INVESTIGATIONS ON EFFICIENCIES OF HT SOLAR COLLECTORS FOR DIFFERENT FLOW RATES AND COLLECTOR TILTS

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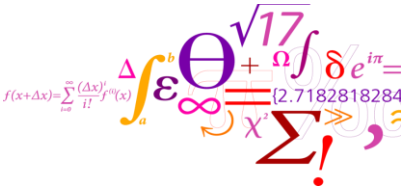

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- Tests on collectors efficiencies and incidence angle modifiers at different flow rates and tilts

- Theoretical investigations and validation of the theoretical investigations on collectors efficiencies.

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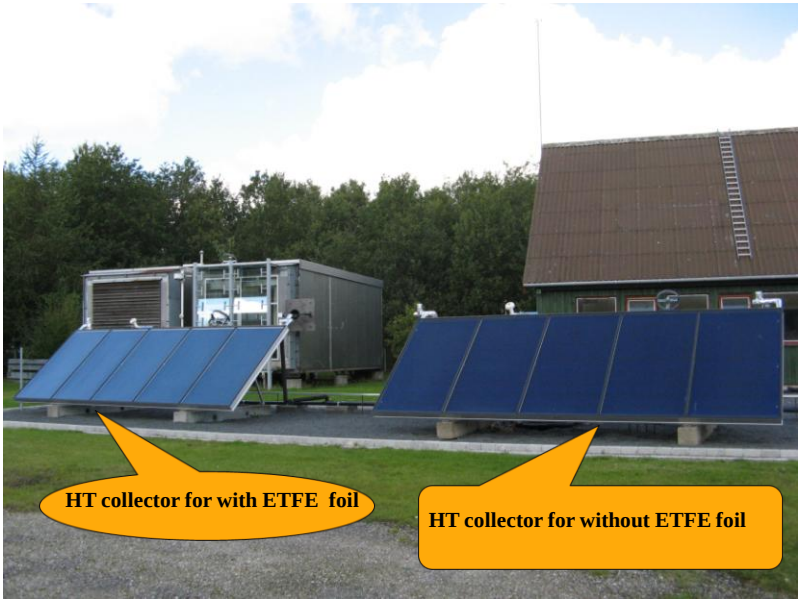

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Plan for experimental tests

Solar collector fluid	Volume flow rate, l/min	Collector tilt,°
40% propylene glycol/water mixture	25	45
40% propylene glycol/water mixture	10	45
40% propylene glycol/water mixture	5	45
40% propylene glycol/water mixture	25	30
40% propylene glycol/water mixture	25	60
Water	25	45

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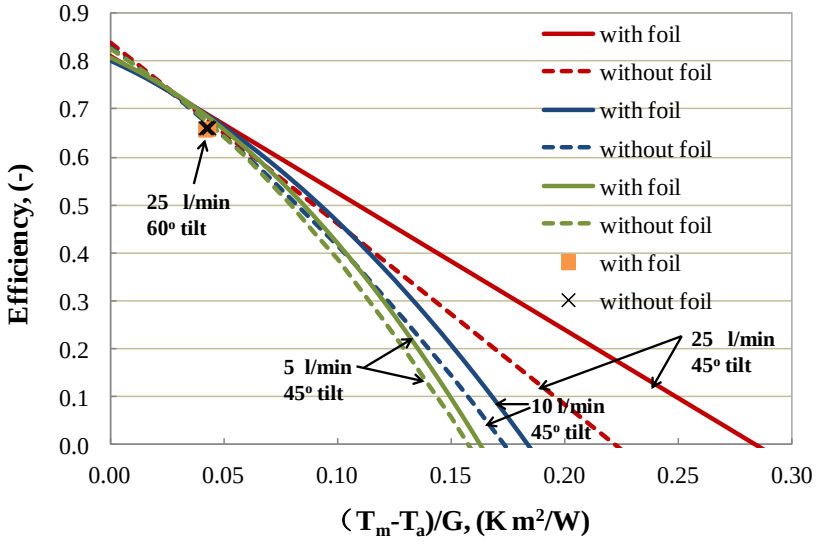
Measured efficiencies for a collector tilt of 45°and 60°, 40% propylene glycol/water mixture and an incidence angle of 0°



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Measured efficiencies for a collector tilt of 45°, 40% propylene glycol/water mixture and an incidence angle of 0°

(1) Efficiencies At flow rate 25 l/min

$$\eta_{1,w} = 0.811 - 2.60 \times (T_m - T_a)/G \quad (1\text{-}1)$$

$$\eta_{1,n} = 0.840 - 3.77 \times (T_m - T_a)/G \quad (1\text{-}2)$$

(2) Efficiencies At flow rate 10 l/min

$$\eta_{2,w} = 0.80 - 2.16 \times (T_m - T_a)/G - 0.0119 \times (T_m - T_a)^2/G \quad (2\text{-}1)$$

$$\eta_{2,n} = 0.828 - 3.26 \times (T_m - T_a)/G - 0.0086 \times (T_m - T_a)^2/G \quad (2\text{-}2)$$

(3) Efficiencies At flow rate 5 l/min

$$\eta_{3,w} = 0.806 - 2.13 \times (T_m - T_a)/G - 0.0172 \times (T_m - T_a)^2/G \quad (3\text{-}1)$$

$$\eta_{3,n} = 0.827 - 2.94 \times (T_m - T_a)/G - 0.0146 \times (T_m - T_a)^2/G \quad (3\text{-}2)$$

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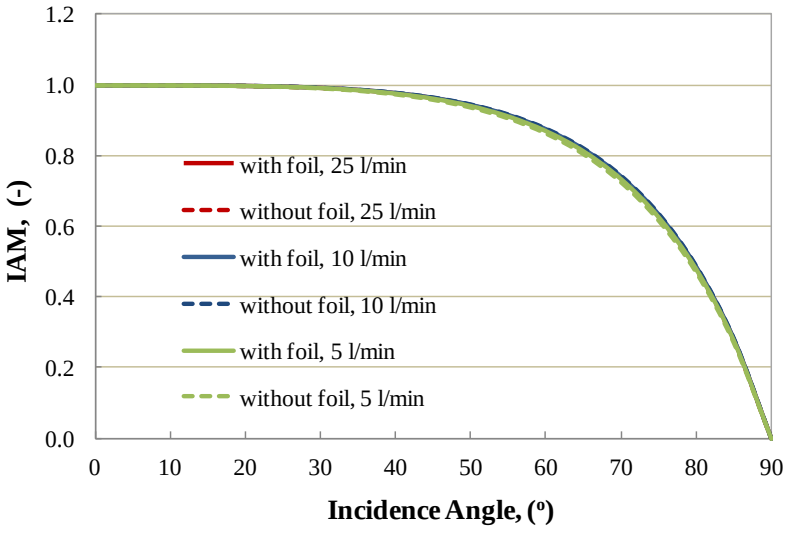
Measured IAM for 45º tilt and 40% propylene glycol/water mixture



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- Tests on collectors efficiencies and incidence angle modifiers at different flow rates and tilts

- Theoretical investigations and validation of the theoretical investigations on collectors efficiencies.

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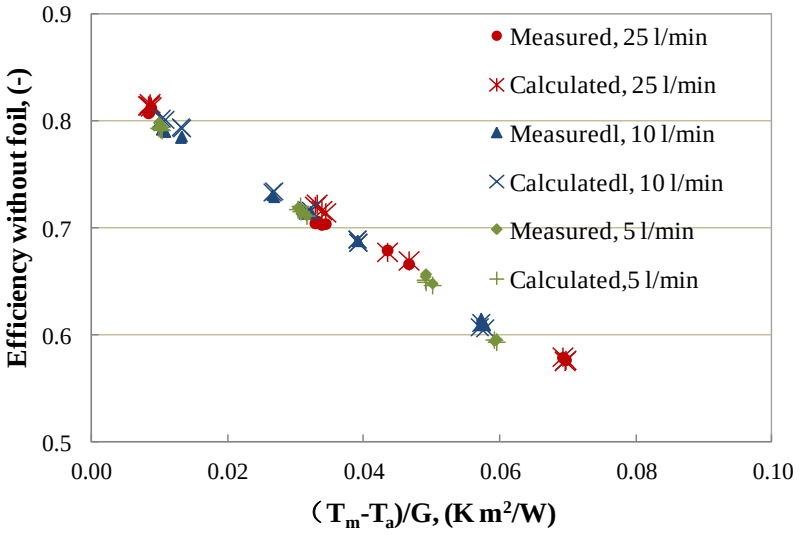
Measured and calculated efficiencies for the flat plate collector without foil for a collector tilt of 45º, 40% propylene glycol/water mixture and an incidence angle of 0º at flow rate of 25 l/min, 10 l/min and 5 l/min



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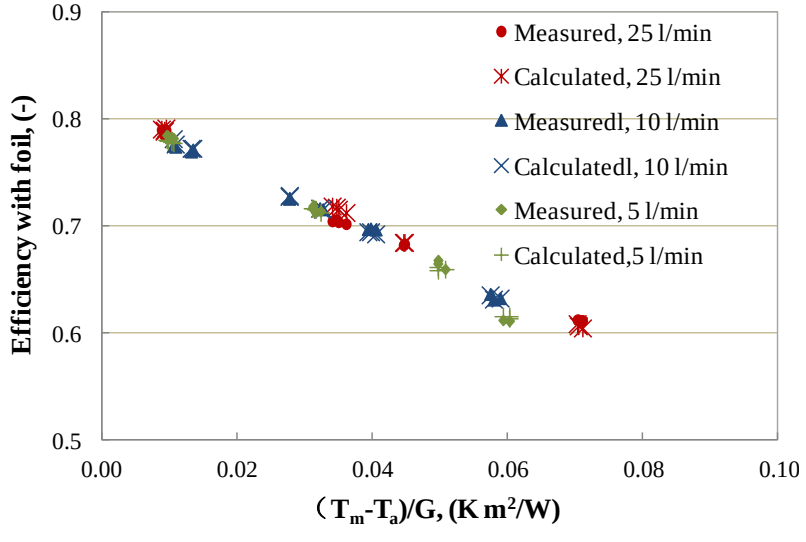
Measured and calculated efficiencies for the flat plate collector with foil for a collector tilt of 45º, 40% propylene glycol/water mixture and an incidence angle of 0º at flow rate of 25 l/min, 10 l/min and 5 l/min



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Calculated efficiencies for a collector tilt of 45º, 40% propylene glycol/water mixture and an incidence angle of 0˚

(1) Efficiencies At flow rate 25 l/min

$$H_{1,w} = 0.817 - 1.93 \times (T_m - T_a)/G - 0.0028 \times (T_m - T_a)^2/G \quad (4\text{-}1)$$

$$H_{1,n} = 0.848 - 3.80 \times (T_m - T_a)/G - 0.0012 \times (T_m - T_a)^2/G \quad (4\text{-}2)$$

(2) Efficiencies At flow rate 10 l/min

$$H_{2,w} = 0.808 - 2.64 \times (T_m - T_a)/G - 0.0064 \times (T_m - T_a)^2/G \quad (5\text{-}1)$$

$$H_{2,n} = 0.844 - 3.85 \times (T_m - T_a)/G - 0.0042 \times (T_m - T_a)^2/G \quad (5\text{-}2)$$

(3) Efficiencies At flow rate 5 l/min

$$H_{3,w} = 0.802 - 2.16 \times (T_m - T_a)/G - 0.0153 \times (T_m - T_a)^2/G \quad (6\text{-}1)$$

$$H_{3,n} = 0.822 - 2.77 \times (T_m - T_a)/G - 0.0170 \times (T_m - T_a)^2/G \quad (6\text{-}2)$$

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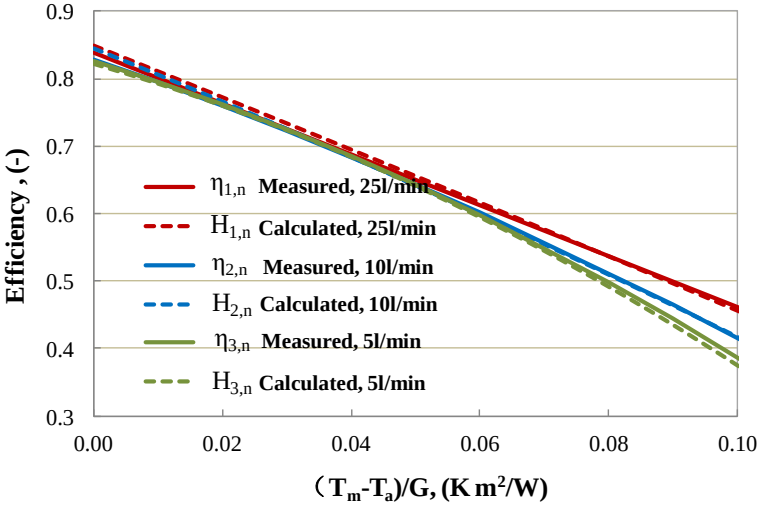
Comparison of the efficiencies from calculations with the efficiencies from measurement for the flat plate collector without foil for a collector tilt of 45º, 40% propylene glycol/water mixture and an incidence angle of 0º at flow rate of 25 l/min, 10 l/min and 5 l/min



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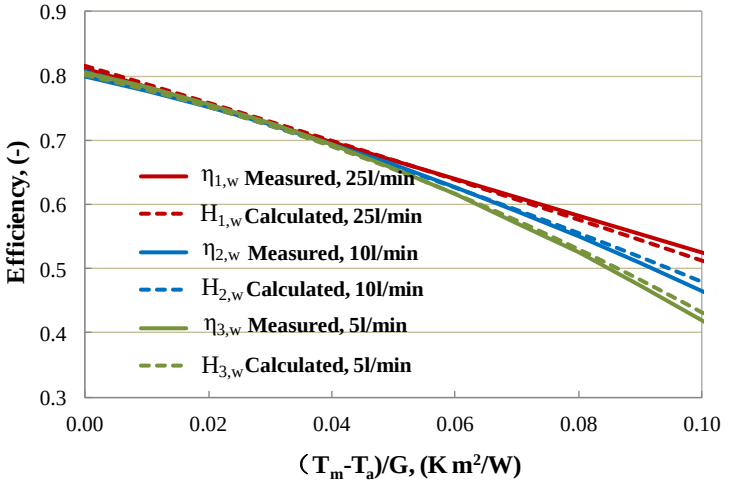

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Efficiencies of a flat plate solar collector as a function of flow rates for a collector tilt of 45º, 40% propylene glycol/water mixture and an incidence angle of 0º under the condition with total solar radiation of 1000 W/m2

$$H_n = (0.8143 + 0.2199F - 0.5680F^2 + 0.5177F^3) - (3.1226 + 1.1189F - 1.4588F^2)\, T_m^* - (13.4233 - 0.5756F)\, T_m^{*2} + 35.5255 T_m^{*3} \quad (7)$$

$$H_w = (0.7923 + 0.1672F - 0.4357F^2 + 0.4005F^3) - (2.3956 + 0.8537F - 1.0865F^2)\, T_m^* - (9.1450 - 0.9949F)\, T_m^{*2} + 17.45 T_m^{*3} \quad (8)$$

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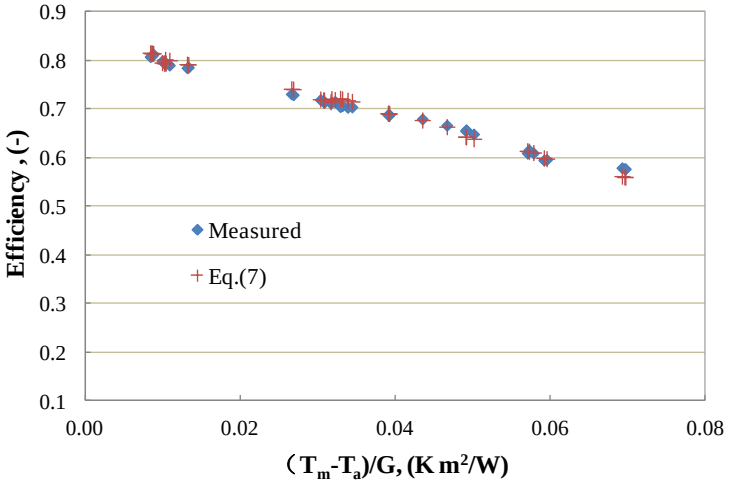
Measured efficiencies and calculated efficiencies from Eq.(7) for the flat plate collector without foil for a collector tilt of 45º, 40% propylene glycol/water mixture and an incidence angle of 0º at flow rate of 25 l/min, 10 l/min and 5 l/min



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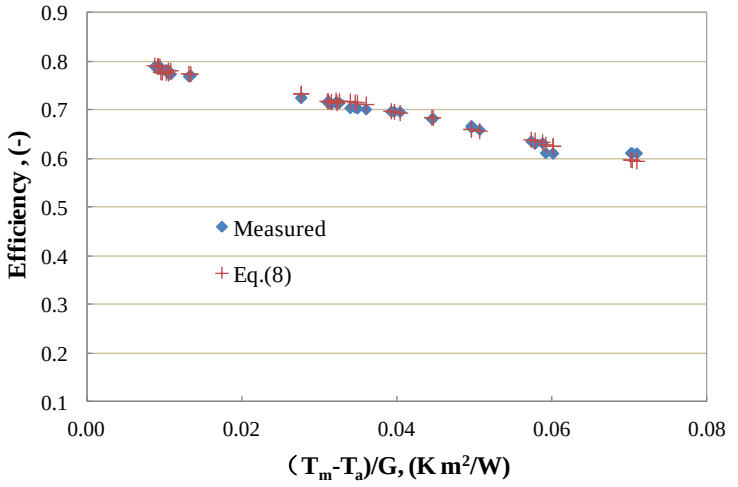

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Results

- Start efficiency for solar collector without foil 2-3%-points higher than start efficiency with foil
- Heat loss coefficient 0.7-1.2 W/m^2K lower for solar collector with foil than heat loss coefficient for solar collector without foil
- Incidence angle modifier almost the same for collectors with and without foils
- For increased volume flow rate the solar collector efficiency is increased: higher start efficiency, lower heat loss coefficient and higher incidence angle modifier
- Collector efficiencies lower for collector tilt of 30º than for collector tilt of 45º

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Thank You!

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