ANALYZE OF METEOROLOGICAL DATA FOR DEVELOPMENT OF SOLAR COLLECTORS

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Abstract. In practice different sort of solar collectors for domestic water heating are used. More widely spread is flat plate solar collectors. Their efficiency does not exceed 40%, but they are cheaper and simpler in exploitation. The device for measuring the temperature, relative humidity and intensity of solar radiation on two surfaces, perpendicular to solar rays and kept at any angle to the horizon has been developed. By means of this device during the summer months of 2005 and 2006 the four parameters have been measured, gathered into the memory of a computer and analyzed.

Key words: solar radiation, radiation intensity, collectors, development.

Introduction

Large variety of solar collectors are invented and implemented in practice. For domestic water heating among them so called flat plate solar collectors more widely are used [1-7]. They are cheaper and simpler by construction in comparison with other ones. Flat plate collectors usually are provided with absorbers made of metal plate (steel, copper) and tube-shape heat exchangers. Absorbers made like thin box, metal plate with inside canals for the circulation of heat transfer medium, vacuum tube absorbers of different construction are also known. The efficiency of flat plate solar collectors with metal plate absorbers in practice usually does not exceed 40%. Many attempts by the scientists of different countries are made to increase this value [2-4]. There are several directions where the scientists are working in order to improve the efficiency of solar collectors. One of them is to increase the absorption ability of flat plate collector absorbers. Another direction is to provide the collector with a device for tracking the sun [9]. It means that all the day round solar rays are striking the working surface of the collector perpendicularly. This method improves the heat yield of solar collector, but at the same time it makes the collector device more expensive. In order to increase the intensity of solar radiation striking the absorber, it is possible to provide the collector with reflectors (mirrors), directing the falling on them solar radiation to the absorber from its rear surface. This also increases the price of the device.

The objective of the research was to investigate the increase in heat yield, if the collector is tracking the sun, and to base the purposefulness of providing the collector device with additional equipment for keeping the surface of the collector perpendicular to the sun beams all the day round.

Materials and Methods

In order to state the difference in radiation intensity on the surface of a collector stationary placed at certain angle to the horizon, and the intensity of radiation striking the collector surface placed perpendicularly to the solar beams, a special device MD-4 has been developed Fig. 1 [8]. The device was provided with sensors for measuring the air temperature and its relative humidity, and two pyranometer thermo batteries for measuring the intensity of solar radiation. Thus by the device it is possible to measure and fix in the memory of a computer the intensity of solar radiation on a surface perpendicular to the sun beams, and on a surface located at any angle to the horizon, as well as measure and fix the air temperature and relative humidity. The acquisition of these parameters has been started during summer months (July and August) in 2004 and continued in (April-October) 2005 [10] and (March-September) 2006.

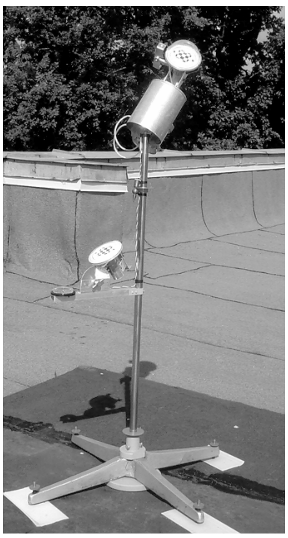

Fig. 1. **Meteorological data acquisition device MD-4**

The device MD-4 on the roof of a house at Ulbroka (Riga region) has been placed. Data measuring was performed in every 12-15 minutes.

From the data storage device HOBO H08-007 modulus, which was connected to the device MD-4, by means of the program “BoxCar” the data were transformed into the memory of a computer and further by the program *Microsoft Excel* processed and analyzed.

Results and discussion

There large amount of information has been obtained, and a careful analyze of the results has been made. As an example the value of air temperature, relative humidity and intensity of solar radiation on 17 March 2006 in Fig. 2 are presented.

The summary of these data obtained during May 2005 and 2006, for example, in Fig. 3 and Fig. 4 is given.

From the data analyze it follows that in 2006 tracking the sun thermo battery had registered considerably more heat energy in May, June, July and September, but less than in April, August and October in comparison with 2005. Remarkably bigger amount of energy this battery has gathered in July – 316 kWh·m^{-2}. It is by 19% more than in 2005.

The stationary working thermo battery in May, June and August of 2006 had gathered approximately the same amount of energy than in 2005. By 53% less heat energy both thermo batteries have gathered in May and October 2006 in comparison with the same time of 2005.

From the data analyzes it is stated that rather big amount of heat energy is registered in March, April and September.

It means that using updated solar collectors it is possible to produce hot water from March till including September.

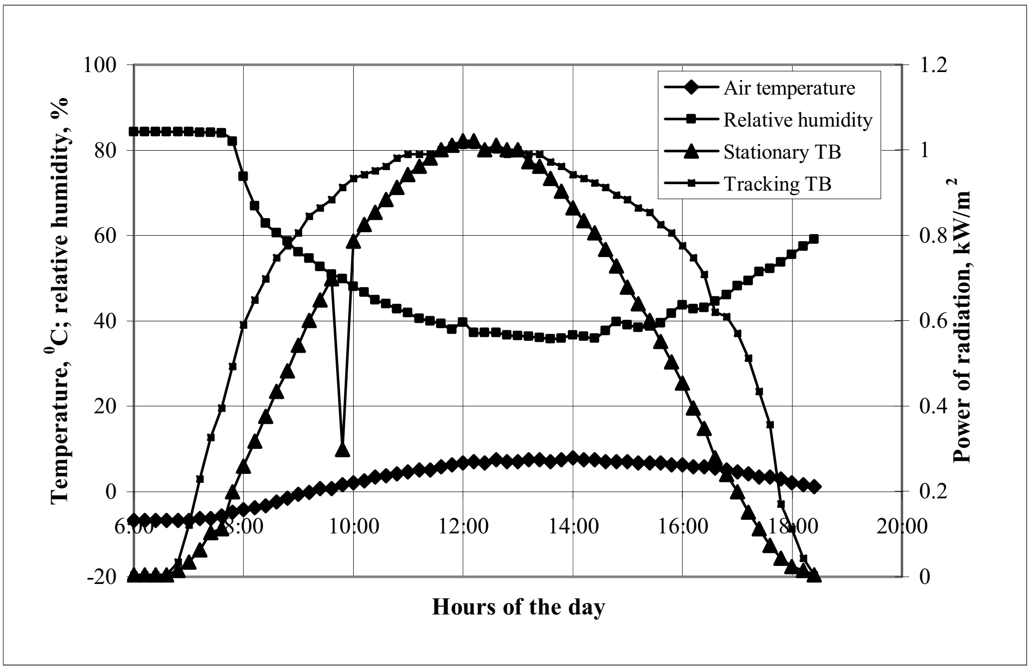

Fig. 2. **Air temperature, relative humidity and intensity of solar radiation on 17 March 2006 at Ulbroka** (Riga region)

Maximal air temperature 35.7 ^{o}C in 2006 has been registered on 8 and 9 July at 15^{12} and 13^{24} p.m., but the lowest one on 8 March (-21 ^{o}C) at 5^{00} a.m.

In 2006 in comparison with 2005 lower air temperature has been in April and May, but higher from June till November. There is no coherence between the air temperature and obtained amount of heat energy.

Thus in July 2006 the average registered air temperature was by 1.9 ^{o}C higher than in 2005, but amount of energy obtained by both thermo batteries – tracking the sun and stationary places has been bigger by 10.3% and 19.2% accordingly.

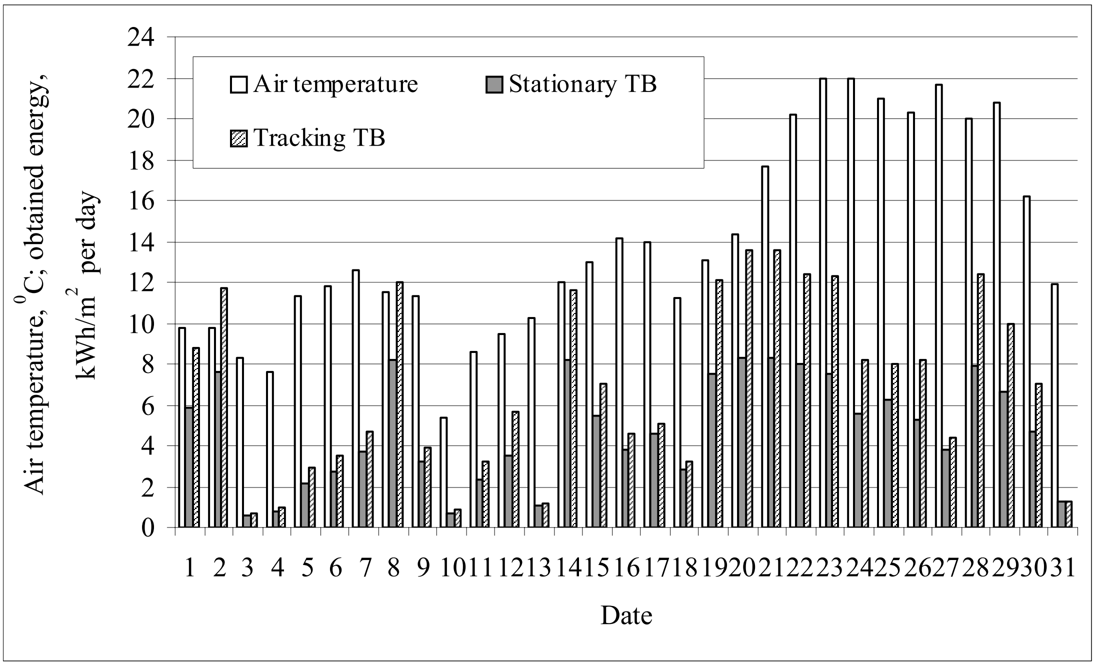

Fig. 3. **Air temperature and intensity of solar radiation on the surfaces tracking the sun and placed stationary at optimal angle to the horizon during May 2005**

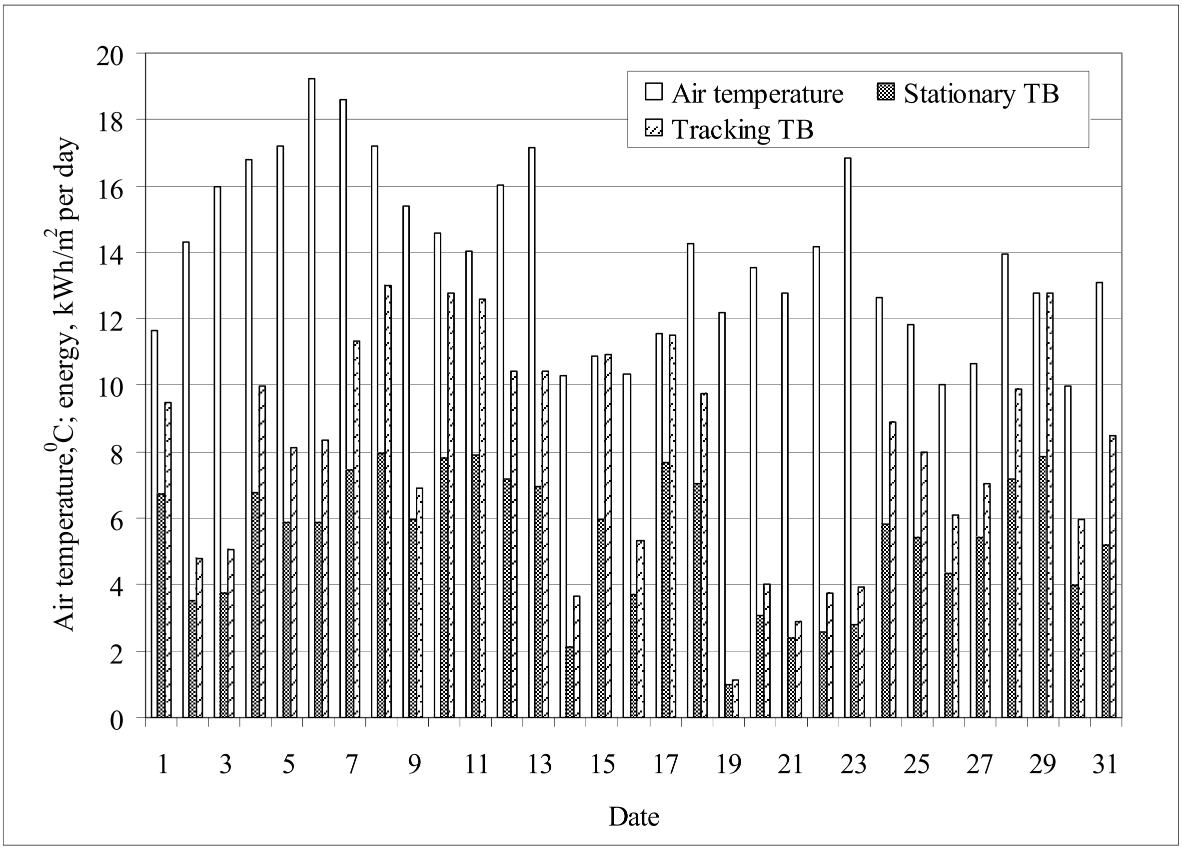

Fig. 4. **The air temperature and intensity of solar radiation on the surfaces tracking the sun and placed stationary at optimal angle to the horizon during May 2006**

On the other hand in August 2006 when the air temperature has been by 1.3 ^{o}C higher than in 2005, the obtained amounts of energy are smaller by 2.2% and 7.9% accordingly (Table 1).

Table 1. **Amount of energy registered by stationary Q_{st} and tracking the sun Q_{tr} thermo batteries, global Q_{gl} energy and average temperature T_{av} at Ulbroka from 1 March till 1 December 2005 and 2006, kWh/m²**

Month	Q_{st}		Q_{tr}		Q_{gl}	T_{av}, °C	
	2005	2006	2005	2006		2005	2006
March	0	127	0	157	79	-	-1.47
April	140	124	188	167	120	8.9	8.0
May	170	167	227	247	170	14.0	13.8
June	185	183	256	287	206	18.1	18.7
July	185	204	265	316	192	21.5	23.2
August	137	134	202	186	146	18.6	19.9
September	117	135	159	175	87	15.7	16.7
October	98	52	117	62	43	9.3	10.8
November	22	0	26	0	15.4	4.0	-
Total, kWh/m²	1054	1126	1440	1597	1058.4		

In Table 2 the comparison of registered amount of energy by months and total during years 2005 and 2006 is given. As it is seen, in 2006 the stationary located thermo battery has registered by 3.2% less energy than in 2005, but tracking the sun thermo battery, by 1.8% more than in 2005.

Table 2. **Comparison of amount of registered at Ulbroka energy in 2005 and 2006 by months, kWh/m²**

Month	Q_{st}		Q_{tr}		Q_{gl}
	2005	2006	2005	2006	
April	140	124	188	167	120
May	170	167	227	247	170
June	185	183	256	287	206
July	185	204	265	316	192
August	137	134	202	186	146
September	117	135	159	175	87
October	98	52	117	62	43
Total, kWh/m²	1032	999	1414	1440	964

From Table 1 and Table 2 it follows that the biggest difference in the amount of obtained energy between separate months is 53%, but smaller, during the period of investigation (3.2%).

The number of days with the same amount of obtained heat energy has been calculated for 2006 from March till November (245 days) and results presented in Table 3.

Table 3. **Distribution of the days measured in 2006 by the equal amount of energy obtained during a day by stationary located thermo battery Q_{st}, and tracking the sun Q_{tr} from 1 March till 1 November (245 days), kWh/m² at Ulbroka**

	Right boundary of the interval, kWh/m² per day													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Q_{st}	18	32	22	30	21	31	49	36	6	0	0	0	0	0
Q_{tr}	15	27	16	20	16	25	13	13	28	17	17	16	15	7

The value of one interval equal to 1 kWh/m² per day has been chosen. *Microsoft Excel* program all 245 days has divided as follows: days of stationary working thermo battery are divided into 9 intervals, but tracking the sun, into 14 ones. It means that maximum amount of energy registered by stationary working thermo battery does not exceed 9 kWh/m² per day, but tracking the sun, 14 kWh/m² per day. The number of days with amount of obtained energy within intervals from 8 to 9 kWh/m² per day and from 13 to 14 kWh/m² per day, is 6 and 7 accordingly. During the biggest number of days, 49 the stationary working thermo battery has registered energy from 6 to 7 kWh/m² per day.

Tracking the sun thermo battery during 28 days has registered amount of energy equal to 8 and 9 kWh/m^2 per day. During 72 days within the interval from 10 to 14 kWh/m^2 per day the amount of energy measured by tracking the sun thermo battery is higher as maximum of energy obtained by stationary working thermo battery.

In total during 2006 tracking the sun thermo battery of the device MD-4 has registered by 44% more heat energy that stationary located. It indicates that the development of the structure of tracking the sun solar collector has to be continued.

Conclusions

1. The obtained amount of heat energy does not depend on surrounding air temperature.
2. In 2006 the amount of obtained by thermo battery tracking the sun heat energy has been by 44% higher than obtained by stationary located one.
3. There in Latvia it is possible to use solar collectors for water heating at least from April till including September.

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