Tellus Functional Solar Test

Customer:

Savo-Solar Oy
Insinöörinkatu 7
FI-50100 Mikkeli

Target:

Solar collector SF100-01 made by Savo-Solar
Gross area 2.15 m² (2.05 m x 1.05 m)
Aperture area 2.00 m²
Absorber area 1.98 m²

The absorber is made of copper.

Testing time:

26th and 27th of May, 2011

The Purpose of the Test:

Measurement of the efficiency of the solar collector at the volume flow rates of 2.6 l/min and 3.5 l/min.

Test Method:

Solar Radiation: > 800 W/m²
Flow medium: water
Flow rate: 2.6 l/min (78 kg/h/m²) and 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 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 EN 12975-2 are a 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.

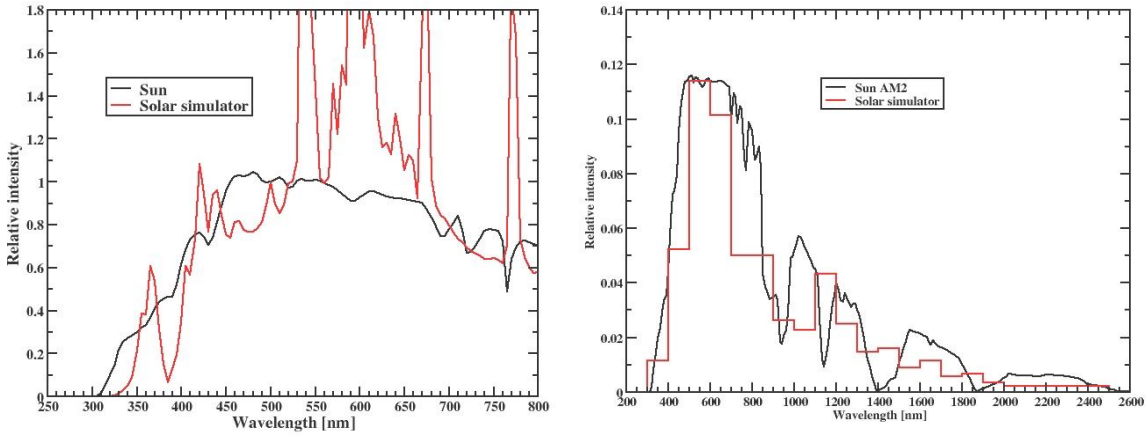


Table 1. The amounts of solar radiation, the radiation from the solar simulator and the allowed tolerances in the ranges of ultraviolet (UV), visible radiation and thermal radiation (IR). Total radiation 850 W/m²

	UV [W/m²]	Visible [W/m²]	IR [W/m²]
Sun	53	425	372
Solar simulator	49	454	347
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 2.6 l/min

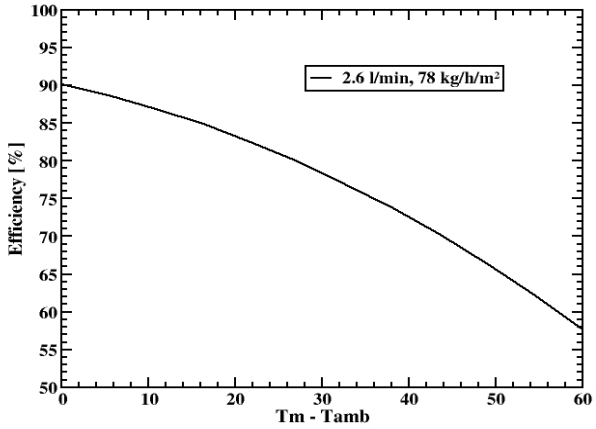
The mean over pressure during the efficiency test in the absorber pipes was calculated to be 30 kPa. The inlet of water was to the left connection in the collector when looking towards the collector. The tilt angle of the solar collector was 55°.

The absorber area of the solar collector used in the efficiency calculations was 2.00x0.99 m^2 which is 1.98 m^2. The incident perpendicular radiation intensity E onto the solar collector was measured from a 9x7 matrice to be 850 ± 75 W/m^2.

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. Tm is the mean of Tin and Tout.

R	Cp	V	Tin	Tout	Tamb	Tout-Tin	Tm-Tamb	(Tm-Tamb)/E	η
0.9967	4181	2.58	22.00	30.49	28.11	8.49	-1.86	-0.0022	90.4
0.9967	4181	2.58	22.02	30.46	28.18	8.45	-1.94	-0.0023	89.9
0.9967	4181	2.58	21.98	30.51	28.34	8.52	-2.09	-0.0025	90.7
0.9967	4181	2.55	21.89	30.54	28.30	8.65	-2.09	-0.0025	91.0
0.9682	4204	2.61	83.24	88.85	29.02	5.62	57.03	0.0671	59.1
0.9683	4204	2.80	83.23	88.60	29.01	5.37	56.90	0.0669	60.6
0.9683	4204	2.67	83.09	88.75	29.02	5.66	56.90	0.0669	61.0
0.9804	4188	2.60	61.38	68.51	29.06	7.13	35.89	0.0422	75.4
0.9805	4188	2.60	61.37	68.44	29.04	7.06	35.86	0.0422	74.7
0.9898	4181	2.48	41.93	50.20	28.71	8.27	17.35	0.0204	84.1
0.9897	4181	2.46	41.97	50.39	28.72	8.42	17.46	0.0205	84.8

The efficiency measurements were made in the order: ΔT=0°C, ΔT=57°C, ΔT=35°C and ΔT=17°C.



The efficiency curve is figured. The efficiency was calculated using the absorber area of the collector.

$$\eta = 90.1 - 0.236(T_m - T_{amb}) - 0.0051(T_m - T_{amb})^2$$

Efficiency measurement at the volume flow of 3.5 l/min

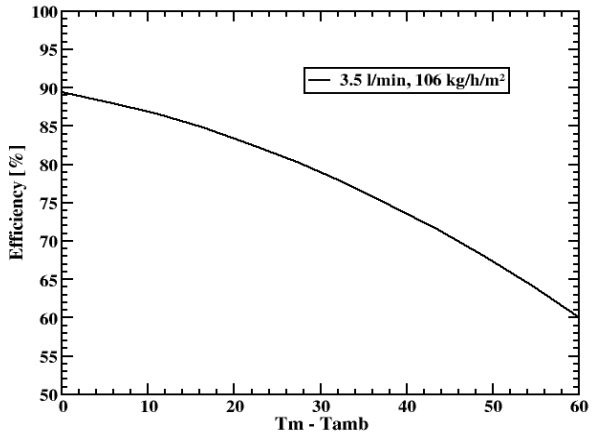
The mean over pressure during the efficiency test in the absorber pipes was calculated to be 30 kPa. The inlet of water was to the left connection in the collector when looking towards the collector. The tilt angle of the solar collector was 55°.

The absorber area of the solar collector used in the efficiency calculations was 2.00x0.99 m^2 which is 1.98 m^2. The incident perpendicular radiation intensity E onto the solar collector was measured from a 9x7 matrice to be 870 ± 80 W/m^2.

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. Tm is the mean of Tin and Tout.

R	Cp	V	Tin	Tout	Tamb	Tout-Tin	Tm-Tamb	(Tm-Tamb)/E	η
0.9975	4182	3.54	19.83	26.02	24.38	6.19	-1.45	-0.0017	90.5
0.9975	4182	3.54	19.79	25.94	25.58	6.15	-2.72	-0.0032	89.9
0.9975	4182	3.54	19.77	26.00	25.77	6.23	-2.89	-0.0033	89.1
0.9975	4182	3.54	19.78	26.08	25.95	6.31	-3.02	-0.0035	90.1
0.9667	4206	3.26	85.86	90.41	26.35	4.55	61.79	0.0710	58.3
0.9666	4206	3.23	85.90	90.50	26.43	4.60	61.77	0.0710	58.5
0.9667	4206	3.42	85.89	90.32	26.70	4.43	61.40	0.0706	59.6
0.9797	4189	3.46	63.46	68.85	27.08	5.39	39.08	0.0449	74.1
0.9797	4189	3.46	63.47	68.88	27.43	5.41	38.75	0.0445	74.3

The efficiency measurements were made in the order: ΔT=0°C, ΔT=61°C and ΔT=39°C. The efficiency curve is figured. The efficiency was calculated using the absorber area of the collector.



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

$$\eta = 89.4 - 0.206(T_m - T_{amb}) - 0.0047(T_m - T_{amb})^2$$

Used measuring equipment:
Solar simulator: No. 20
Solar radiation: Pyranometer No. 13, calibrated 11th of June, 2010, calibration is valid
Temperatures: AD590, calibrated 20th of May, 2011, calibration is valid

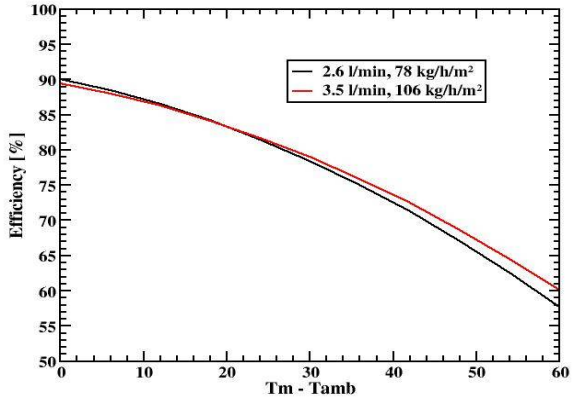
The accuracy of the efficiency measurement is ± 3 %. To the measurement accuracy affects the accuracies in the measurements of temperatures, liquid volume flow, solar radiation and the amount of measurement points.

Conclusions:

The second order efficiency curves of the solar collector at the volume flow rates of 2.6 l/min and 3.5 l/min were calculated using all the relevant measurement results. The absorber area was used in the calculations of the efficiency values.

The efficiency curve of the solar collector at the volume flow of 2.6 l/min is:
$\eta = 90.1 - 0.236(T_m - T_{amb}) - 0.0051(T_m - T_{amb})^2$ (E = 850 W/m2)

The efficiency curve of the solar collector at the volume flow of 3.5 l/min is (the efficiency curve is calculated using three inlet temperature measurement points):
η = 89.4 – 0.206(Tm – Tamb) – 0.0047(Tm – Tamb)2 (E = 870 W/m2)



Remarks:

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

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Signatures:

Littoinen, 31st of May, 2011

Timo Oksa

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