# Tellus Functional Solar Test

**Customer:**

Solar Simulator Finland Ltd.
Keskiläntie 5
FI-20660 Littoinen

**Target:**

Euro C20 AR solar collector
(Wagner & Co Solartechnik GmbH)

Gross area 2.61 m²
Aperture area 2.38 m²
Absorber area 2.38 m²

**Testing time:**

27th -30th of May, 2011

**The Purpose of the Test:**

Measurement of the efficiency of the EURO C20 AR solar collector at the volume flow rate of 4.3 l/min which is equal to 106 kg/h/m².

**Test Method:**

Solar Radiation: > 800 W/m²
Flow medium: water
Flow rate: 4.3 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 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 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.

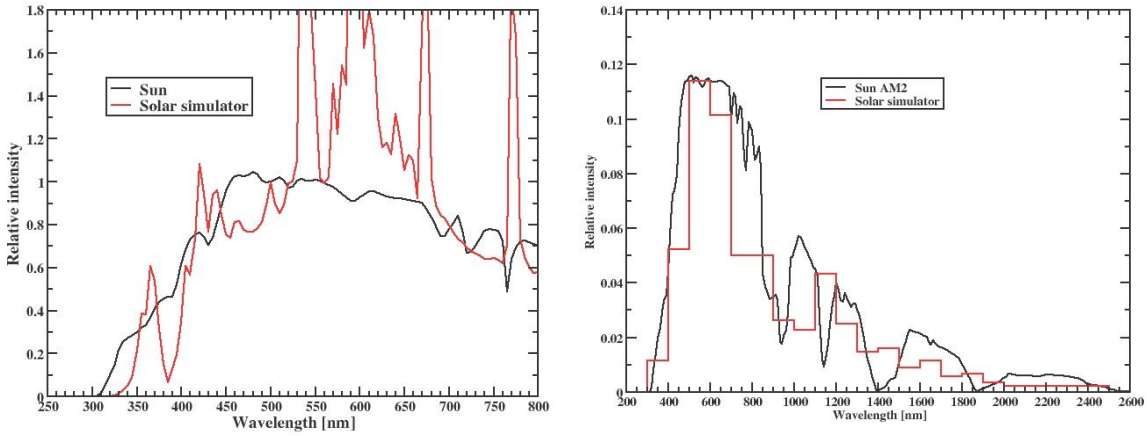



**Table 1.** The amounts of solar radiation, the radiation from the solar simulator and the allowed tolerances in the ranges of ultraviolet (UV), visible radiation and thermal radiation (IR). Total radiation 850 W/m$^2$

| | UV [W/m$^2$] | Visible [W/m$^2$] | IR [W/m$^2$] |
|---|---|---|---|
| Sun | 54 | 425 | 371 |
| 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 mass flow of 106 kg/h/m²**

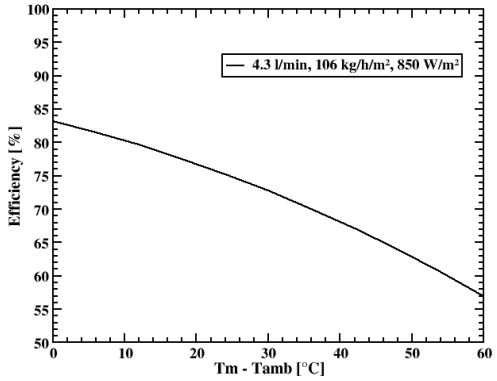
The mean over pressure during the efficiency test in the absorber pipes was calculated to be 30 kPa. The inlet of water was to the left connection in the collector when looking towards the collector. The tilt angle of the solar collector was 55°.

The absorber area of the solar collector used in the efficiency calculations was 2.08x1.144 m² which is 2.38 m². The incident perpendicular radiation intensity E onto the solar collector was measured from a 9x7 matrice to be 850 ± 75 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. Tm is the mean of Tin and Tout.

| R | Cp | V | Tin | Tout | Tamb | Tout-Tin | Tm-Tamb | (Tm-Tamb)/E | η |
|---|---|---|---|---|---|---|---|---|---|
| 0.9972 | 4181 | 4.36 | 21.02 | 26.90 | 29.20 | 5.88 | -5.23 | -0.0059 | 84.2 |
| 0.9973 | 4181 | 4.36 | 20.84 | 26.68 | 29.02 | 5.85 | -5.26 | -0.0059 | 83.7 |
| 0.9973 | 4182 | 4.40 | 20.72 | 26.51 | 28.91 | 5.78 | -5.30 | -0.0060 | 83.5 |
| 0.9964 | 4180 | 4.40 | 24.38 | 30.09 | 28.39 | 5.71 | -1.16 | -0.0014 | 86.2 |
| 0.9706 | 4200 | 4.40 | 80.08 | 84.22 | 28.56 | 4.14 | 53.58 | 0.0630 | 61.2 |
| 0.9706 | 4200 | 4.40 | 80.06 | 84.21 | 29.13 | 4.15 | 53.00 | 0.0624 | 61.4 |
| 0.9707 | 4200 | 4.42 | 80.03 | 84.20 | 29.27 | 4.17 | 52.85 | 0.0622 | 61.8 |
| 0.9706 | 4200 | 4.20 | 80.07 | 84.37 | 30.59 | 4.30 | 51.63 | 0.0607 | 60.7 |
| 0.9820 | 4186 | 3.98 | 59.66 | 64.98 | 30.61 | 5.32 | 31.71 | 0.0373 | 71.4 |
| 0.9819 | 4186 | 3.98 | 59.67 | 65.07 | 30.79 | 5.40 | 31.58 | 0.0372 | 72.6 |
| 0.9909 | 4180 | 4.49 | 40.62 | 45.80 | 31.59 | 5.19 | 11.62 | 0.0137 | 79.4 |
| 0.9910 | 4180 | 4.35 | 40.25 | 45.61 | 31.45 | 5.36 | 11.48 | 0.0135 | 79.5 |

The efficiency measurements were made in the order: ΔT=0°C, ΔT=53°C, ΔT=31°C and ΔT=11°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 4.3 l/min is:

$\eta = 83.2 - 0.259(T_m - T_{amb}) - 0.0030(T_m - T_{amb})^2$ (E=850 W/m²)

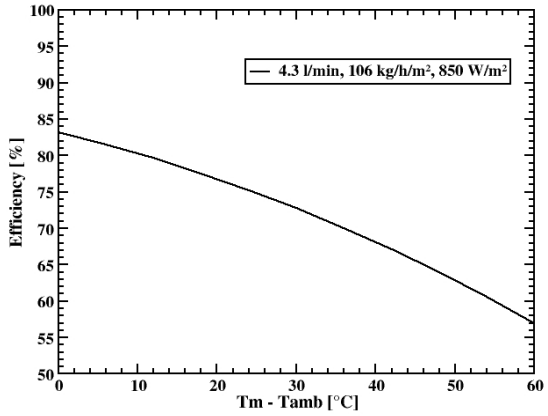
**Used measuring equipment:**
Solar simulator: No. 20
Solar radiation: Pyranometer No. 13, calibrated 11th of June, 2010, calibration is valid
Temperatures: AD590, calibrated 20th of May, 2011, calibration is valid

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 efficiency curve of the solar collector at the mass flow of 106 kg/h/m² is:

$\eta = 83.2 - 0.259(T_m - T_{amb}) - 0.0030(T_m - T_{amb})^2$ (E = 850 W/m²)




**Remarks:**

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

**Signatures:**

Littoinen, 3rd of June, 2011

Timo Oksa

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