Thermal Performance of a Solar Air Heater: Mathematical Model and Solution Procedure

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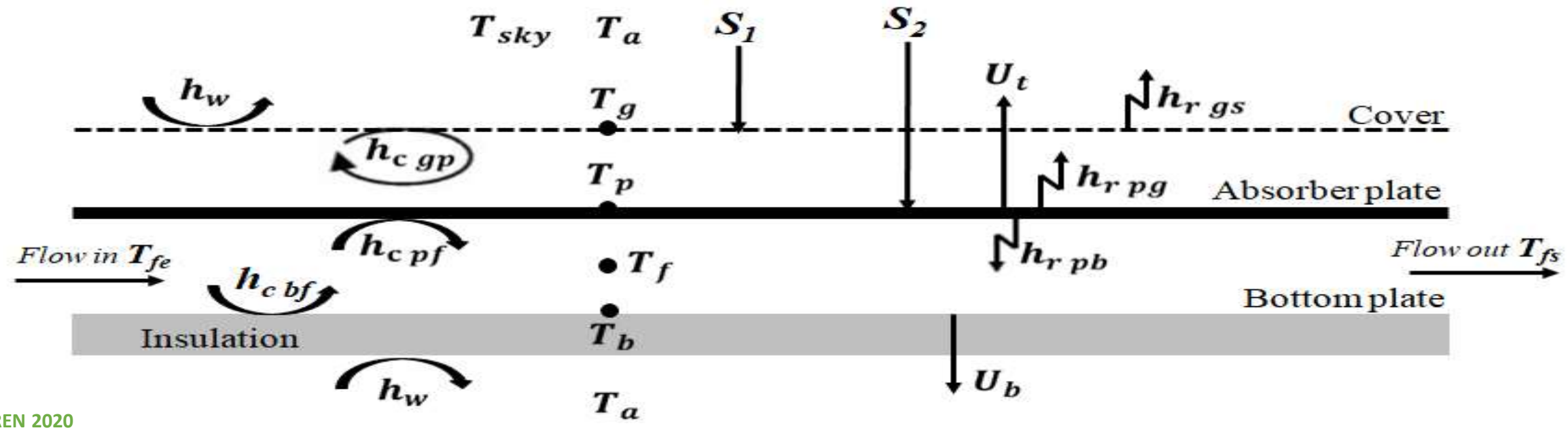
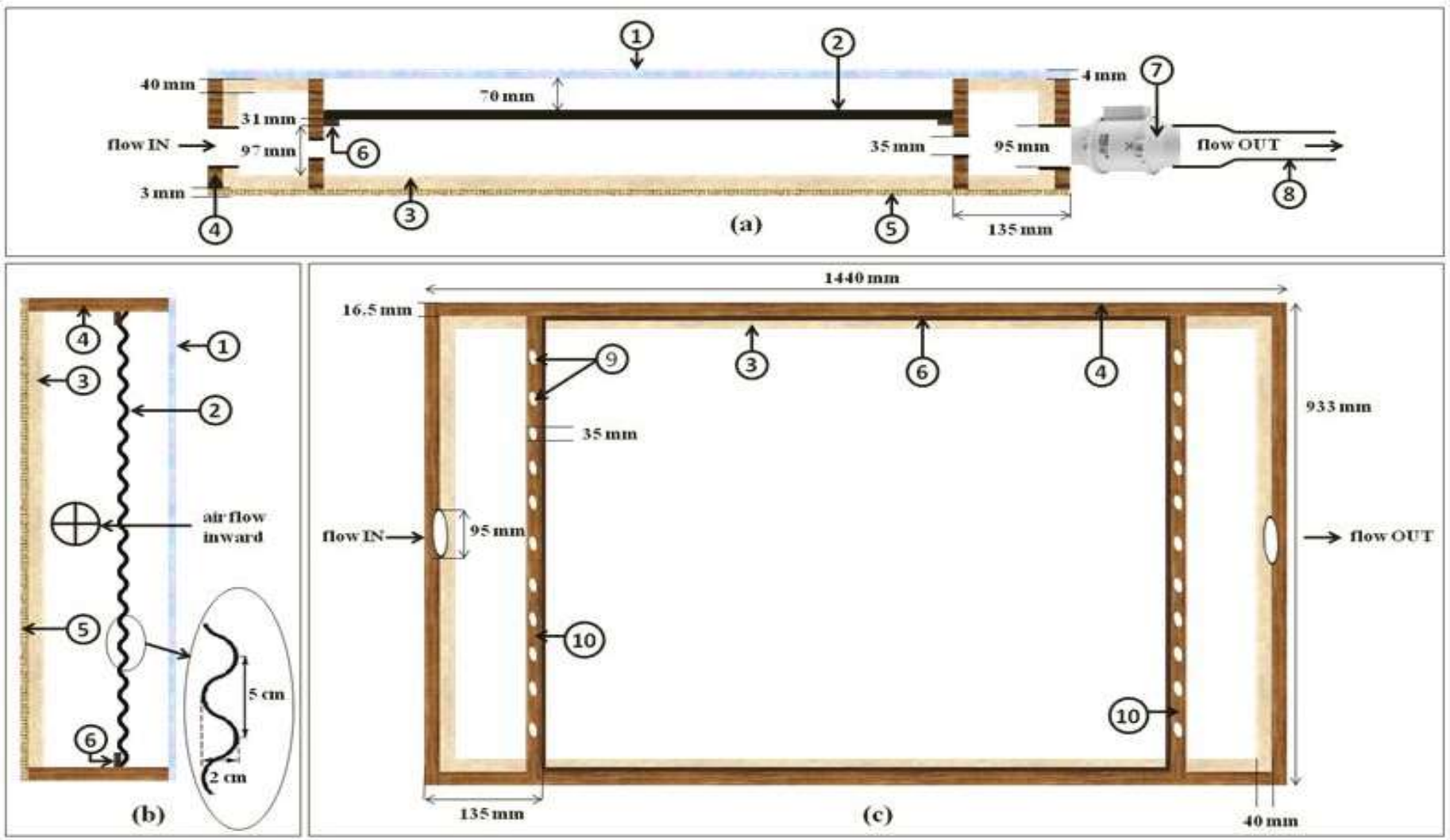


1. Solar air heaters (SAHs)

- Simple devices;
- Conversion of the solar irradiance into heat energy extracted by flowing air in the collector;
- Use: Applications requiring low and moderate temperatures (space heating, agricultural products drying, etc);

Collect a maximum amount of solar energy with a minimum cost.

2. Block diagram of the studied solar air heater



Solar air heater: (a) longitudinal, (b) transverse, and (c) horizontal cross sections. transparent cover (1), corrugated absorber (2), insulation (3), wooden chest (4), plywood (5), absorber support (6), fan (7), tube (8), holes (9), perforated barrier (10).

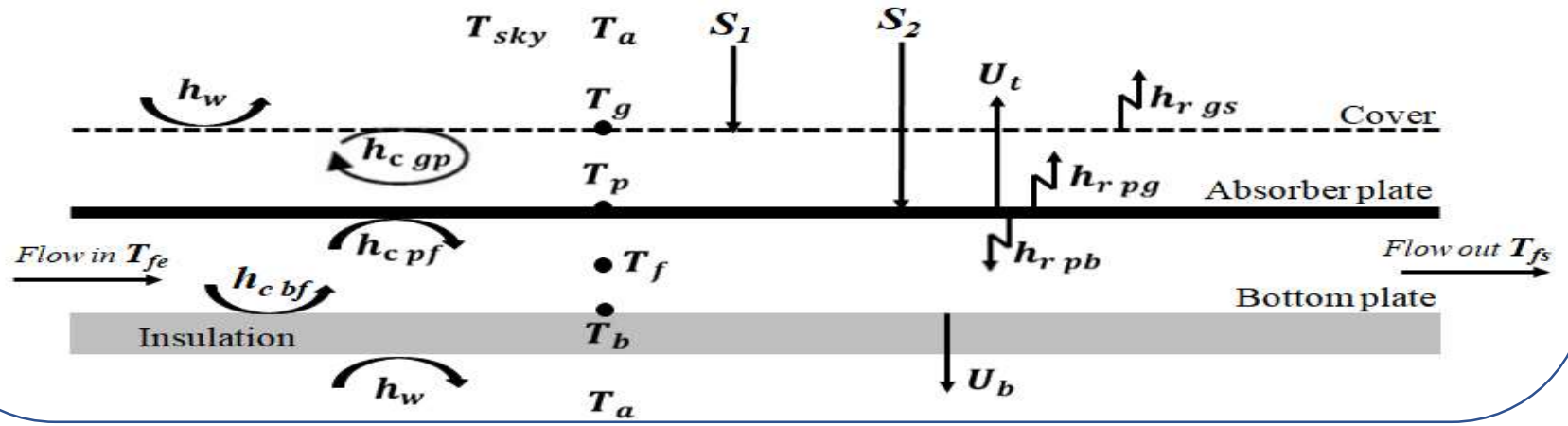
3. Thermal balance equations

Simplifying hypotheses
+
Behavior analysis
of the heater

Mathematical model based on the resolution of the thermal balance equations by the nodal method

- **Dividing the heater into layers;**
- **Establishing the general equations of these layers;**
- **Calculating the thermal balance for each layer.**

Good knowledge of the convective and radiative exchange mechanisms between each component.



3. Thermal balance equations

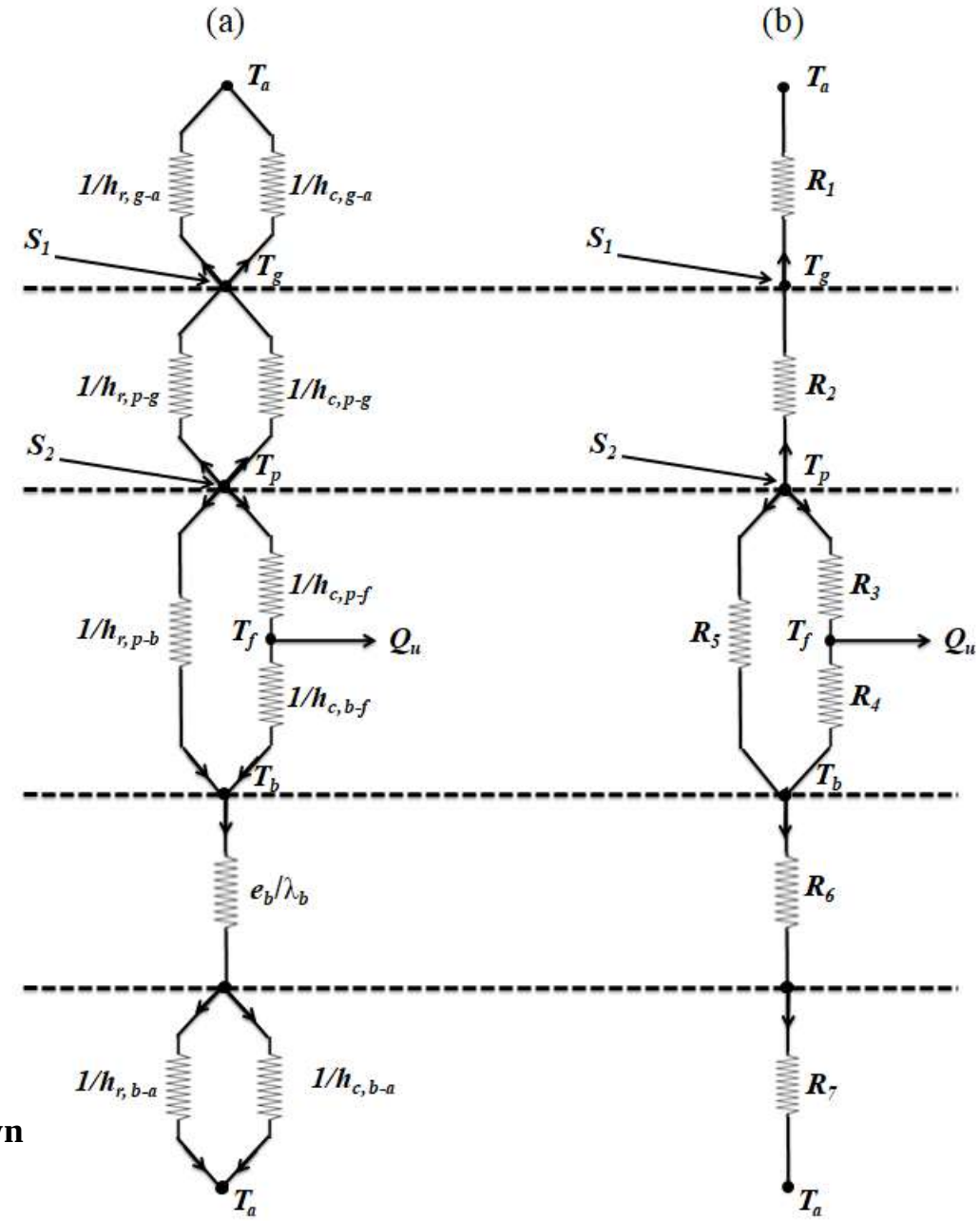
Matrix equation with four (04) dimensions:

$$\begin{bmatrix} U_{t,g-a}+U_{t,p-g} & -U_{t,p-g} & 0 & 0 \\ -U_{t,p-g} & U_{t,p-g}+h_{r,p-b}+h_{c,p-f} & -h_{c,p-f} & -h_{r,p-b} \\ 0 & h_{c,p-f} & -(h_{c,p-f}+h_{c,b-f}+\Gamma) & h_{c,b-f} \\ 0 & -h_{r,p-b} & -h_{c,b-f} & h_{r,p-b}+U_b+h_{c,b-f} \end{bmatrix} \begin{bmatrix} T_g \\ T_p \\ T_f \\ T_b \end{bmatrix} = \begin{bmatrix} U_{t,g-a}T_a+S_1 \\ S_2 \\ -\Gamma T_{fi} \\ U_bT_a \end{bmatrix}$$

$$[A][T]=[B] \quad or \quad [T]=[T_g,T_p,T_f,T_b]$$

$$[T]=[A]^{-1}[B]$$

An iterative process based on <u>Jacobi's method</u> is used to calculate the unknown temperatures T_g, T_p, T_f, T_b.



Thermal network of the studied solar air heater (Electrical Analogy of Heat Transfer)

4. Solar air heater performance