ESTIMATING HEAT LOSSES IN SOLAR COLLECTORS BY IR THERMOGRAPHY AND NUMERICAL SIMULATIONS

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ABSTRACT

The solar collector efficiency (Eq.1) is directly dependent on the heat losses from the absorber plate to the surrounding as well as on an intensity of the absorber plate cooling by working media. Convective and radiative heat losses from the absorber plate are lower when the absorber temperature is kept lower which is directly coupled to more efficient heat transfer between the working media and the absorber. Therefore, in a case of plate collector with tubes attached to the absorber, it is important to ensure a good contact between the tubes and absorber plate, that is in a practice normally done by applying different types of welding or, alternatively, by special gluing procedures.

The geometry of the contact area can be preliminary evaluated by means of a numerical computation of the heat transfer from the heated absorber to the fluid passing throughout tubes, accounting simultaneously for the heat losses to the surrounding air. Such a numerical model is developed in the both 2D and 3D domain for different welding geometry and provided here together with the corresponding absorber temperature fields and efficiency curves. These results are compared with the performed measurements on the simulated solar collector. The comparison indicates fairly good agreement (within 4%) between the computed and test results (Fig.1).

The additional method for inspection of the quality of absorber plate cooling is based on a use of IR thermography camera for recording a temperature field profile over the absorber plate, provided the collector top glazing has been removed before. The recorded IR images clearly indicate places of the improperly formed contact between tubes and plate as well as inefficiently cooled absorber plate areas due to the position and geometry of the tube bank. The recorded temperature field is compared against the numerically obtained one for the case without glazing.

Separate tests and numerical simulations have been done for the unglazed prototype of plate collector without tubes (Figs. 2 and 3). Numerically obtained temperature fields of the absorber are compared against the temperatures measured by IR camera and thermocouples. Using these data and measured collected heat ϕ_c, the local heat transfer coefficients on the working fluid side are calculated and compared with the experimentally obtained ones used in the simulations.

The overall collector efficiency is defined as

$$\eta = \frac{\phi_c}{\phi_s} = \frac{\phi_c}{E_{sun} * A_c} \tag{1}$$

where ϕ_c is the heat collected by collector, ϕ_s is total irradiated solar energy E_{sun} over the used absorber surface area A_c.

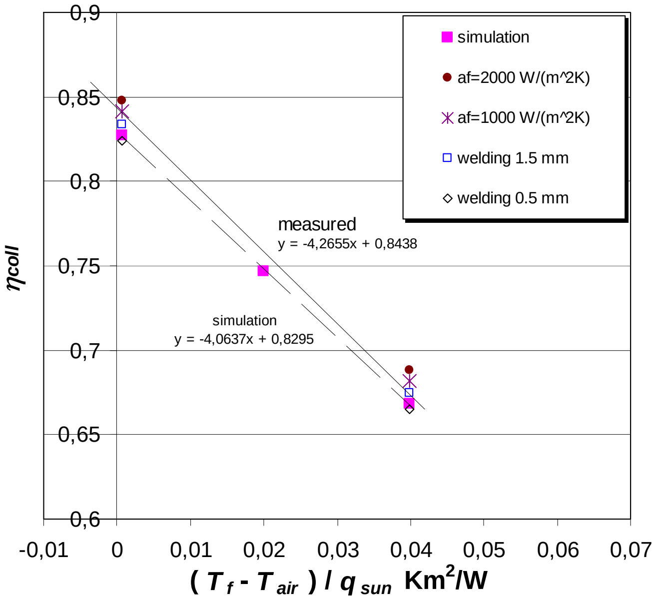

Fig. 1 Comparison of numerically obtained results with measured values

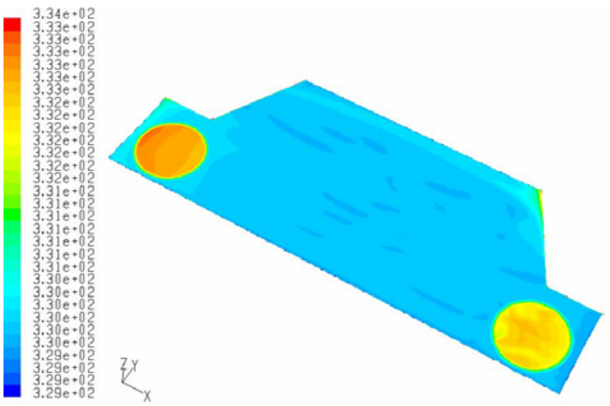

Fig. 2 Numerically obtained temperature field over the absorber plate of the unglazed prototype of plate collector without tubes

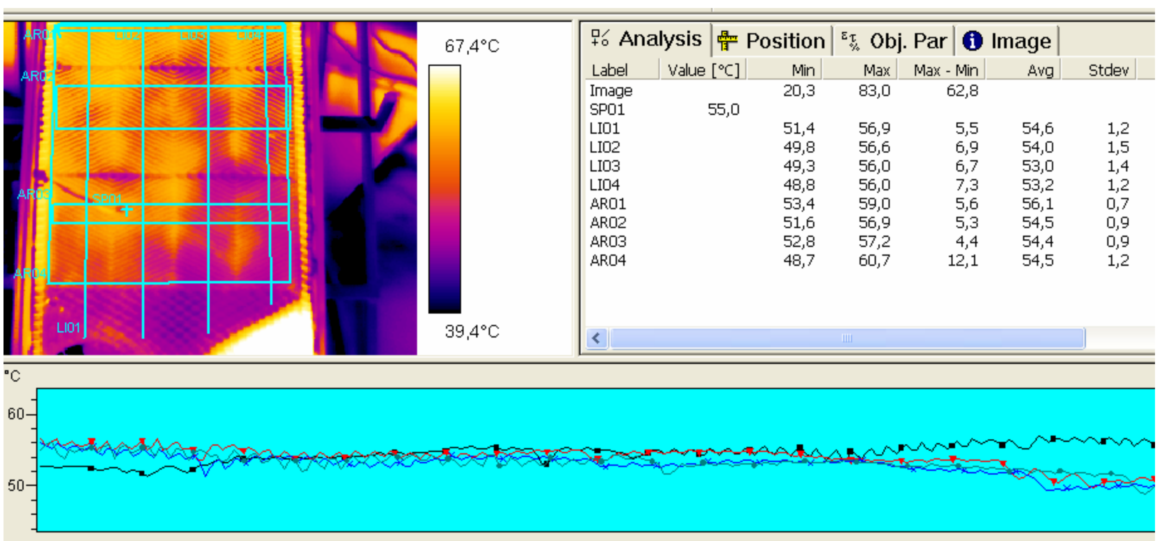

Fig. 3 IR image of tested prototype of plate collector without tubes