Plastic Bottles Solar Collector

V. Bonetti[1]

[1]Ingegneria Senza Frontiere, DESE, Università di Pisa, Pisa, Italy

Abstract

In the Andean region of Southern Peru, poverty and climate are extreme: at 4000m AMSL, insolation is among the highest in the world but the temperature varies more than 30 degrees between day and night. At the community of Livitaca (Chumbivilcas, Cuzco region), the association "Ingegneria Senza Frontiere" is working on a project of bioclimatic architecture: a pilot building constructed with local materials. In this context, it is devised a simple low cost drainback solar heating system, which can accumulate the heat picked up during the day by a rudimentary solar thermal collector within a system of thermal activation of the floor's mass. The aim is to make the temperature warmer at night inside the houses of adobe, lacking of any other heating system. The present study focuses on the solar collector's design suitable for the aim described above: the temperature to be reached at its output is slightly higher than the inlet of the accumulation floor (28 °C), therefore efficiency required is low, due to area high irradiation.

It is then possible to construct the panels with materials available locally and largely recycled, such as low-density polyethylene pipes for irrigation, empty plastic bottles and used tetrapak, plastic bags, according to the model proposed by J.A. Alano. Using COMSOL, we study the behavior of a single pipe of the collector in order to determine, with fixed diameter and dimensions of the bottles, the combination of the internal water speed and the pipe length that represents the best compromise for the system. We also investigate the temperature pattern in the thickness of the pipe, to verify that it remains below the threshold of softening of the polyethylene, condition beyond which it would not be able to withstand the pressure of the system in regime of operation. Moreover we analyze the temperature trend in the condition of absence of water and simultaneous irradiation, which occurs in case of failure of the pumping system. Some simplifying assumptions are taken for the heat exchange: the greenhouse effect is simulated considering the bottle as completely opaque to infrared radiation (despite the fact that plastic is not); exchange between the pipe and the bottle is considered as a radiative and conductive in air's layer, assuming that natural convection is suppressed in the enclosure between bottle and inner pipe; radiative exchange between the outer surface of the bottle and the environment is neglected. The problem, symmetrical with respect to the plane passing through the pipe axis and containing the direction of the solar radiation, is covered in a 3D stationary model in the operating condition and in a 2D stationary to investigate the temperatures in absence of water. The temperature profile in the thickness remains below the critical level in every operating condition, while we detect the threshold of polyethylene's softening is exceeded in a situation of absence of water (failure of the pumping system) and contemporary high irradiation. It remains to investigate the effect of this overheating on the collector's life, in relation to the frequency of faults.

Reference

1. J.A. Alano, "Manual para la Construcción y Instalación del Calefón Solar Compuesto de Embalajes Descartables", Sema, Paranà (2008).
2. J.A. Duffie, W.A.Beckman, "Solar Engineering of Thermal Processes", J.Wiley & Sons (2006).

Figures used in the abstract

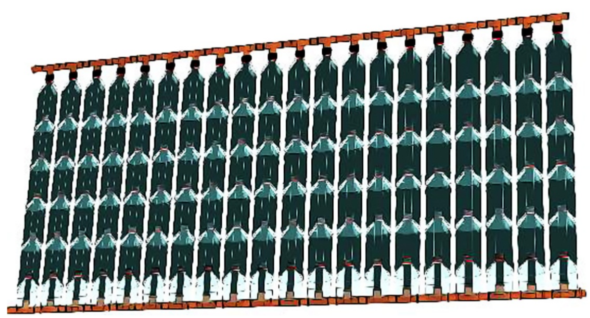

Figure 1: Plastic bottles solar collector's schematic drawing.

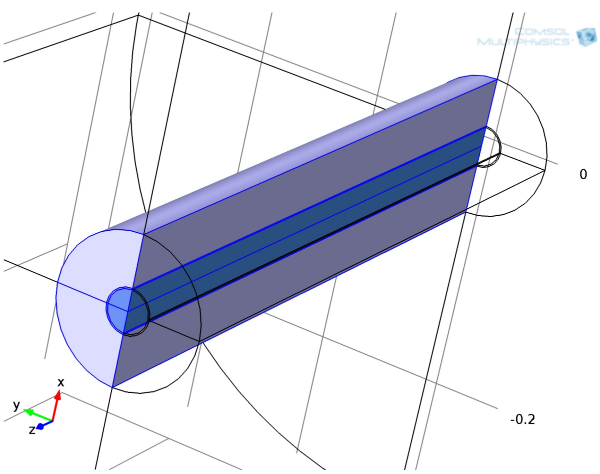

Figure 2: Geometry.

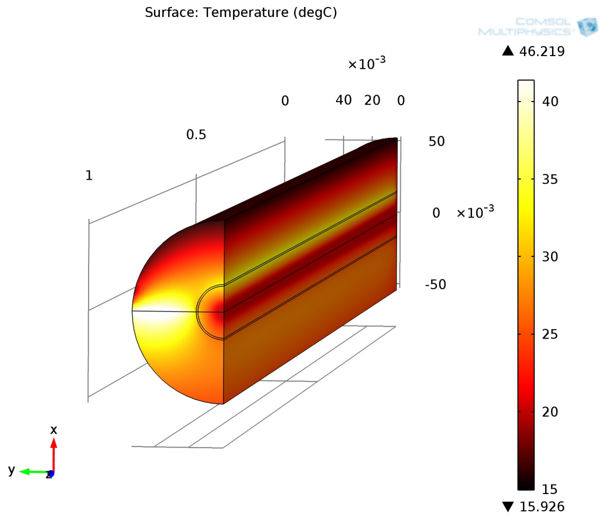

Figure 3: 3D simulation plot.

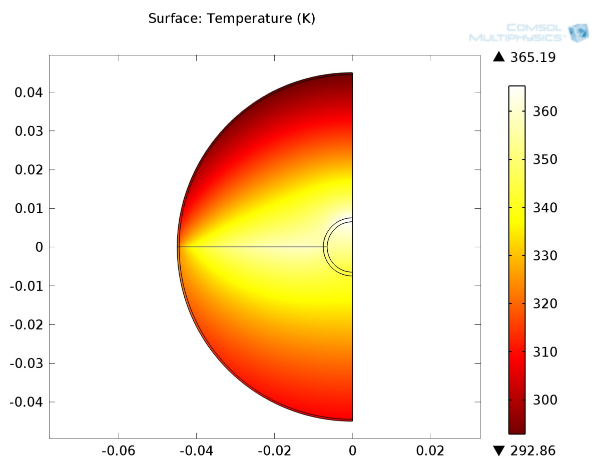

Figure 4: 2D simulation plot.