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Investigations of Solar Collector's in Latvian Conditions

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Abstract. Outdoor air temperature range in the Baltic region is below average values in Europe. Range of outdoor air temperature in the Baltic region is -3 ºC in winter and +16 ºC in summer. And solar radiation intensity is lower in comparison with the average European values. The average solar radiation intensity reaches 1100 kWh/m2 per year in Baltic region. Therefore, there is a particular need to optimize the solar thermal system in the Baltic region.

Solar collector's operation methods investigated on the IPE solar energy polygon according different parameters. The most common types of solar collector's operation were investigated and compared: by the time, by the heat carrier temperature differences of input and output, by the solar radiation intensity and operation control methods in various combinations.

Theoretical and practical advantages and disadvantages of using each control methods were analyzed. Solar collector's operation system could be regulated in accordance with the solar radiation intensity, by the boiler lower temperatures and by the outdoor air temperature to determine precisely the solar collector efficiency of the parameter changes. This may help to avoid the previous operation systems testing regime deficiencies.

The precision of solar collectors operation depends on the type of operation systems: heat losses and the collector efficiency calculation accuracy, the sensor is accuracy, the time between the regulation regimes, and the range of heat carrier pumps action operation sensors.

Currently, companies that offer solar collectors, offer solar collectors complete set with all necessary equipments for the solar collector connection for hot water supply system, or for home heating operation system by the temperature difference of input and output. And no one of them does not offer solar collectors operation systems by the various parameters.

Key words

Solar energy, solar collectors, operation methods, efficiently increasing.

1. Introduction

On the IPE solar energy polygon investigated solar collectors control methods according different parameters. Were investigated and compared the most common types of solar collector's types. There were analyzed theoretical and practical advantages and disadvantages of using each control methods.

Currently, a large number of companies that offer solar collectors, one-third of them offer solar collector complete set with all necessary equipments to the solar collector connection for hot water supply systems, or home heating. Only a few of them offered two or three solar collector operating control modes, where many differences are in the heat carrier pumps action operating range. And not one of them nor offers solar collectors control systems by the various parameters.

2. Methods and Results

A. The operation methods of solar collectors

The solar collector control systems are designed for solar collector circulation pump control according changing weather conditions.

1) Operation by time

Apart from the manual operation system the weakest solar collector's operation system is the operation system by time. Usually equipments of the operation systems are primitive and those could not used for individual program for each day, therefore one program is used for all days of the solar collector's operation time.

Thereby the fact that the weekly average value of solar radiation varies, and changes the sun sunshine hours, then it is not possible fully use the obtaining solar energy in sunny days and fully use the solar collectors operation time of spring and autumn periods, in this time the heat storage tank will be more cooled than heated.

Consequently this solar collector operation type is not widely used anymore.

If only there had been possible to determine operation program for each day there biggest disadvantage would be connected with systems disability to appoint weather conditions and amount of energy from collector workplace and respectively to adapt for it. Therefore in cloudy and rainy days the action of solar collectors would cool accumulation tank.

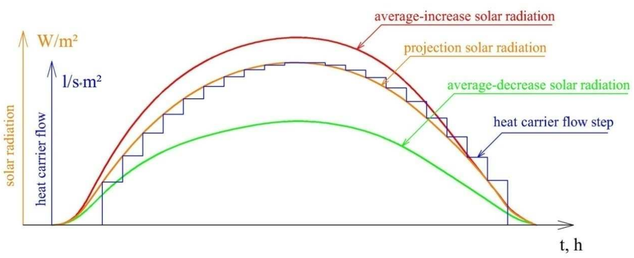

Fig. 1. Heating schedule that shows how the heat depends on the activity of all daily average solar radiation value, and potential of solar radiation deviation.

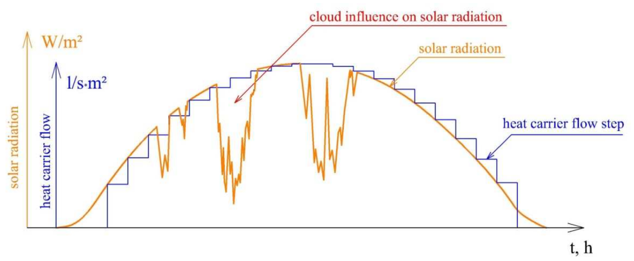

Fig. 2. Heating schedule that shows how the heat depends on the activity of each day average solar radiation value, and potential of solar radiation deviation of cloud activities.

2) The operation of solar collector according to input and output temperature or output and input temperature of accumulation tank

The operation of solar collector according to temperature difference is needed two sensor of temperature. One is for input temperature measuring, but another for output. If the temperature sources store near solar collector the difference of temperature will be gotten. And if we know heatcarrier flow we will determine the energy which was produced by solar collector. But if temperature source will store very close to heat-exchanging apparatus will be gotten the energy which was produced by solar collector also included energy produced by solar collector pipes heat losses between heat –exchanging apparatus and solar collector. This technique is suitable for continuous heatcarrier flow.

To operate the systems at a temperature difference of one temperature source is positioned in the solar collector warmer point. If there is no such place the temperature source is stored at the gate of solar collector. This technique helps to determine the temperature of heatcarrier in solar collector even in stationary phase. The second temperature recourse is necessary to place in water accumulation tank – output pipe of heatcarrier. The pump is activated through a relay, which provided necessary temperature difference. Unfortunately, (in this way) by the operation of solar collectors we won't count the heat loss flow conduits between the accumulating tank and solar collectors. Only the minimum temperature differences between the adopted dependence of pipeline length, usually it is from 1 to 8 K.

Turn on according to condition:

$$(T2 - T1) + a, [K] \tag{1}$$

a - coefficient, which depends on the pipe lengths (3 ÷ 8).

Knockout temperature:

$$(T2 - T1) + b, [K] \tag{2}$$

b - coefficient, which depends on the pipe lengths (1 ÷ 6).

After switching the temperature must be above the exit temperature of not less than one degree:

$$a > b, \tag{3}$$

and

$$a - b \geq 1, [K] \tag{4}$$

Otherwise the low temperature changing the heat pumps are often turning on and off. This facility will promote accelerated aging and measuring inaccuracies due to thermal inertia.

Third temperature sensor may be placed in the water heat accumulated tank top point, which will signal about accumulation tank overheating. In the event of overheating is necessary to eliminate solar collector circulation pump operation, which will stop temperature increases in accumulation tank.

But the temperature of the solar collectors will rise sharply. Studies show that, the Latvian region of stationary phase the temperature in some solar collectors in the sunniest days can climb to 180º C. Solar collectors can withstand at the maximum temperature, solar collector can withstand from 300º C until 600º C, depending on the collector type and brand. Consequently solar collectors in the Baltic Sea region are not at risk of overheating.

Even in our climate may be a transient temperature rise above 160º C more profitable to use the temperature sensor with high thermal resistance. For example, the PT100 or PT1000 platinum temperature sensors, working from -200º C to 850º C range.

Management determines the temperature difference between the instantaneous system performance benefits and the opportunity to adjust the solar collector operation; the system allows getting the instantaneous maximum efficiency.

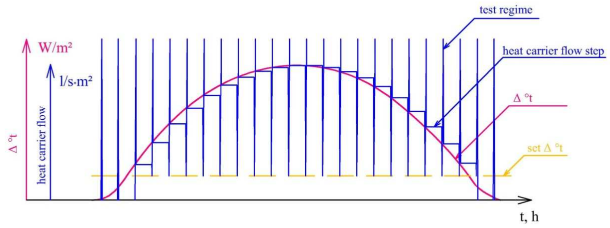

Fig. 3. Heat schedule that shows flow varies depends on temperature difference, including test regimes.

The main energy loss will be in all test period (beginning at each step), the productivity will be tested at different flow rates.

3) The heat flow rate

To obtain maximum effectiveness is necessary to provide the optimum heat flow rate. The speed decrease of heat flow increase heat losses in pipes for each cubic meter of the heat, especially between the solar collector and the accumulating tank. But with increasing flow rate, decreases efficiency of heat exchanger and coolant flow will go with high temperatures which will promote increased energy loss.

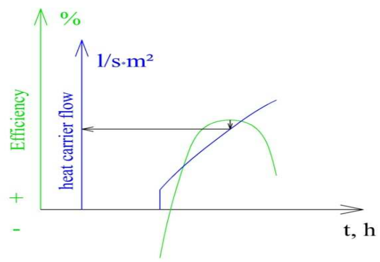

Fig. 4. Heating schedule shows the principle of automation control, depending on the heating temperature difference.

At too small or too large flow rates of heat loss may even be greater than the absorbed solar energy collector amount. Particularly large losses, in the testing regime, will be near insufficient weather parameters of productivity, when all flow rates of heat productivity will be negative.

At that time will be spent the energy from the accumulation tank to the testing regime. But, while too little testing arrangements may be insufficiently precise look after weather changes and work with the lowest productivity, not as capable. Therefore, the testing regime and associated with a number of heat loss, as well as deviations from the operating system requires the operating mode is the main weaknesses of theses operation type.

4) Operation by solar radiation intensity

Very rarely, only on special order, the solar collectors is guided by the heat source - solar radiation intensity.

The operation of solar collector by solar radiation intensity and accumulation tank button temperature.

You can adjust the management of the solar collector solar radiation intensity, the lower boiler temperatures and outdoor air temperature if determine precisely where the solar collector efficiency of the parameter changes. To calculate the size required for the flow to increase accuracy and increase reliability estimates would be useful to supplement the system with the flow and return temperature sensors.

If the heat capacity of the substance in the formula:

$$q = c*m*\Delta t, \tag{5}$$

where q - amount of energy, c - heat capacity of the substance, m - the mass, Δt - the temperature difference;

Distributed to the two parts of the formula over time:

$$\frac{q}{T} = \frac{c*m*\Delta t}{T}, \tag{6}$$

From there, the energy divided by time is power:

$$\frac{q}{T} = P, \tag{7}$$

And quantity of the substance divided by the time is flow:

$$\frac{m}{T} = Q, \tag{8}$$

We are getting:

$$Q = \frac{P}{c*\Delta t}, \tag{9}$$

Flow rate depends on:

$$Q = \frac{P_s*\eta_c - P_{c.h-l} - P_{p.h-l}}{c*\Delta t}, \tag{10}$$

P_s - solar radiation intensity, ηc - solar collector absorption efficiency, $P_{c.hl}$ - solar collector heat loss, $P_{p.hl}$ - piping heat losses;

Whence:

$$P_{c.h-l} = (t_c - t_a)* K_c, \tag{11}$$

K_c - solar collector heat loss coefficient, t_c - temperature in the solar collector, t_a-ambient temperature,

and

$$\Gamma_{p.h-l} = \sum_{i=1}^{n} \Gamma_{p.h-l.\,n} = \sum_{i=1}^{n} (t_n \quad t_a) K_{p.\,n} \tag{12}$$

t_n - given pipeline stage temperature (may be conditional or reversing flow temperature), $K_{P.\ n}$ - given pipeline stage heat loss coefficient.

In the end are getting heat loss coefficient of single stage:

$$K_p = \frac{l}{\sum R} = l/\left(\frac{1}{\pi*d_1*\alpha_1} + \sum_{i=1}^{k} \frac{1}{2*\pi*\lambda_k} * ln\frac{d_{k+1}}{d_k} + \frac{1}{\pi*d_2*\alpha_2}\right) \tag{13}$$

l - pipe length, ΣR - izolated pipeline full thermal resistance, d_1 - Inner diameter, α_1 - inner surface of the thermal conductivity coefficient, λ_k - given pipe layer heat conductivity coefficient, d_k - given the internal diameter of the pipe layer, d_{k+1} - given the pipeline layer of outer diameter, d_2 - insulation design surface diameter, α - thermal insulation design surface conductivity.

It can be avoided by pre-testing management systems deficiencies and the overall productivity of sunny days during the increase of approximately 9%.

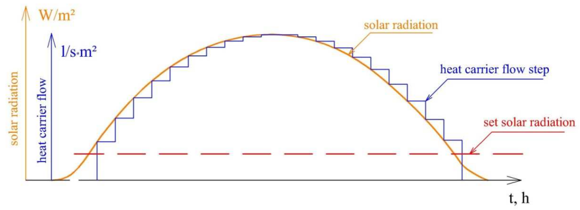

Fig. 5. Heat schedule that shows flow varies depends on solar radiation.

Solar collectors work accureancy will depend on: (not including heat loss and the collector yield calculation accuracy) of solar radiation meter accuracy, the time between the adjustment times, and like all previous forms of management, the productivity of the heat pump range.

Weaknesses: no data on the solar collector output for different values of the intensity of solar radiation and solar collector heat loss, heat loss calculation must be precise; solar radiation measuring instruments are expensive, fast erosium process, necessity of calibration every few years.

To get a solar collector yield at different values of the intensity of solar radiation and heat losses of solar collector needed to conduct the experiment. On the investigated IPE solar energy polygon are also subjected a series of experiments, the solar collector output for different values of the intensity of solar radiation and solar collector heat loss values.

4.1) PV like a solar radiation meter

Solar radiation meter accuracy should be similar to the heat pump operation control options. In less able to regulate the heat pump operation, the less can choose the intensity of solar radiation accuracy. Ex.: If the installed solar collector systems in the private home of one - two families, the solar collector operation can be controlled by a small solar panels productivity. But anyway it will be necessary to follow the solar technique condition and every five years spanned the solar system productivity. Therefore, during the time period of solar battery activity there will be the productivity decrease (an average one per cent per annum).

3. Conclusion

To get most effectively function of solar collector systems, it is certainly necessary for automation, which regulates a capacity according to various parameters. Automation accuracy depends on the complexity of the system. Than more efficient is the system itself, than more automation response to small environmental changes. By contrast, system complexity makes the system less protected from damages and increased it costs. If are used latest automated technology it getting possible accurately determined the solar collector system activation time and the required capacity without energy usage for the testing regimes. This is very important for regions with low solar radiation potential.

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