Introduction: The design of a drying chamber for dehydration purposes requires the knowledge of exergetic and energetic efficiencies, i.e. a thermodynamic comprehension [1]. We model the case of a so-called indirect solar dryer [2] that includes a thermal isolated chamber attached to a solar collector as the source of thermal energy. We compare the effect of conductivity against inlet velocity.

Computational Methods: The exergy is defined as the maximum amount of work that can be produced by a given flux until the equilibrium conditions are obtained[3]. We use both, the heat transfer and CFD modules for an initial non isothermic laminar flux. The outlet velocity obeys:

\[ u = -U \cdot n \]

The inlet heat flux transferred from the solar collector satisfies:

\[ -n \cdot (-d \cdot k \cdot \nabla T) = d \cdot q_u \]

The exergy values are calculated to obtain the efficiency of the chamber [3], given by:

\[ E_{x_{dci}} = C_{pa} \left[ (T_{dci} - T_a) - T_a \ln \frac{T_{dci}}{T_a} \right] \]

\[ E_{x_{dco}} = C_{pa} \left[ (T_{dco} - T_a) - T_a \ln \frac{T_{dco}}{T_a} \right] \]

\[ E_{x_{loss}} = E_{x_{dci}} - E_{x_{dco}} \]

\[ \eta_{ex} = \frac{E_{x_{dco}}}{E_{x_{dci}}} = 1 - \frac{E_{x_{loss}}}{E_{x_{dci}}} \]

The geometry includes a 2D model of the chamber with a single tray and an upper chamber, we compare results for two different materials and two different inlet velocities.

Results:

Table 1. Initial Conditions and Efficiency Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Units</th>
<th>Case A</th>
<th>Case A1</th>
<th>Case B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet Velocity</td>
<td>m/s</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Thermal conductivity</td>
<td>W/(K·m)</td>
<td>155</td>
<td>155</td>
<td>400</td>
</tr>
<tr>
<td>Efficiency</td>
<td>%</td>
<td>19.79</td>
<td>15.06</td>
<td>14.85</td>
</tr>
<tr>
<td>General heat inlet flux=500W/m²[4]</td>
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<tr>
<td>Air temperature=293.15 K</td>
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</tr>
</tbody>
</table>

Figure 2. Simulation’s Geometry

Air Outlet

Air Inlet

Conclusion:

The highest efficiency was obtained for a low conductivity and low inlet velocity because the drying process is governed by an adiabatic behavior inside the chamber.

References: