THE USE OF A HYBRID SYSTEM FOR COOLING ROOT PARSLEY

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Abstract

The use of renewable energies is a global trend in our days. The purpose is to protect the environment by reducing the energy coming by the primary sources. In this international context, it is interesting to see if some of the household appliances can be adjusted to these requirements. For this purpose, a solar thermo-electric refrigerator was realized. The hybrid system was used to preserve vegetables – root parsley by choice. An important aspect that has to be taken into consideration is that the experiment took place during winter, when the solar irradiation was extremely low – it was reached a maximum value of 80 W/m^2. This influenced the behaviour of the hybrid refrigerator in a negative way. But with all these, the analysis of the experimental results shows that the solar thermo-electric hybrid cooler can be used instead of the conventional refrigerator that we have in our homes for keeping root parsley in normal rated conditions (0˚C - 1˚C).

Key words: solar thermo-electric refrigerator, solar irradiation, root parsley, temperature, preservation

INTRODUCTION

All over the world, people are trying to replace the energy coming from the primary sources with the one obtained from renewable sources – sun, wind, water, etc. The simplest way is to use only one type of the renewable energies. But things become more interesting when more renewable sources are mixed resulting hybrid systems. This is the case of a solar thermo-electric refrigerator. It links the photovoltaic PV system (which delivers electrical energy) with the cooling thermo-electric (TEC) modules – that realize the heat transfer between two environments, based on the pass of the electrical energy.

By making an excursion into the scientific literature, we could see that this type of equipment knew a considerable development in the last decades. Even though such kind of hybrid systems can be used in different applications, they are still in the research stage (Abdul-Wahab S.A. et al., 2009, Xi H. et al., 2007, Mare R., 2011, 2012a,b, Cristea A. and Mare R., 2012, Mare R. and Rus T., 2013). One of the most important fields of interest in which a solar thermo-electric cooler can be used is refrigeration in respect to preserving food products. Some researchers like Abdul-Wahab et al., Mare and Cristea, Mare and Rus, already conceived different experimental versions of such a complex hybrid system. But no such product was yet produced in series for trade market. During their experiments, they cooled liquids, meat and carrots in various quantities. No one specifies anything about more types of vegetables. In respect to this and to environment protection, the present study emphasis the behaviour of the solar thermo-electric cooler in the case of preserving root parsley in winter conditions and the possibility of replacing the conventional refrigerator with the new one (based on renewable energies only).

MATERIAL AND METHOD

Wishing to protect more the environment by using only renewable sources, a solar thermo-electric hybrid cooler was realized and used during the experiment instead of a conventional refrigerator that we all have at home. The new refrigerator was made of cooling thermo-electric modules that transferred the heat from the cooling room (in which the root parsley was stocked) to the cooling agent – water. In this way, the classical refrigerant that could harm the environment was eliminated from the system. The entire cooling process was fulfilled at the pass of the electrical energy given by the photovoltaic panel – as it can be seen in figure 1. So, the electrical energy coming from the national delivery network (which almost entirely comes from the primary energy sources) was replaced with the energy given by the Sun or by the clouds from the sky that reflects the light.

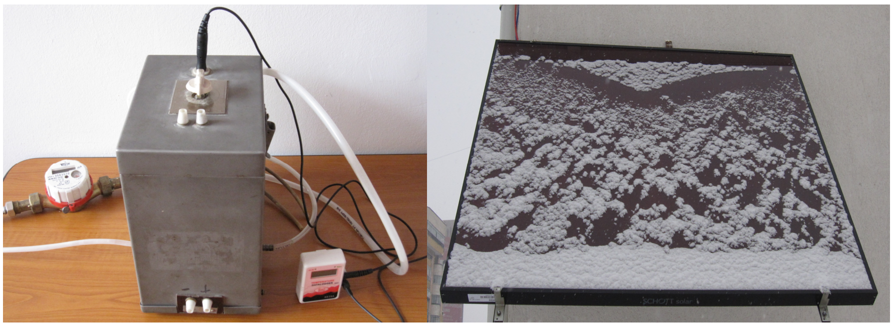

Fig. 1 The experimental solar thermo-electric hybrid system

The solar irradiation was monitored with a pyrometer. The entire electrical energy given by the photovoltaic (PV) panel was stored in a "deep-cycle" gel battery and then delivered to the thermo-electric refrigerator. Because the measurements were made in winter conditions and the PV panel was partially covered with snow, the fluctuations introduced in the system were pursued and reduced by a charge controller.

The inner temperature of the cooling room of the refrigerator and of the root parsley, too, was registered with a temperature data logger and laser infrared thermometer.

The registered values of the variation of temperature of the root parsley were analysed with specialized programs and in the end, compared to the normal rated values in order to determine if the solar thermo-electric hybrid system can be used for preserving vegetables.

RESULTS AND DISSCUSIONS

The independent values registered by the temperature data logger show a variation of the temperature of the root parsley between 16.2˚C (at the beginning of the experiment) and 0.8˚C (at the end of it) (see fig. 2). According to the Government Resolution no. 1279, the rated temperature for preserving the root parsley is between 0˚C and 1˚C. By reaching the final temperature of 0.8˚C, the parsley can be kept in the solar thermo-electric cooler in good and healthy conditions.

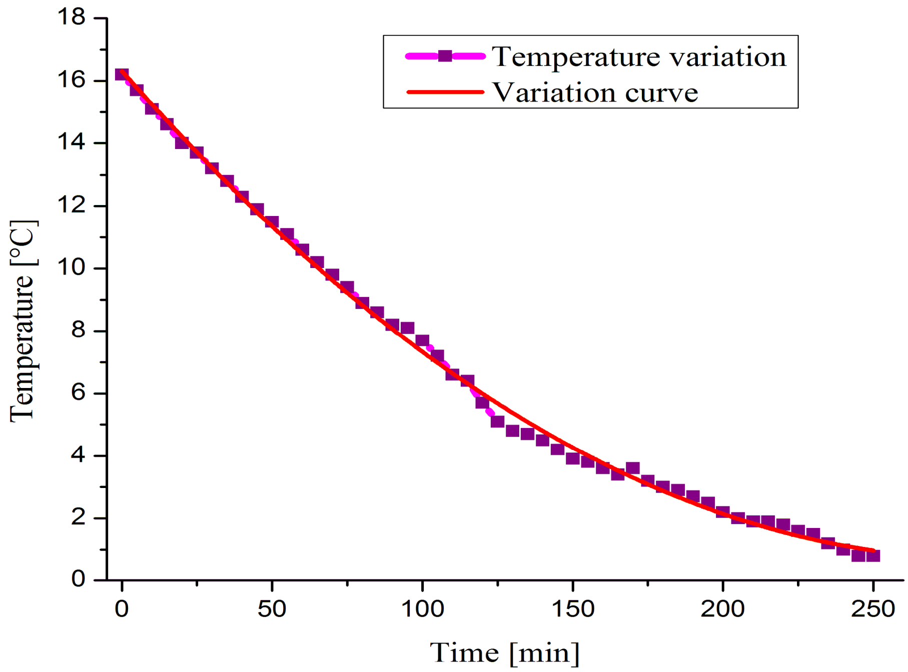

Fig. 2 Temperature variation in time

Besides the punctual values, a variation curve of the temperature was made to highlight the difference between the variation during the experiment and how it should be in theory. In the first part of the cooling period of time, the temperature decreased constantly. At the point of around 8˚C, in the middle of the experiment, the temperature of the root parsley started to register the most pronounced fluctuations from the variation curve (comparing to the extreme working parts). This aspect is very well pointed by figure 3 which presents the residuals of the temperature's variation according to the curve.

In the last part of the experiment, the decrease of the temperature was extremely low, even though the time was almost equal to the first part.

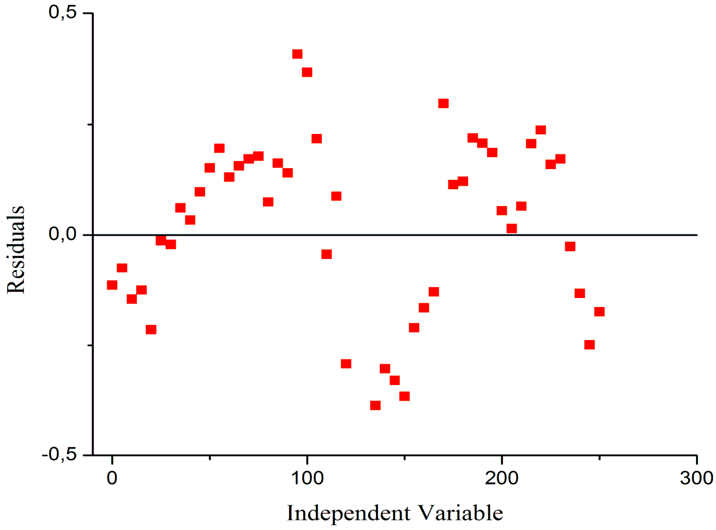

Fig. 3 Residuals for the cooling process

While in the first half of the cooling period of time the temperature dropped with more than 11˚C, in the last one, the decrease was of only 4˚C. Responsible for this are the bad weather conditions – snow – that led to an extremely low solar irradiation. The maximum value of 80W/m^2 was registered for a short period of time. The mean of the solar irradiation was of 37W/m^2, but in the last part of the experiment, the value of the solar irradiation dropped under 20W/m^2, reaching even 1W/m^2 at the end of the experiment. These low values could not ensure a sufficient charging rate of the storage battery. The discharging rate of the battery being higher, it led to the impossibility of the battery to sustain the operation in normal conditions of the thermo-electric cooler. As a result, the temperature of the root parsley had the same value for more registrations.

The experiment was stopped at the minimum temperature of 0.8˚C because the charging level of the battery was too low and the most important aim of the study was achieved, too. It has been demonstrated that the root parsley can be well preserved by using a hybrid cooling system based only on renewable energies.

It is interesting to make a parallel between the results obtained in this study and the ones from the experiment of Mare and Rus (2013). Even if both experiments were driven with the same hybrid cooling system in bad weather conditions and the composition of the root parsley is close to that of carrots, the results obtained differed. In the case of carrots, the temperature couldn't be dropped in the rated interval of preservation.

CONCLUSIONS

This study assesses that the solar thermo-electric cooling systems are environmentally friendly equipment. They can replace with success the traditional refrigerators used in our day life. By adopting this type of hybrid cooler, only renewable energies are used and the pollutant factors are totally eliminated.

Even though a series of experiments were made in the field of solar thermo-electric refrigeration, many problems and issues still expect their answers. And we have demonstrated here that the same hybrid device can present different behaviour in close working conditions – bad weather and same loading – vegetables from the same family. But with all these, in this experiment, the root parsley reached the temperature of 0.8˚C which ranges in the rated interval of good and healthy conservation of vegetables. In other words, the root parsley can be eaten by people after preserving it in the solar thermo-electric refrigerator.

In order to develop a very performant cooling hybrid system based exclusively on renewable energy sources, further experiments must be taken. Undoubtedly, the results will offer important responses to the yet unsolved mysteries.

REFERENCES

1. Abdullah M.O., Ngui J.L., Hamid K.A., Leo S.L. and Tie S.H., 2009, Cooling Performance of a Combined Solar Thermoelectric-Adsorption Cooling System: An Experimental Study, Energy Fuels 23 (11), pp. 5677-5683
2. Abdul-Wahab S.A., Elkamel A., Al-Damkhi A.M., Al-Habsi I.A., Al-Rubai'ey' H.S., Al-Battashi A.K., Al-Tamimi A.R., Al-Mamari K.H. and Chutani M.U., 2009, Design and experimental investigation of portable solar thermoelectric refrigerator, Renewable Energy 34, pp. 30-34
3. Buiga A., Dragoş C., Lazăr D., Mare C. and Parpucea I., 2010, Statistică descriptivă. Curs Domuța C., 2009, Irigațiile în Câmpia Crişurilor, Editura Universității din Oradea, pp. 50-120
4. Cristea A. and Mare R., 2012, Environment protection by using a solar thermo-electric refrigerator for cooling milk and meat, Bulletin USAMV Cluj-Napoca 69(2), pp. 152-159
5. Hotărâre nr.1279 din 17.11.2008 cu privire la aprobarea Reglementării tehnice „Ambalarea,transportarea şi depozitarea fructelor, legumelor şi ciupercilor proaspete", Republica Moldova
6. Kim D.S. and Ferreira I., 2008, Solar refrigeration options – a state-of–the-art review, Int. J. of Refrig. 31, pp. 3-15

7. Le Pierres N., Cosnier M., Luo L., and Fraisse G., 2008, Coupling of thermoelectric modules with a photovoltaic panel for air pre-heating and pre-cooling application; an annual simulation, Int. J. of Energy Res. 32, pp. 1316-1328
8. Mare R. and Rus T., 2013, The analysis of temperature variation and efficiency of an experimental thermo-electric – photovoltaic system when cooling carrots, Bulletin of the TUB 6(55) – series 1, pp.261-266
9. Mare R., 2011, Inside temperature variation of a TE refrigerator electricity network-driven versus PV supply, Math. Model. in Civil Eng. 7(4), pp. 141-148
10. Mare R., 2012a, The behaviour of a solar thermo-electric refrigerator in the case of cooling milk, Math. Model. in Civil Eng. 8(4), pp. 125-132
11. Mare R., 2012b, Theoretical and experimental contributions to the interconnection of the photovoltaic and thermo-electric cooling systems, PhD. Thesis
12. Xi H., Luo L. and Fraisse G., 2007, Development and applications of solar-based thermoelectric technologies, Renew. and Sust. Energy Rev. 11(5), pp. 923-936