Heat And Moisture Transport In Loamy Sand Soil At High Temperatures

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Abstract

As the adoption of renewable energies increases, driven by governmental efforts to mitigate global warming, high-temperature ground thermal energy storage (GTES) units have become a critical technology for storing solar energy. Understanding the transport phenomena of heat and moisture in soil is essential for improving the design and efficiency of these GTES units. This study focuses on analyzing heat and moisture transport in Matilda soil at high temperatures, up to 90°C.

The analysis was conducted using COMSOL Multiphysics® software, employing the Partial Differential Equations (PDE) module. The problem setup involved formulating heat and mass transfer equations based on Deru's work and implementing these equations in COMSOL. The study relied heavily on custom PDE formulations, focusing on two main variables: temperature and matric liquid potential.

In COMSOL, the soil column was modelled as a cylindrical domain, replicating the design used in the experimental studies by Hedayati et al. The finite volume method (FVM) was used to discretize the governing equations. The temperature gradient was set from 10°C to 90°C along the height of the cylinder, with an initial moisture content of 0.26, based on the experimental model. The model included multiple coefficients and parameters, defined using functional expressions, to capture the complex interactions between heat and moisture.

The numerical results were validated against experimental data, demonstrating that the model successfully captured the observed moisture migration and temperature distribution.

Reference

[1] M. Deru, A Model for Ground-Coupled Heat and Moisture Transfer from Buildings, Technical Report (NREL/TP-550-33954, Contract No. DE-AC36-99-GO10337), National Renewable Energy Laboratory, Golden, CO, 2003.

[2] M. Hedayati-Dezfooli, W. H. Leong, A Design of Experimental Apparatus for Studying Coupled Heat and Moisture Transfer in Soils at High-Temperature Conditions, Experimental Heat Transfer, DOI: 10.1080/08916152.2019.1600618 (2019).

Figures used in the abstract

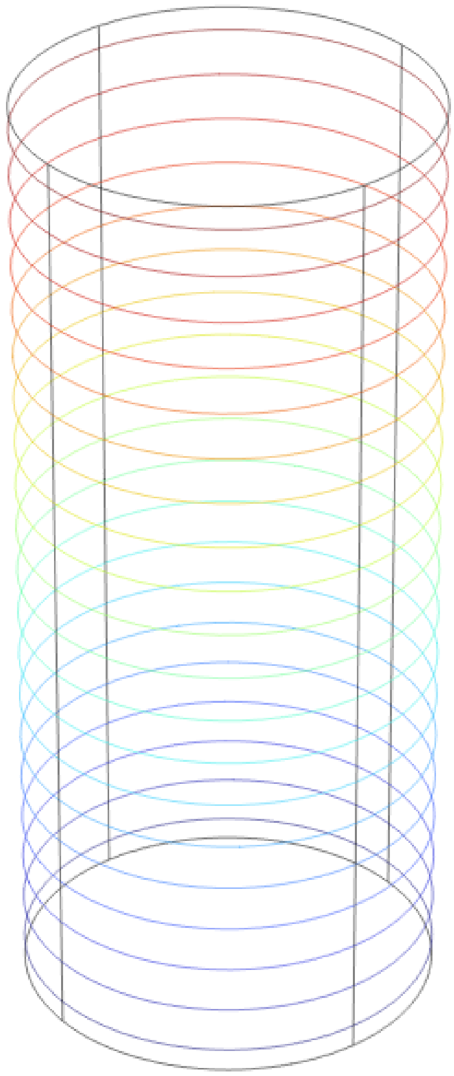

Figure 1 : Temperature distribution along the cylinder at t = 9000 seconds.

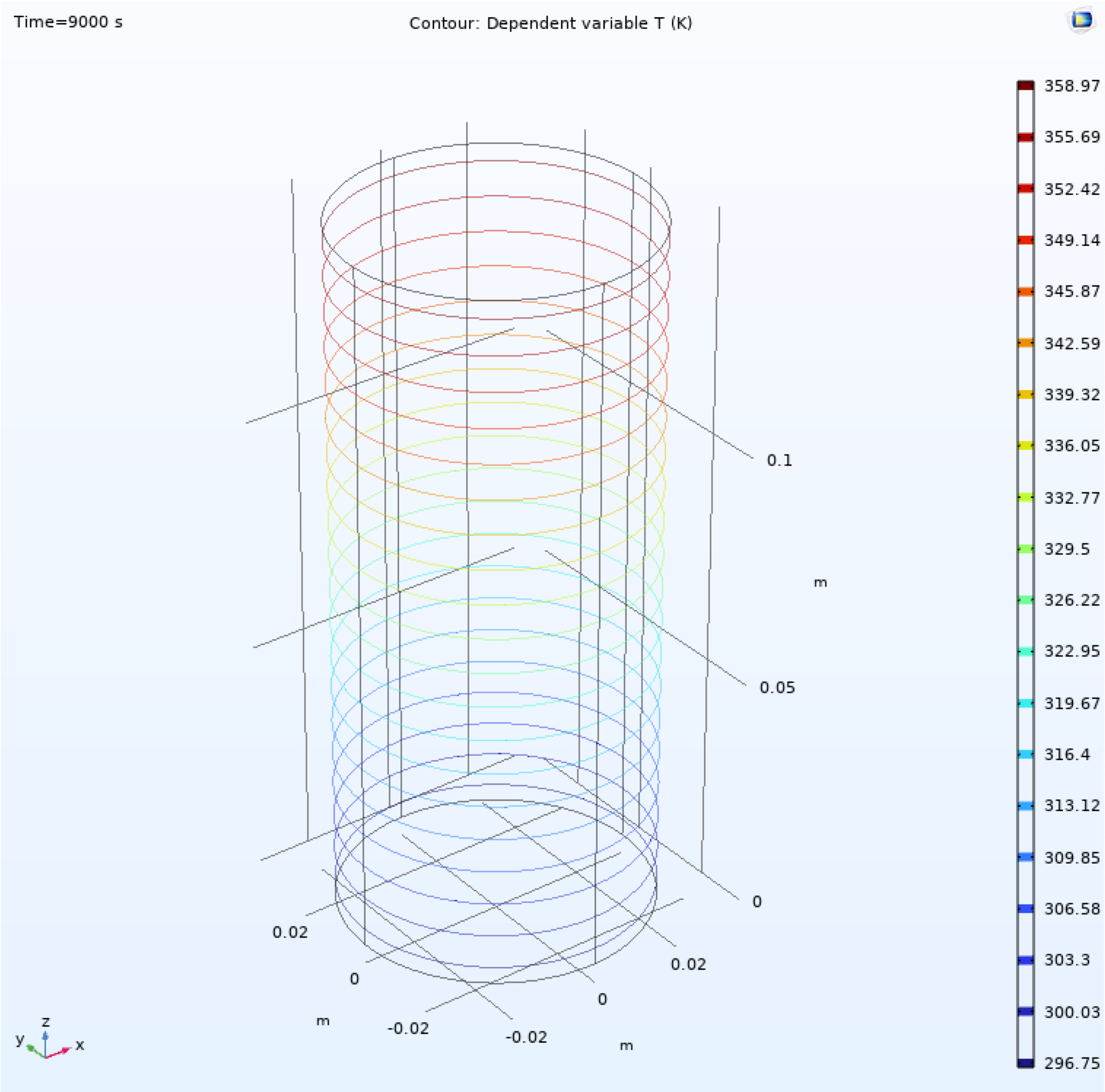

Figure 2 : Temperature distribution along the cylinder at t = 9000 seconds.