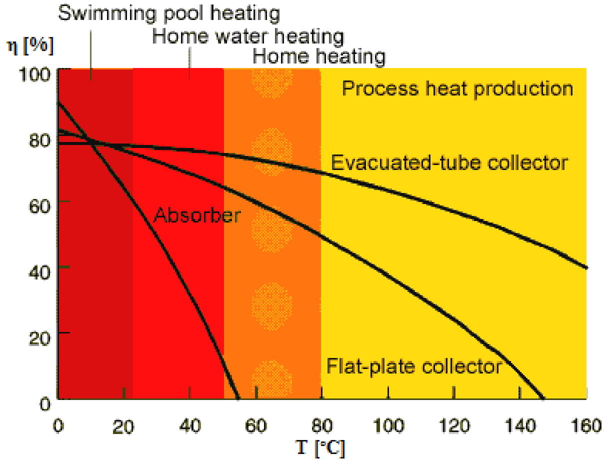


Pic. 1. Typical solar water-heating systems

Solar system is controlled by solar controller SR1188. Controller compares the temperature between collector T1 and storage tank T2 (bottom part), if the temperature difference （DT） rises up to the preset switch-on DT（DTon) or is over it, circuit pump is triggered, and then storage is heated until DT drops to the switch-off DT (DToff) or when the storage temperature rises up to its preset maximum temperature. Then circuit pump is ceased.

For the home water heating evacuated tube solar collector can achieve efficiency (pic. 2) close to the 80% (within solar radiation: 1000W/m2).

Our investigation was analyzed with the real experimental data. Solar system for heating the domestic water with one vacuum tube collector (pic.3) has also high efficiency (almost 70%).



Pic. 2. Graph of efficiency and temperature ranges of various types of collectors (radiation: 1000 W/m^2)

The ambient temperatures for each investigated day were from -1,4 to 8 [°C] with the solar radiation from 746 to 843 [W/m2]. High efficiency depends mostly on solar dose of radiation. Vacuum tube collector (compared with flat plate solar collector) passively track the sun through the day. Besides special reflector behind the tubes with an optimally located focus point directs solar radiation onto the absorber tubes in an ideal way, even when the radiation angles are different.

Fig.3. General view a vacuum tube solar collector that installed on the roof building № 8 Education and Research Institute of Energetic, Automatic and Energy Saving

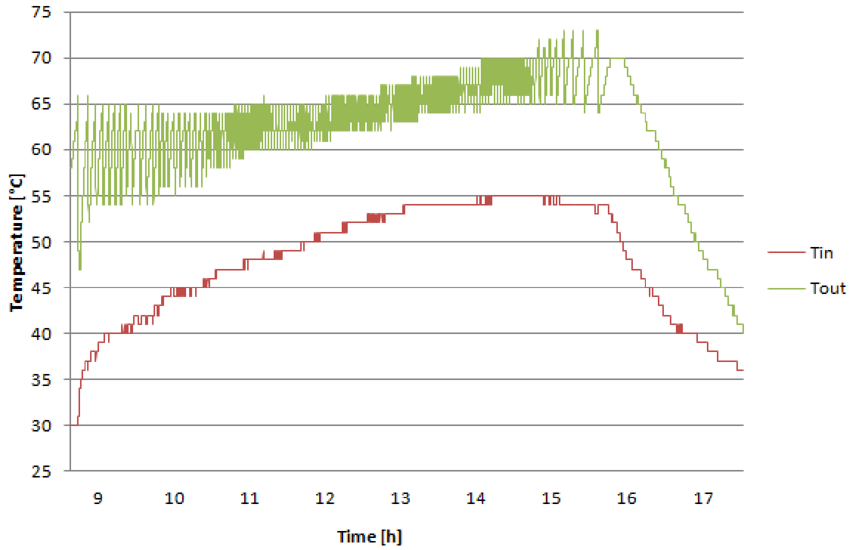
For the reliable analysis the data about the daily temperature and dose of solar radiation are also needed. The daily temperatures are read from Central Geophysical Observatory in Kiev (Ukraine). The average daily solar irradiance is calculated by on-line calculator from the International Geographical Information System site.

There were compared three days from the autumn and winter season. Solar collector efficiency was determined for each day selected for analysis [3]:

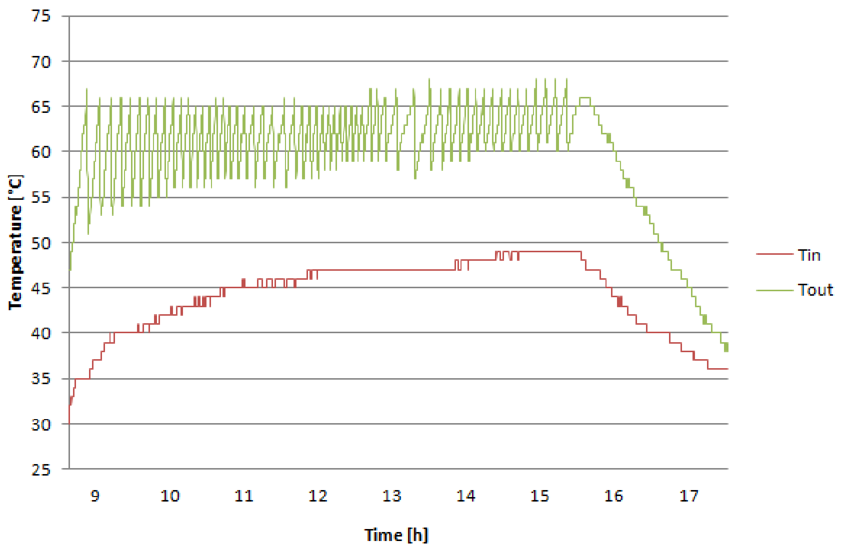
$$\eta_{s.c} = \eta_{on} - k_1 \frac{T_{s.c} - T_a}{q_c} - k_2 \frac{(T_{s.c} - T_a)^2}{q_c}, \qquad (1)$$

where: $\eta_{s.c}$ – solar collector efficiency; η_o – solar collector optical efficiency; k_1, k_2 – empirical coefficients; q_c – heat flux density, W/m^2; $T_{s.c}$ – output temperature of solar collector, °C; T_a – ambient temperature,°C.

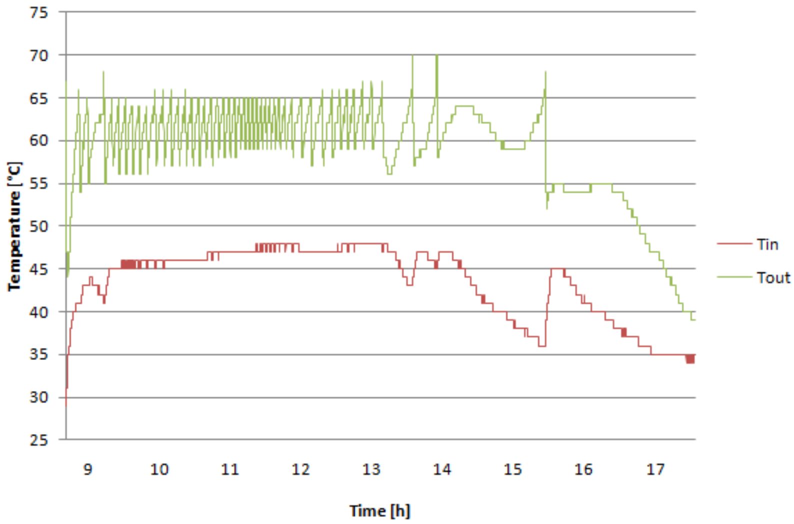
Results. The results of three compared days (18.11.2013, 14.12.2013 and 07.01.2014) were presented by charts and table. There were chosen days with very good weather conditions. The charts with the input and output temperature of solar collector (pic. 4-6) were presented from 9 a.m. to 5 p.m., because of the highest operational conditions for the solar system [4].



Pic. 4. Inlet (Tin) and outlet (Tout) temperature of the vacuum tube collector on 18.11.2013



Pic. 5. Inlet (Tin) and outlet (Tout) temperature of the vacuum tube collector on 14.12.2013



Pic. 6. Inlet (Tin) and outlet (Tout) temperature of the vacuum tube collector on 07.01.2014

Parameters like solar collector optical efficiency, empirical coefficients and heat flux density are constant for each kind of solar collector. For vacuum tube solar collector with 30 tubes and aperture area 2,81 m^2 it is shown in the table 1. Output temperature of the solar collectors for each day (12:00) was about 65 °C. The ambient temperature was different for each day. The solar irradiance (G) is read at 12:00 for each day. Solar collector efficiency oscillated from 0,67 to 0,69.

Tab.1. Parameters and appearance of the solar collector for each investigated day

Parameter	Date		
	18.11.2013	14.12.2013	07.01.2014
η_o	0,76		
k_1	1,362		
k_2	0,002		
q_c [W/m^2]	1000		
$T_{s.c}$ [°C]	65		
T_a [°C]	8	-1,4	0,1
G [W/m^2]	843	746	804
$\eta_{s.c}$	0,69	0,67	0,68

Conclusions

For the autumn-winter period the solar collector efficiency for the days with very good weather conditions reached nearly 70%. The highest efficiency was at particular point (or period, as 'DT' was almost constant from 10 a.m. to 3 p.m.) of the day, when operational conditions of solar collector were the highest.

The average efficiency of the solar system for the all autumn-winter period will be probably about 30%, maybe less, because of different and hard weather conditions (mostly cloudy, windy and cold days). About 20% of all days from this period can achieve high efficiency, but it is possible.

For the home water heating evacuated tube solar collector can achieve efficiency close to 80% (within solar radiation 1000W/m^2). Our investigation was conducted using the real experimental data. Solar system for heating the domestic water with one vacuum tube collector has also high efficiency (almost 70%). So it is well verified.

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В статті представлені основні аспекти використання сонячних систем для нагрівання води для побутових потреб на прикладі стандартної сонячної установки, створеної як об'єкт дослідження в Навчально-науковому інституті енергетики, автоматики та енергозбереження НУБіП України. Отримані діаграми вхідної і вихідної температури вакуумного сонячного колектора.

Сонячна енергія, гаряче водопостачання, ефективність колектора, вакуумний сонячний колектор.

В статье представлены основные аспекты использования солнечных систем для нагрева воды для бытовых нужд на примере стандартной солнечной установки, созданной как объект исследования в Учебно-научном институте энергетики, автоматики и энергосбережения НУБиП Украины. Получены диаграммы входящей и выходящей температуры вакуумного солнечного коллектора.

Солнечная энергия, горячее водоснабжение, эффективность коллектора, вакуумный солнечный коллектор.