COMSOL Multiphysics® Model of a Solar Dryer

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Abstract

Introduction:
The cultivation of cocoa is a traditional activity in Bahia-Brazil which has brought significant benefits to the local economy through cycles of growth and decline, the latter mostly due to plague of witches' broom (Crinipellis perniciosa) which greatly reduced the production and cocoa quality.

For [2] cocoa production still generates about 90,000 jobs in the region (which includes direct, indirect and induced jobs throughout the production chain), particularly in the passage between Ilheus-Itabuna.

Chocolate has cocoa as the main component, and several steps are required along the chain for the production of this, among them are: the fruit harvest, removal of almonds, fermentation and drying. Our focus will be on the drying of almonds.

Currently, there are many ways of drying grain, for example, by combustion or through solar energy through the traditional barges or greenhouses. What is proposed in this article, however, is a vertically solar kiln for drying grain (Fig. 1). The traditional method of drying using barges is labor intensive, and needs large areas to do such activity. The proposed system has dimensions 1x1x2, where we see a valorization of the height in the drying process due to the stacking of trays in its interior, each containing a layer of fresh beans, which through a tray flow system it is possible entry of fresh almonds in the kiln and removal of almonds dry.

In this scenario we seek to calculate the temperature field obtained inside the tower depending on the conditions set.

Using COMSOL Multiphysics® software:
To perform the simulation the Heat Transfer Module considering Surface-to-Surface Radiation was used. The geometry is subjected to solar irradiation and also to the forces of the winds, where were used respectively the conditions External Radiation Source and Convective Heat Flux. The Surface-to-Surface Radiation, feature enabled the consideration of radiation between surfaces as well as configure the material surrounding the tower (agricultural plastic) to transparent at short wavelengths and opaque to long wavelengths. The Fig.2 shows details of the conditions considered, where the radiation A, B and C are, respectively, visible light, infrared in

short wavelengths and infrared in long wavelengths. Others data about Heat transfer and values of some constants necessary for the simulation were obtained according to [1-3].

Results:
In principle, the tower was simulated without considering the trays inside, and then they were considered as shown in Figures 3 and 4, respectively. Without considering the trays, the prevailing temperature in inner the tower is the environment defined in the simulation, this primarily due to the convective effects.

When considering the stacked trays, the temperature field of the tower reaches the expected (about 40 ° C). This is mainly due to radiation emitted from the trays within the tower (Figure 4).

Conclusion:
With use of COMSOL Multiphysics was possible to show that the project meets the basic specifications of operation, where a fairly realistic simulation was developed with ability to set bands of radiation, and this was precisely one of the main conditions for modeling the system in question.

Reference

[1] FRANK P. INCROPERA; DAVID P. DeWitt – Fundamentos de Transferência de Calor e de Massa. Quinta edição. Ed. LTC. Rio de Janeiro, 2003.
[2] NEIVA, SANDRO. O CACAU hoje no Brasil. Pervitin Filmes, 2010. Disponível em: http://pervitinfilmes.blogspot.com.br/2010/01/o-cacau-hoje-no-brasil.html
[3] SALES, J.H. ; NOBRE FILHO, G.W.L. ; SANTOS, E.C. . UTILIZAÇÃO DE SOFTWARE CAD E CAE NO DESENVOLVIMENTO DE PRODUTO SUSTENTÁVEL PARA AQUECIMENTO DE ÁGUA. ANAIS DO SIMPÓSIO INTERNACIONAL DE INOVAÇÃO TECNOLÓGICA - SIMTEC, v. 1, p. 332-342, 2013.

Figures used in the abstract

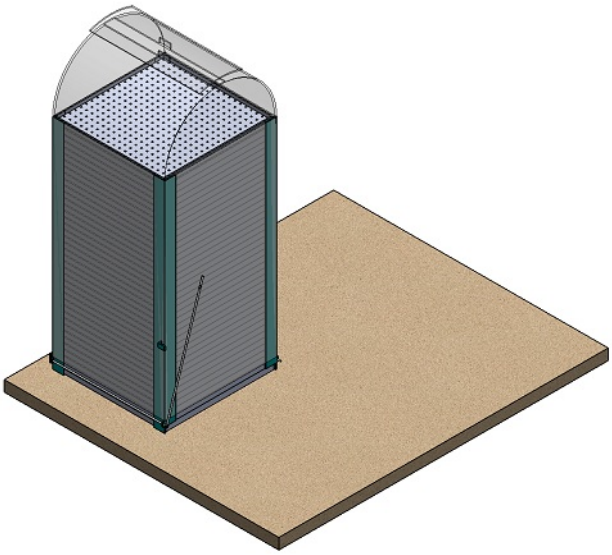

Figure 1: Geometry of the tower.

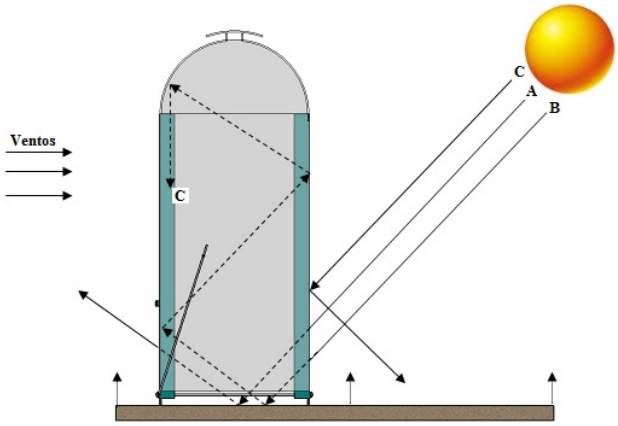

Figure 2: Physic system.

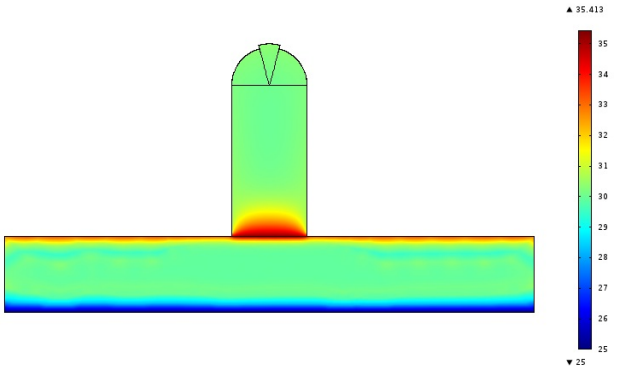

Figure 3: Temperature field without considering the trays.

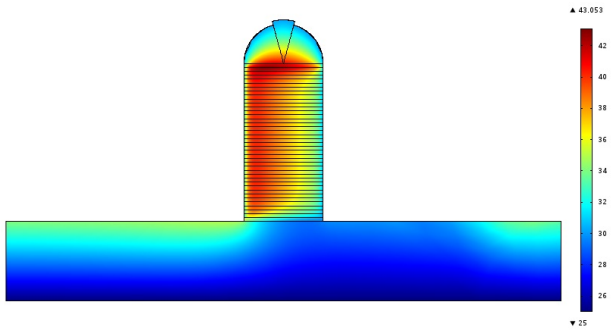

Figure 4: Temperature field considering the trays.