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THE IDLING OF A COOLING HYBRID SYSTEM IN WINTER TIME IN CLUJ COUNTY

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Abstract: *The renewable energy sector is a very important domain nowadays that is significantly exploited. To follow the actual trend, a cooling hybrid system made of a solar thermoelectric cooler was built. Experiments were conducted with it in the case of idling in all kind of winter weather conditions of the Cluj-Napoca city (snow, clouds and sun). The analysis confirmed that in the presence of snow, solar irradiation' value is very small and the cooler cannot work if the electric energy wasn't previously stored in the battery. In the other two cases, there are no problems. Also, the temperature registered during idling showed the system can work as both cooler and freezer, depending on the need.*

Key words: *cooling hybrid system, idling, winter, weather conditions.*

1. Introduction

The renewable energies' sector significantly developed in the last years. The general tendency is to use these renewable energy sources in both in- and off-grid systems [1], [2]. No matter whether in the area exists or not electric current supply system, people tend to install photovoltaic systems (PV) or wind turbines to their houses or companies, too. In Romania, this phenomenon knows an important growth from several years [3-5].

In the case of the autonomous systems, the main important disadvantage is that these off-grid systems produce direct current (DC) while our equipment needs alternative current (AC). Therefore, the inverter is needed and it leads to a greater complexity of the PV systems and an increase of the acquisition price. Fortunately, these two elements can be removed and skipped by using DC equipment. Such a type is the solar thermoelectric cooler presented in papers 6-14. As it was already specified by the authors in the previous papers, it is a complete hybrid system based only on photovoltaic and thermoelectric energies. The PV system supplies the necessary DC current to the thermoelectric modules which realized the heat transfer between the cooling room and the cooling water.

It is not enough only to build such an equipment. It is very important to analyse its operation in different cases and to conclude if it is efficient enough to enter in a production line in order to be used by

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Fig. 1. *The cooling hybrid system*

people. Even though the operation cases of the solar thermoelectric cooler can be multiples, first of all, the most important is the case of idling. In consequence, this study aims to emphasis the influence of the winter weather conditions on the cooling hybrid system and its behaviour in Cluj County, Romania (preciously in Cluj-Napoca city).

2. Material and Methods

The cooling hybrid system that uses the DC current provided by the photovoltaic system is the same as the one presented already in papers 9-13 and mentioned above, in the previous chapter of the study.

To summarize its componence, the solar hybrid system (Fig. 1) consists of a photovoltaic panel and a cooler with thermoelectric modules (TEC). The direct current passes through a charge controller and is stocked in the storage battery. From here, the current is delivered to the TEC modules which realize the heat transfer between the cold room of the refrigerator and the cold cooling water.

All parameters involved in the process were measured with specialized instruments and soft-wares – pyrometer, temperature data logger, laser infrared thermometer, special programmes for the electric and photovoltaic parameters.

The measurements obtained during the idling of the cooling hybrid system were analysed with special programmes (i.e. OriginLab, Eviews, etc.) and then discussed within this study.

The experiments were conducted in winter weather conditions. The purpose was to see if this type of refrigerator can operate in the winter period of the temperate climate encountered in Cluj-Napoca.

3. Results and Discussions

In winter time, when snow was present, the solar irradiation was extremely low, somewhere around a mean of 40 W/m2. This value was so small that the photovoltaic system was not able to produce enough electricity for the operation of the solar thermoelectric cooler. The situation changed when snow stopped. When the weather was mostly cloudy, the solar irradiation increased to an average of 215 W/m2, while during a shiny day, the mean was around 400 W/m2. In both last cases, the amount of the electric energy produced ensured the electricity demand for a good operation of the hybrid cooler.

This aspect reflected very well into the values of the photovoltaic measured parameters (amperage, voltage, power) showed in figure 2.

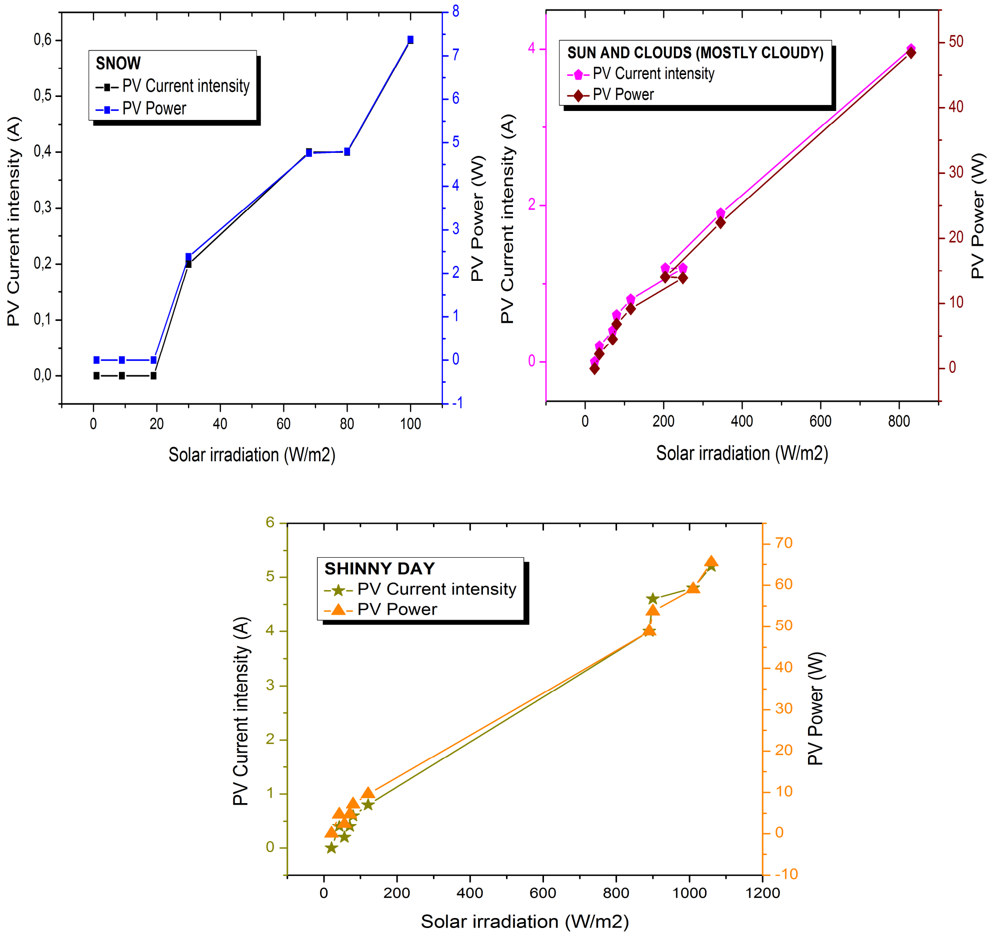

Fig. 2. *The influence of the solar irradiation on the PV parameters in different weather conditions*

This enforces the direct proportionality between power and amperage. The extremely closed trend is also sustained by the stagnation or by the very low constant and linear decrease of the voltage during the idling of the solar thermoelectric cooler. Figure 3 confirms it. Besides the two stagnation on a very short period of time (comparing to the entire working interval) in the case of snow and sun, the voltage decreased linear and constant with 0.1 V every step.

Even though the hybrid cooler worked in the same conditions (of idling) in all three weather cases (snow, clouds and sun), the intensity of the electric current registered a linear trend in the presence of snow (see Figure 4). Only one small decreasing step was made in this situation from 5.5 A to 5.4 A. In the other two cases, the decreases are more visible (biggest). Even if the solar irradiation approached to zero (because of the present clouds, of the evenfall/night) and the thermoelectric cooler was still functioning, the DC current intensity entered for more than the half of the working period in stagnation (it kept the same value of amperage).

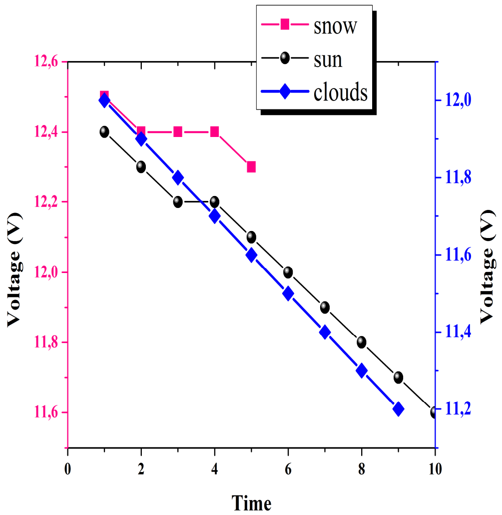

Fig. 3. *Voltage' almost linear decrease in time*

different food products) and also as a freezer.

The most particular case is the one with sun. During this experiment, the amperage registered more decreasing steps than in any other situation. It is very interesting because, normally, anyone would suppose that in a shiny day with the biggest solar irradiation value, the DC current intensity should be almost linear.

During winter, especially when it snows, the solar irradiation is usually very low. As an important consequence, the storage battery cannot be charged enough during one day and it is not able to supply the necessary amount of electricity that the cooling thermoelectric modules require.

Therefore, as an independent system, this cooler cannot function some periods of time (day or even more days). In order to start working, a supplementary energy source is needed or an oversize of the photovoltaic system - panels.

As regarding the efficiency of the cooling hybrid system in the idling case, it can be used both as cooler and freezer. The inside temperature of the system allows it to work as a cooler and refrigerator (by ensuring the proper temperature to store

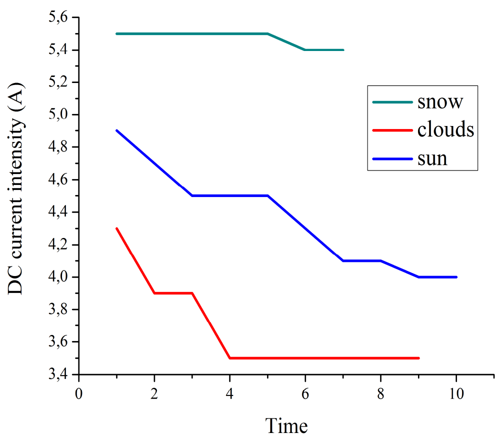

Fig. 4. *Variation of the DC current in time*

Temperature dropped down from almost 25°C at the beginning to -3°C in few hours of idling (fig. 5). The lowest temperature of -3°C was registered in multiple experiments that took place. This confirmed that we are not talking about a random situation and it could happen as long as the need of electric energy is stored into batteries. But the solar thermoelectric cooler was tested for other temperatures, too; but these times, the value did not decrease so much (fig. 6). The purpose was to see if the refrigerating temperature for preserving food in rated conditions can and is achieved [15].

If it is wanted that this hybrid system to be used only as a refrigerator, a temperature sensor must be mounted inside the cooling room. Its role it would be to transmit when to start and stop the solar thermoelectric cooler.

3. Conclusions

The experiments of idling, realized in all types of winter weather conditions – snow, clouds and sun – demonstrated that the cooling hybrid system that consists of a solar thermoelectric cooler can function as a refrigerator and even as a freezer. For a better control of the temperature, in the future, temperature sensors can be mounted inside the cooling room.

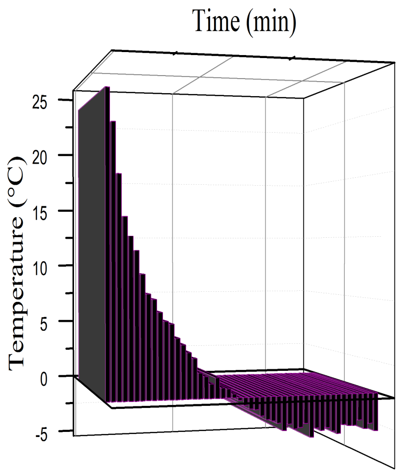

Fig. 5. *Temperature variation in time (with negative values)*

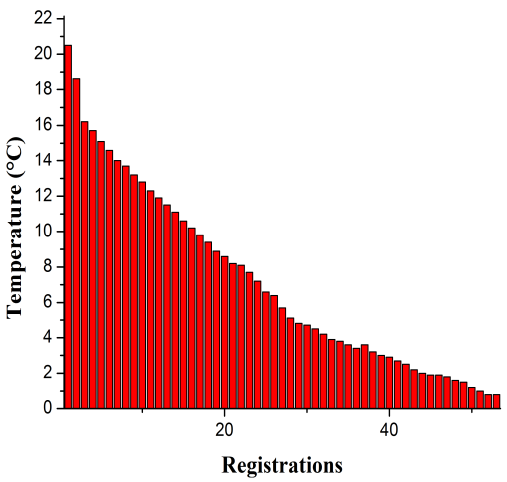

Fig. 6. *Temperature for refrigeration*

They will be helpful to establish a better temperature variation field and certainly, they will also lead to the improvement of the efficiency of the hybrid cooler.

The analysis of the recorded data showed the solar thermoelectric cooler cannot work every time is snowing. Usually, the solar irradiation has too small values and they do not afford the storage of the entire necessary amount of electric energy required by the thermoelectric modules. Extra electric energy sources are needed in the system.

The cooling hybrid system presented in this study is a very good start for a new generation of refrigerating equipment based only on renewable energy sources. It is true it is not extremely performant, but with improvements, it could become a serious contra-candidate to the already existing cooling devices (especially for those who use only the off-grid electric systems).

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