INVESTIGATIONS OF AIR SOLAR COLLECTOR EFFICIENCY

Aivars Aboltins, **Janis Palabinskis**, **Aigars Lauva**, **Guntis Rušķis**
Latvia University of Agriculture
Aivars.Aboltins@inbox.lv, Janis.Palabinskis@llu.lv; Aigars.Lauva@inbox.lv

Abstract. In 2005 in the research laboratory equipment for experimental research into the materials of solar air collectors was built for research purposes. The construction of the equipment allows simultaneous comparative studies of materials and types. The experimental data are metered and recorded in the electronic equipment REG. Covered material polystyrol with absorbers steel-tinplate and black colored wood was researched in relation to others and location at different places of absorber. The ambient air worming degree at a stationary and sun following air collector with an equal coating surface and absorbers is compared. The air heating degree ΔT in the solar collector is dependent on solar radiation I, air velocity v, type and place of absorbers. In the experimental equipment, with dimensions 10x50x100 cm , the air got hot to ΔT = 6 °C in stationary positions with steel-thin plate and sun following position it rose to ΔT = 10 °C at the velocity v = 0.55 m/s. On the supposition that the heating degree of air in the collector is linear dependent on sun radiation, expressions of this relation with different absorber materials of the sun following collector are found.

Key words: sun radiation, air temperature, polystyrol.

Introduction

The sun is the most powerful heat generator, which neither of the heat sources created by mankind can compete with. Yearly the earth is reached by the solar energy 15000 times more than the power industry of the whole world can produce. It means that only a tiny part of solar energy is being used for the sake of mankind.

Nowadays more attention has been paid to environmental protection thus ways how to use alternative energy are being explored more widely. Therefore, research into the usage of solar energy is going on and extending.

Sun, that alternative energy source more and more widely is used in national economics. One of the simplest using ways in practice is sun heating air collectors which are simple to make, cheap to exploit, ecologically friendly and widely used, particularly in agricultural production drying. Drying as well as all costs of its first treatment and storage depend upon equipment, the balance cost of buildings, power supply systems, the amount of the drying material and its moisture content, the level of cleanness and energy carrier's prices, which are rising.

Increase in the utilization of solar energy is closely connected with research into solar collectors. The necessary amount of heat for grain drying with active ventilation from July to September can be obtained by making use of solar radiation. In Latvia at midday in this period of time the average solar radiation power on the horizontal surface is more than 600 W/m^2. The air heated this way is not toxic and electrically neutral.

The research work of air solar collectors started more that ten years ago at the Latvian Agricultural University by prof. E. Berzins [1, 2]. The investigations are direct for grain drying with solar collector heating air.

For investigations we made one a man movable solar collector [7] in 2007 and sun following collector in 2008.

The efficiency of the solar collector depends on the collector covered material; absorber and its place in the collector, air velocity in the collector [4-6]. The main efficiency parameter of a solar collector is the air heating degree and we chose it as the criterion of efficiency.

Materials and methods

The aim of the research is to find the optimal technical solutions, utilized materials, operation parameters and power possibilities for a solar collector. In the laboratory 0.1x0.5x1.0 meters long two experimental solar collectors ware constructed for research into the properties of absorber materials. The covered material is a polystyrol plate. The keynote of the equipment is to conduct comparative studies of the utilized materials as absorbers for the solar collector and studies of efficiency of the stationary and sun following collector (Fig. 1).

Air velocity at all experiments was $v = 0.55$ m/s.

Fig. 1. **Stationary and sun following collectors in experiments**

Building material industry offers new materials whose applicability to solar collectors has not been studied. The collector has been built so that it can be easy to use in a laboratory setting. At this stage of experiments we compare different materials of absorbers (black coloured wood and black coloured steel-thin plate) and absorber (steel-thin plate) location in the collector. In both experimental equipments equal conditions for the experiment are ensured.

The experimental data are recorded by means of an electronic metering and recording equipment of temperature, radiation and lighting REG [3]. It is equipped with 16 temperature transducers and metering sensors of solar radiation and lighting. The reading time of the data can be programmed from 1 to 99 minutes (1 minute in our case). The recorded data are stored in the REG memory (there is place for 16 384 records) and in case of need it is transferred to a computer for archiving with further processing. For evaluation and analysis of the results software REG – 01 has been developed, which is meant for transfer to the computer and processing of the recorded data. The information is stored in the form of a table and in case of need it is depicted as a graph.

Results and discussion

We can distinguish two parts of the investigation: the first comparing absorber materials and their location in the collector, the second – comparing the air heating degree of stationary and sun following collectors.

In the experiments, the collector covered material was polystyrol plate. This material has gained immense popularity due to such properties as fire safety, mechanical crashworthiness, translucence and high UV radiation stability. It is easy to bend polystyrol plates and they do not need previous treatment.

We took black coloured wood and one side coloured steel-thin plate as absorbers**.** We also investigated the situation when the absorber (steel-thin plate) is put in the middle of the collector (Fig. 2.).

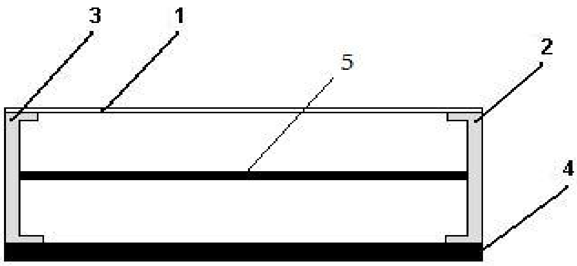

Fig. 2. **Schema of solar collector frontal view:** 1 – covered material (polystyrol); 2, 3 – side surface /plastic/; 4 – floor of collector; 5 – absorber (steel-thin plate)

At first we compared the temperature growth in stationary solar collectors with absorber (steel-thin plate) situated at the bottom (Fig. 3) and middle of the collector (Fig. 4). The experimental results show, that the heating degree in the collector with the steel-thin plate in the middle is more (up to two times) that in the collector with the absorber at bottom. The temperature difference in the exit reaches up to 6 degrees with sun radiation 1000 W/m^2.

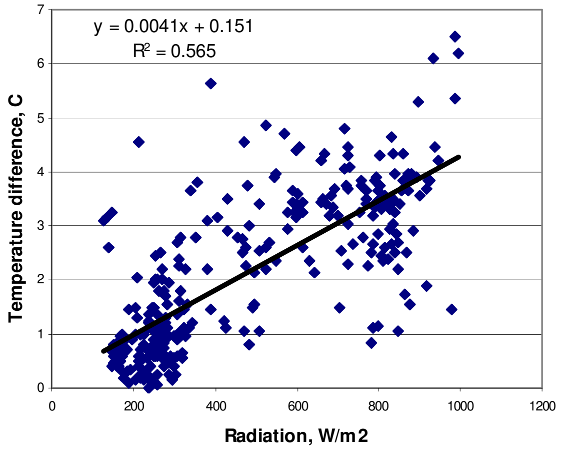

Fig. 3. **Air heating temperature difference Δ*T* of black colored steel-thin plate (*at bottom*) absorber depending upon solar radiation at air velocity *v* = 0.55 m/s**

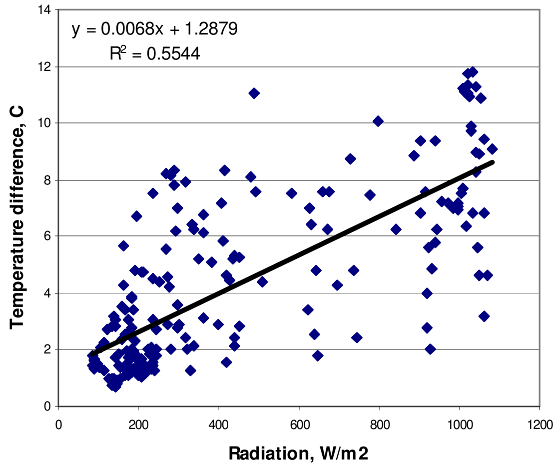

Fig. 4. **Air heating temperature difference Δ*T* of black colored steel-thin plate *(in middle)* absorber depending upon solar radiation at air velocity *v* = 0.55 m/s**

Secondly we compared the efficiency of the sun following collector and stationary collector. The sun following collector guarantees perpendicular location of the plane of the absorber to the flow of sun radiation.

The experimental data show, that the sun following collector is more efficient than the stationary collector with similar absorbent and location of absorbent (see Fig. 5, Fig. 6).

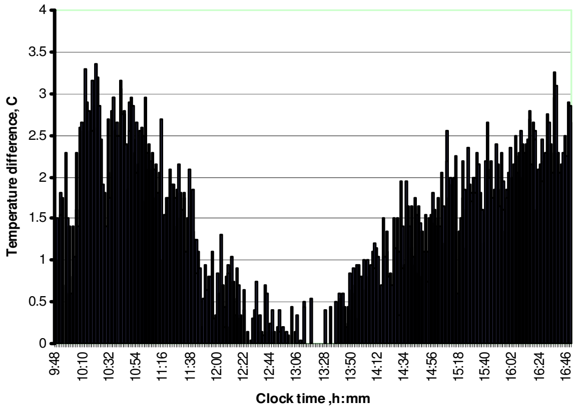

Fig. 5. **Air heating temperature difference of sun following and stationary collector at clock time with absorber steel-thin plate (*at bottom*)**

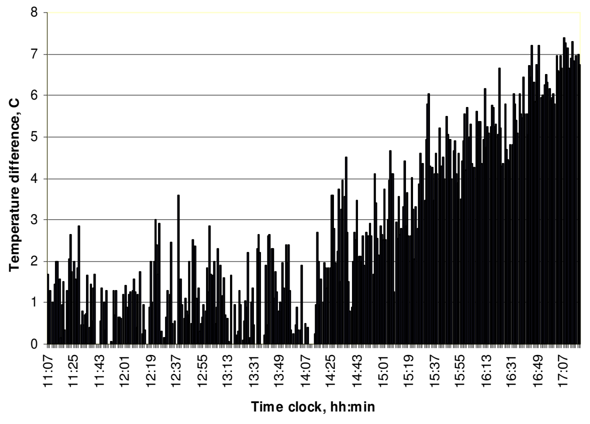

Fig. 6. **Air heating temperature difference of sun following and stationary collector at clock time with absorber steel-thin plate (*in middle*)**

If you compare sun following collectors with different absorbents and their locations you see that the best absorber is the black coloured steel-thin plate, located in the middle of the collector (Fig. 7-9).

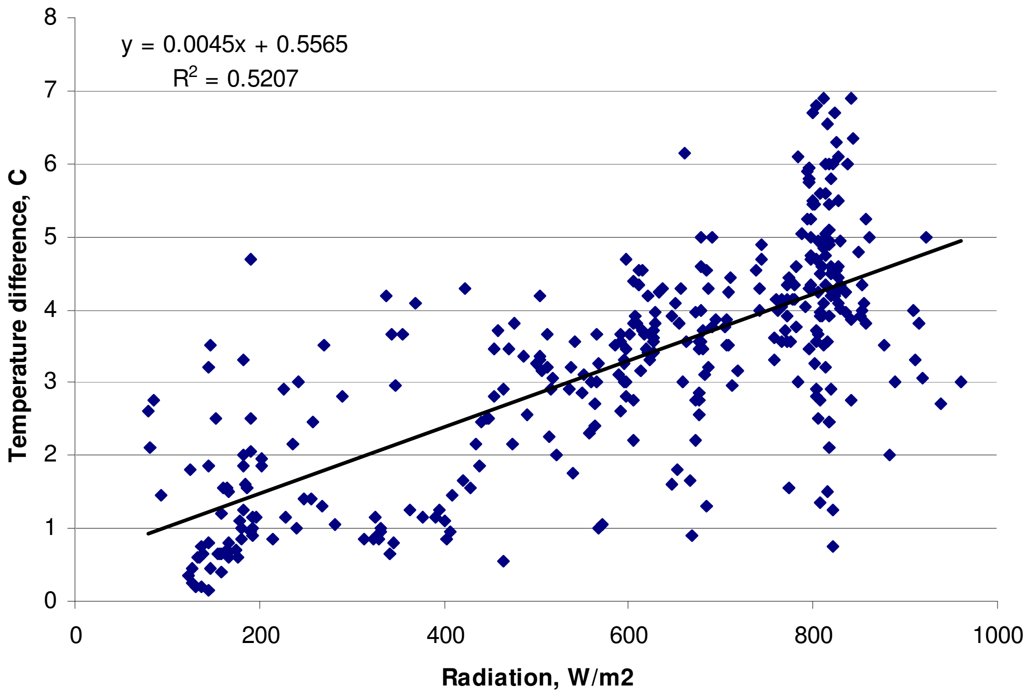

Fig. 7. **Air heating temperature difference with black coloured wood absorber depending upon solar radiation in sun following collector**

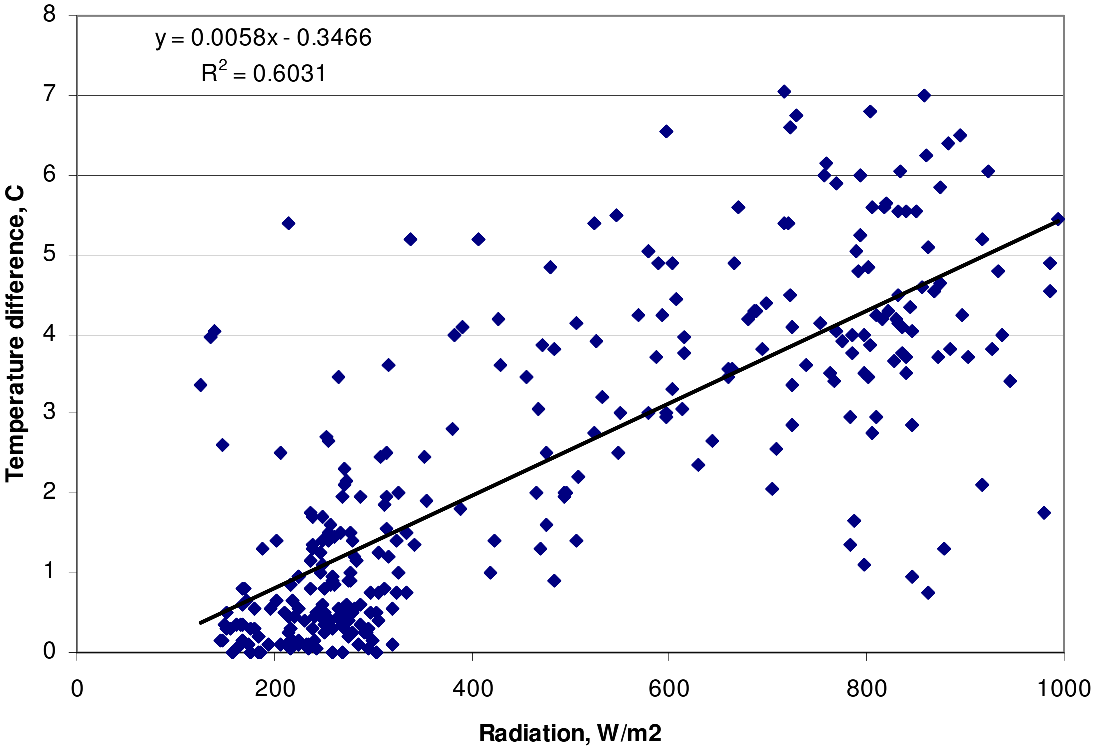

Fig. 8. **Air heating temperature difference with black coloured steel-thin plate (*at bottom*) absorber depending upon solar radiation in sun following collector**

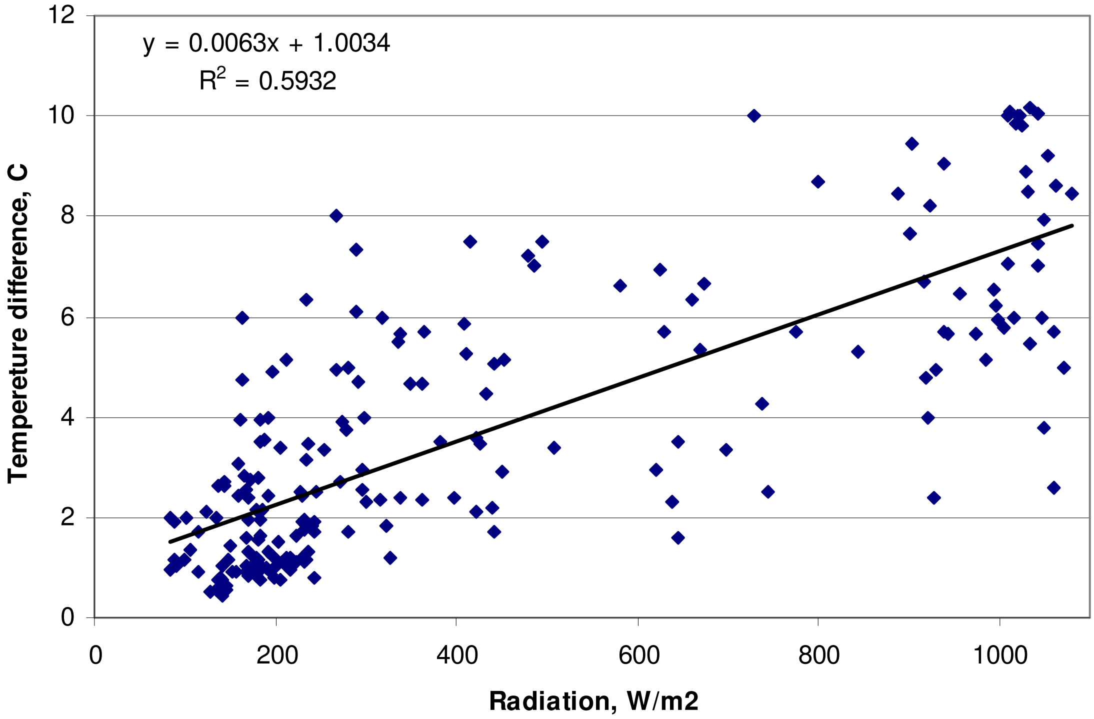

Fig. 9. **Air heating temperature difference with black coloured steel-thin plate (*in middle*) absorber depending upon solar radiation in sun following collector**

Certainly, the air temperature growth in the collector depends on the climatic conditions (wind, clouds, ambient air temperature etc), covered and absorber materials of the collector and its cleaning. The sun following collector's efficiency (air temperature growth) is close depending on sun radiation. The plate of this collector is at all times situated perpendicular to the flow of sun radiation.

At working time the flow of sun radiation changes the angle to the plate of the stationary collector and it has an effect on air temperature growing. Fig. 3, 4 show that at midday, when sun following and stationary collector plates are direct in similar direction difference of the heating degree is near to zero.

Conclusions

1. The most effective absorber is steel-tinplate at the middle of the collector for stationary and sun following collectors. For stationary collectors with a steel-tinplate absorber in the middle temperature grows up to 5 degrees more than when this absorber is situated at bottom.
2. Comparing the sun following and stationary collector temperature heating degree for the sun following collector it is 3 degrees higher (with sun radiation 1000 W/m2) than stationary with a colored wood or steel-tinplate absorber at bottom.
3. Comparing analytical expressions of temperature difference and radiation (Fig. 6-8) for sun following collectors with different absorbers, it is obvious, that a more larger proportionality coefficient (coefficient of temperature growth) is 0.0063 (steel-tinplate absorber in the middle) but the lowest 0.0045 (black colored wood absorber)
4. The research results demonstrate a close correlation between the air heating degree ΔT and the solar radiation at various absorbers and their location. This expression corresponds to absorbent area 0.5 m^2 with correlation $r \in (0.72\,;0.77)$.
5. Air solar collectors due to their physical and mechanical properties are suitable to be used in Latvia for agricultural purposes. At favorable weather conditions the heating degree of ambient air reaches 10 degrees with the absorber area 0.5 m^2 and air velocity v = 0.55 m/s.

References

1. Bērziņš, E., Immermanis, E., Lukevics, E.. Gaisa uzsildes saules kolektora maketa izmēģināšanas rezultāti. (The results of investigations of model of air solar collector) LLU Raksti, (1998), Nr 16 (293), 54-57.(in Latvian)
2. Эгилс Иммэрманис, Эдвинс Берзиньш. Результаты исследования солнечного воздухонагревательного коллектора. (The results of investigations of model of air solar collector) LŽŪ Universiteto mokslo darbai (2000), 5(1), стр. 175 -182 (in Russian)
3. REG 2004 *Tehniskais apraksts un lietošanas pamācība* (Technical description and using instruction), 11 pp. (in Latvian).
4. A.Lauva, A. Aboltins, J. Palabinskis, N. Karpova-Sadigova *Comparative studies of the solar material collector* //Proceedings of the 5th International Scientific Conference "Engineering for Rural Development "18-19 May (2006) – Jelgava, p.90-94 (ISSN 1691-3043)
5. A.Aboltins, J.Palabinskis, A.Lauva, J.Skujans, U.Iljins *The material investigations of solar collector* // Proceedings of the 6th International Scientific Conference "Engineering for Rural Development " 24-25 May (2007) – Jelgava, 18-23 pp
6. J. Palabinskis, A. Lauva, A. Āboltiņš, N. Karpova-Sadigova. *Movable Air Solar Collector and its Efficiency.* 7th International Scientific Conference „ Engineering for Rural Development", Jelgava, Latvia, 29-30 May, (2008), p 51 - 56.
7. J. Palabinskis, A. Aboltins, A. Lauva, N. Karpova-Sadigova. *The comparative material investigations of solar collector*. Proceedings of the Agronomy Research. Volume 6 „Engineering of Agricultural Technologies. Special Issue, Kaunas, Lithuania, 17.–20. 09. (2008,) P. 255 - 261.