

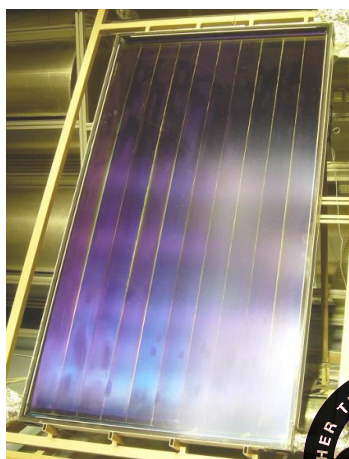
Tellus Functional Solar Test

Customer:



Savo-Solar Oy
Insinöörinkatu 7
FI-50100 Mikkeli

Target:



Solar collector SF100-03 made by Savo-Solar
Gross area 2.15 m² (2.05 m x 1.05 m)
Aperture area 2.00 m²
Absorber area 2.00 m²

The absorber is made of aluminium.



Testing time:

8th of September, 2011

The Purpose of the Test:

Measurement of the efficiency of the solar collector at the volume flow rate of 3.5 l/min.

Test Method:

Solar Radiation: 830 W/m²

Flow medium: water

Flow rate: 3.5 l/min (106 kg/h/m²)

Simulated wind: 0 m/s

Four different inlet temperature values with two to four measurements at each point in steady state conditions to determine the equation of the efficiency.

The absorber area instead of the gross area of the solar collector was used in calculating the efficiency. The test method is based on the standards ASHRAE 93-77 and EN 12975-2.



Validation of test method:

ASHRAE 93-77 and SFS-EN 12975-2 are suitable methods to measure the efficiency of solar collectors in various conditions. The effect of the flow rate to collector efficiency is made by measuring the efficiency curves of the solar collector at the given range of flow. The function of the efficiency curve is fitted using all relevant measurement points.

Performed actions:

Simulated radiation

The solar radiation was simulated with many metal halide lamps. This type of lamp is widely used to simulate solar radiation. The spectrum of the solar simulator and the AM2 spectrum in the wavelength range of 300 – 800 nm are in the figure. There are some characteristic peaks in the spectrum of the simulator lamps. These peaks have no significant effect in solar thermal testing.

On the right there is a figure of the energy distribution of the solar simulator.

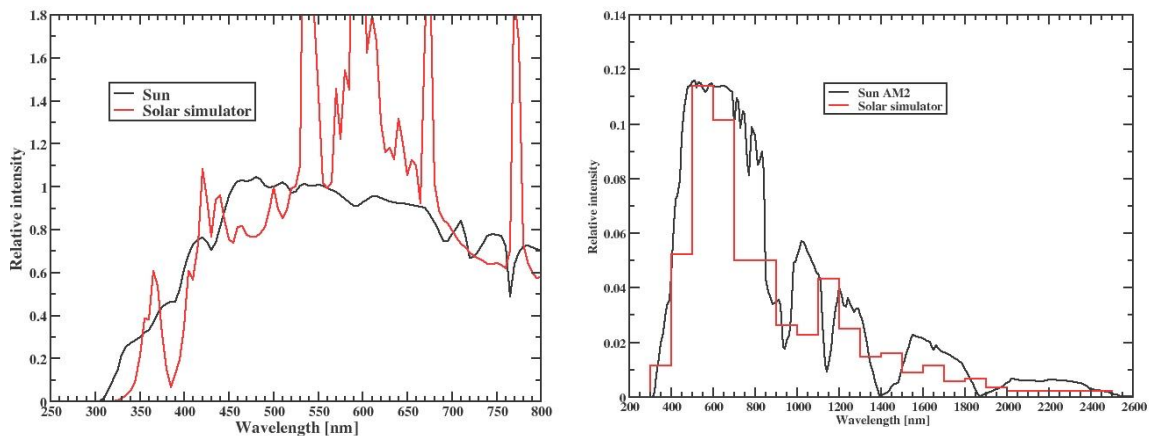


Table 1. The amounts of solar radiation, the radiation from the solar simulator and the allowed tolerances in the ranges of ultraviolet (UV), visible radiation and thermal radiation (IR). Total radiation 860 W/m²

	UV [W/m ²]	Visible [W/m ²]	IR [W/m ²]
Sun	54	430	376
Solar simulator	50	459	351
Allowed tolerances e.g. according to IEC 68-2-5 (1975)	± 30%	± 10%	± 20%

To control the long way IR-radiation incident to the solar collector the distance between solar simulator and solar collector was in this test 4.5 m.

Efficiency measurement at the volume flow of 3.5 l/min

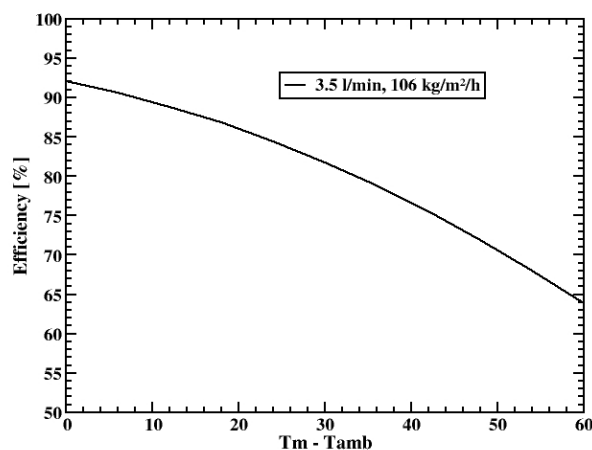
The mean over pressure during the efficiency test in the absorber pipes was calculated to be 30 kPa. The inlet of water was to the left connection in the collector when looking towards the collector. The tilt angle of the solar collector was 55°.

The absorber area of the solar collector used in the efficiency calculations was 2.00x0.997 m² which is 2.00 m². The incident perpendicular radiation intensity E onto the solar collector was measured from a 9x7 matrix to be 830 ± 60 W/m².

The efficiency of the solar collector was measured at four measurement points. The stability of the measurement point was checked by a five minute loop during which the inlet and outlet temperatures in the solar collector should stay stable. The absorber area is used in the efficiency calculations. The measurement results are tabulated. T_m is the mean of T_{in} and T_{out}.

R	Cp	V	T _{in}	T _{out}	T _{amb}	T _{out} -T _{in}	T _m -T _{amb}	(T _m -T _{amb})/E	η
0.9955	4179	3.52	27.38	33.54	25.82	6.16	4.65	0.0056	90.7
0.9954	4179	3.52	27.47	33.63	26.21	6.16	4.34	0.0052	90.8
0.9954	4179	3.52	27.49	33.64	26.19	6.16	4.38	0.0053	90.7
0.9954	4179	3.52	27.50	33.65	26.29	6.16	4.29	0.0052	90.7
0.9685	4204	3.60	83.45	87.78	26.48	4.33	59.14	0.0713	63.8
0.9685	4204	3.64	83.48	87.85	26.74	4.37	58.92	0.0710	65.1
0.9686	4204	3.68	83.39	87.70	26.93	4.30	58.62	0.0706	64.9
0.9686	4203	3.53	83.25	87.74	26.23	4.49	59.27	0.0714	64.8
0.9821	4186	3.56	59.45	64.78	26.35	5.33	35.77	0.0431	78.4
0.9821	4186	3.54	59.47	64.80	26.84	5.32	35.29	0.0425	77.9
0.9901	4181	3.36	42.12	48.44	27.46	6.32	17.82	0.0215	88.4
0.9903	4181	3.50	41.64	47.67	27.26	6.02	17.40	0.0210	87.8

The efficiency measurements were made in the order: ΔT=4°C, ΔT=59°C, ΔT=35°C and ΔT=17°C. Every measurements are made in steady state conditions.



The efficiency curve of the solar collector at the volume flow of 3.5 l/min is:

$$\eta = 92.0 - 0.213(T_m - T_{amb}) - 0.0043(T_m - T_{amb})^2$$

Used measuring equipment:

Solar simulator: No. 20

Solar radiation: Pyranometer No. 13, No. 25, calibrated 15th of June, 2011, calibration is valid

Temperatures: AD590, calibrated 7th of September, 2011, calibration is valid

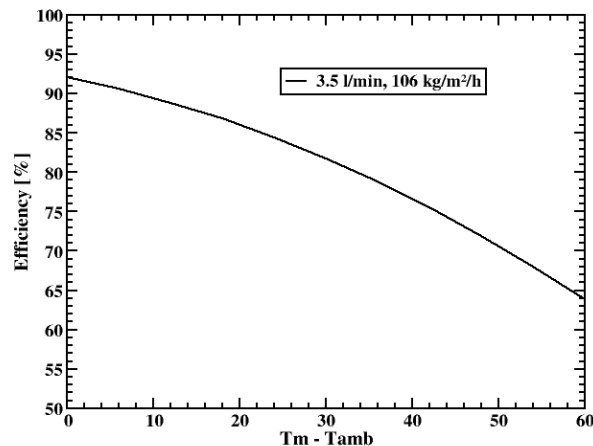
The accuracy of the efficiency measurement is $\pm 3\%$. To the measurement accuracy affects the accuracies in the measurements of temperatures, liquid volume flow, solar radiation and the amount of measurement points.

Conclusions:

The second order efficiency curve of the solar collector at the volume flow rates of 3.5 l/min is calculated using all the measurement results. The absorber area was used in the calculations of the efficiency values. The intensity of the solar radiation was 830 W/m².

The efficiency curve of the solar collector at the volume flow of 3.5 l/min is:

$$\eta = 92.0 - 0.213(T_m - T_{amb}) - 0.0043(T_m - T_{amb})^2$$



Remarks:

Actions, operations and reporting are in accordance with IEC/ISO 17025 'General requirements for the competence of testing laboratories'.

Document history: Original test report Savo-SolarPischow__tr060911HS.pdf

Signatures:

Littoinen, 1st of November, 2011



Timo Oksa

