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OPERATING OF SOLAR COLLECTORS AT LOW EXTERNAL AIR TEMPERATURE

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ABSTRACT

The depletion of the fossil energy sources and the commonalty's growing power demand effect more interest in renewable energies. The applying of the renewable energy sources is very low for the capabilities. One of the reason is the unduly high prices of the equipments and thereby the very extended rate of return. In our research started at the University Of Szeged, College Faculty of Food Engineering we proposed the development of equipments wich have good efficiency and lower costs than the actually available models. At first we started to develop collectors that can be manufactured with low costs also in small series. We made four test collectors, which we carried out the comparative measurements with. These measurement allowed to examine the factors affecting the collectors' efficiency as well as to develop other type of collectors for different purposes. For the measurements we built an electronic measuring data collecting system. The data obtained justified our conceptions: the efficiency of our collectors reached, moreover, in spring and autumn may exceeds the efficiency of products, which are on the market, and the previously calculated price is the third of the price of them.

1. TYPES AND APPLICATIONS OF SOLAR COLLECTORS

The development of solar energy is possible with solar cells and solar collectors. The solar cells make electric power, the collectors make heat from the absorbed solar energy. The sorts of collectors by construction are flat and tube collectors. The flat collectors are cheaper and more simple, but the efficiency is less than vacuum tube collector's, especial in late autumn and early spring, when the external air temperature is lower. The cause is the vacuum-insulation of the absorber surface. For very high power there are some other types, e. g. concentrating collectors with mirrored parabolic surfaces. This types are used in powerplants.

As one of our goal was developing and manufacturing of collectors having low costs, but good efficiency and short rate of return we designed and measured flat collectors. Basically the flat collectors comprise a pipe system soldered to an absorber surface painted with a special solar coating, and a closed, insulated housing covered with a good light-admitting solar glass on the top side. The collector transfers the heat to the fluid circulated through the pipe system.

Usually the transferred heat used for service hot water heating, but with eligible development the system can be suitable for heating assistance. One of the effects determining the efficiency is the external air temperature. The less higher difference between external temperature and the absorber surface's temperature results more higher efficiency (fig. 5.), because the convective heat flux to the external air is directly proportional with this difference. According to it the collectors has to transfer the heat to the heating system on a limited temperature, therefore these can assist the low temperature heating systems (e. g. floor heating, wall heating).

2. THE EFFECTS DETERMINING THE EFFICIENCY OF THE COLLECTORS

It results from above that the insulation of the housing affects the efficiency widely. Our test collectors are different from the other current ones: we applied special polycarbonate cover instead of glass. This has much better insulating quality, so the collector is applicable in late autumn, unlike the other collectors.

The painting of the absorber surface can affect the efficiency greatly too. The most applied material is the selective solar coating which absorbs and reflects the radiated energy in different wavelength interval. These materials' exact formulas are secret, and the materials are not available. The professional literature includes inordinate datas about these coatings' efficiency-enhancement effect. Instead of selective coating we used solar lacquer coating. The effect of solar lacquer upon efficiency we compare with common mat black painting's (fig. 4.).

As we can indicate the efficiency is affected by the back surface of the absorber. The efficiency is higher if the back surface is bright, only the front surface is painted (fig. 2.).

3. TECHNOLOGICAL PROBLEMS

During the manufacturing one of the problems was the choosing of the right soldering method and solder for the joint of the pipe system and the absorber surface. The applied black solar lacquer needs to be dried in furnace. The soft soldering does not resist the drying temperature, so we have to apply brazing solder. It's disadvantage that the brazing solder is disposed to corrosion. We do not have observed corrosion yet.

During the design it is an important criterion to resist the temperature of the idle operation. If the system is out of service, the fluid does not circulate, the temperature and the pressure can be higher greatly. It is required to build in a safety pressure limiting valve for all types of collectors. For polycarbonate-covered collectors it is very important that the polycarbonate is less heat-proof then the glass, and the heat expansion is greater. These problems can be cleared with a safety heat exchanger, that transfers the needless heat to the air.

4. THE TEST COLLECTORS AND THE MEASURING SYSTEM

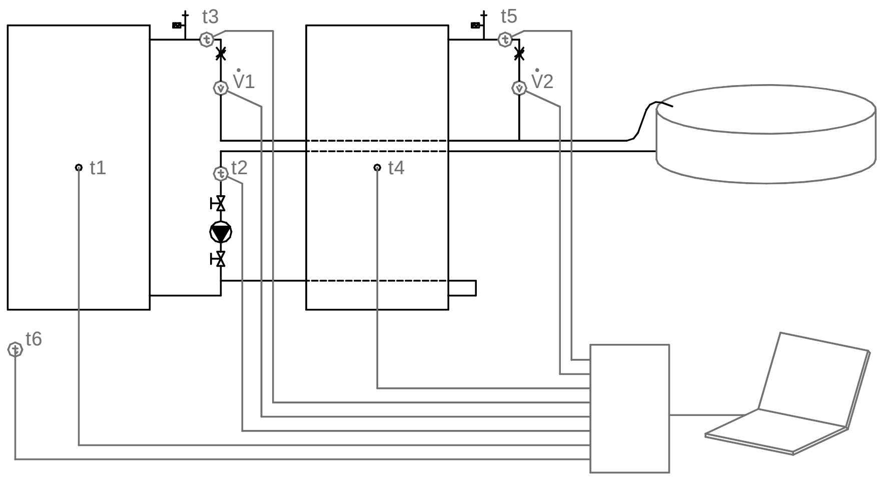

Fig. 1. The connection diagram
of the digital measuring system

For the measurements we made four collectors. We tested these in pairs, so we could measure the differences between the glass and the polycarbonate cover, the absorber coatings, the painted or bright back surface of the absorber. We accomplished measurements in different weather conditions, with PLC-controlled digital data collecting system. The loading of the collectors was the warming of a pool's water. For the efficiency calculating we used the solar radiation intensity diagrams located on www.naplopo.hu.

5. RESULTS

On the next figures we can see diurnal results of some summer measurements.

As we can see on the figure, in summer the glass cover effects higher efficiency, because the better insulating quality of the polycarbonate proceeds only in a less degree, and the transparency of glass is better than polycarbonate's. In autumn the correlation of the efficiencies is changed. We designed more collectors suitably for the different applications.

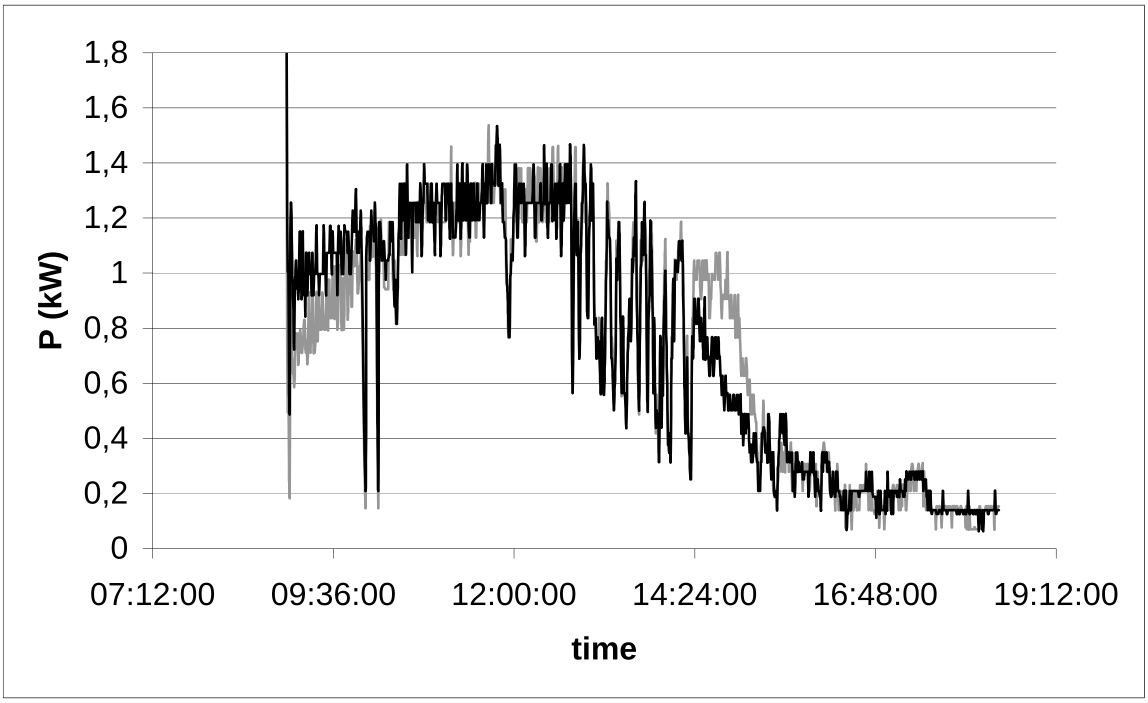

Fig. 2. Absorber with solar-lacquer-painted (black data line), and bright, non-painted back surface (grey data line)

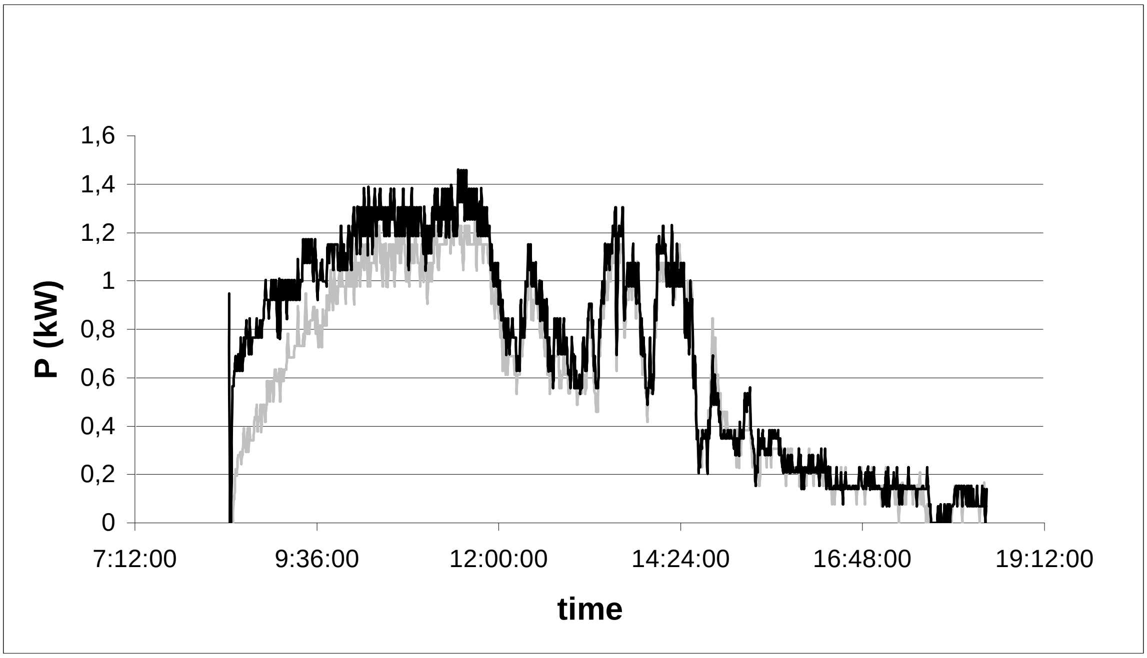

Fig. 3. Glass (black data line) and polycarbonate cover (grey data line), in summer

The efficiency at low external temperature is higher than the common flat collectors', therefore the operating period can be extended in spring and autumn. The growth of the convective losses and the low quantity of solar radiation does not enable the operating in winter.

The efficiency used to be drawed in function of the X-factor:

$$X = (T_m - T_k)/G_k\left[m^2K/W\right]$$

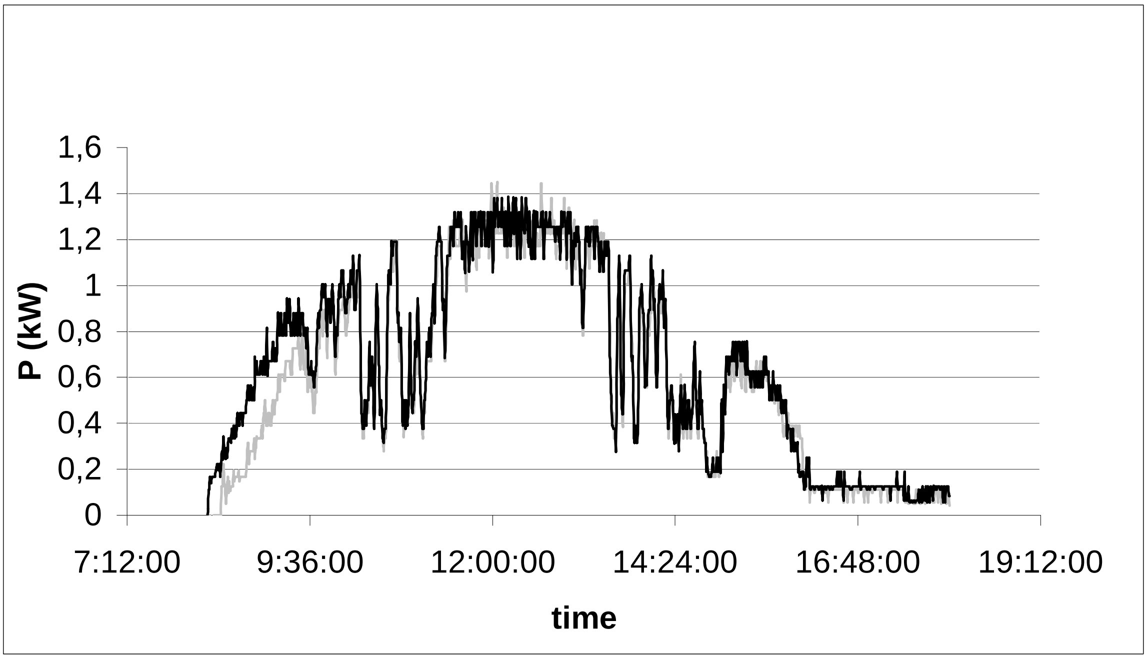

Fig. 4. Solar lacquer (black data line)
and Trinát black mat paint (grey data line)

The $(T_m - T_k)$ is the different between the temperature of the absorber surface and the external temperature, G_k the perpendicular solar radiation on the cover. The value of X is maximal in summer. The next diagram is the summary of the measurement results recorded in summer, autumn and winter. The diagram shows the efficiency of three different collector types in function of X:

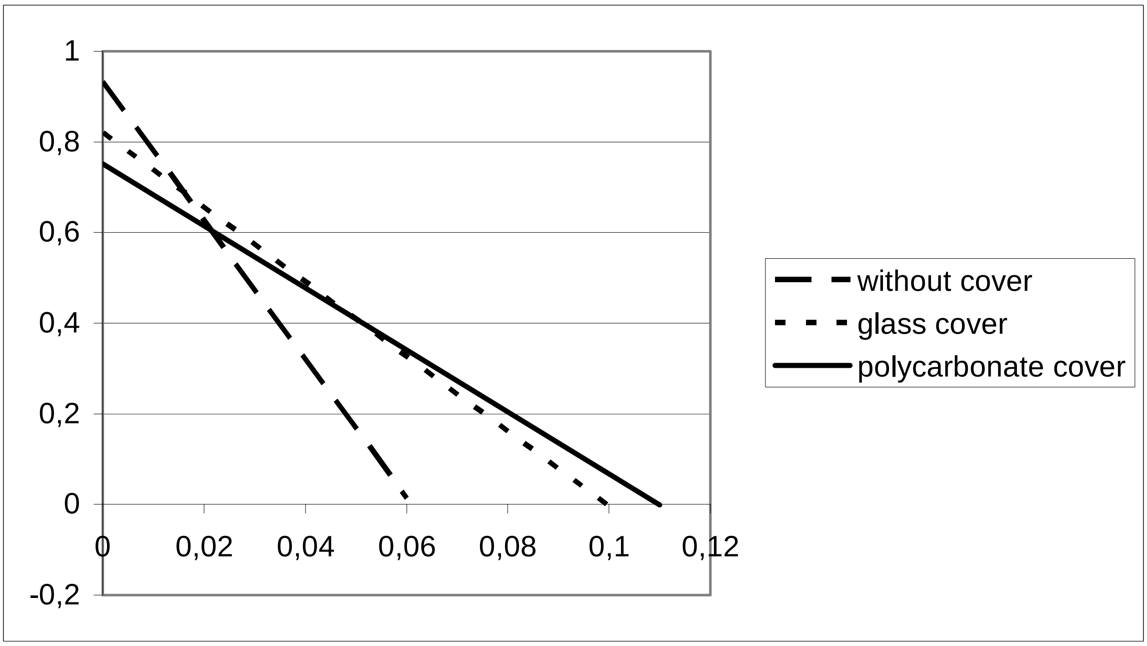

Fig. 5. Efficiency of three collector types in function of the ambient thermal step and the intensity of the solar radiation

SUMMARY

Accordingly our goals we managed to design flat collectors having short rate of return and good efficiency at lower external air temperature. The starting of the line production is in progress, we have orders for 200 m^2 of flat solar collectors ere now.

One of our further plans is the development of other collector types. We design devices for the utilization of the surplus power of the collectors in summer, and devices for the utilization of the other types of renewable energies, e. g. geothermal energy.