Virtual Modelling of Thermo-Physiological Comfort in Clothing

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Introduction

The dynamic heat and moisture transmission characteristics of clothing are extremely important phenomena that control the thermo-physiological comfort of a person [ref. 1-3]. Heat and moisture absorption in hygroscopic materials are inseparably interrelated (fig. 1).

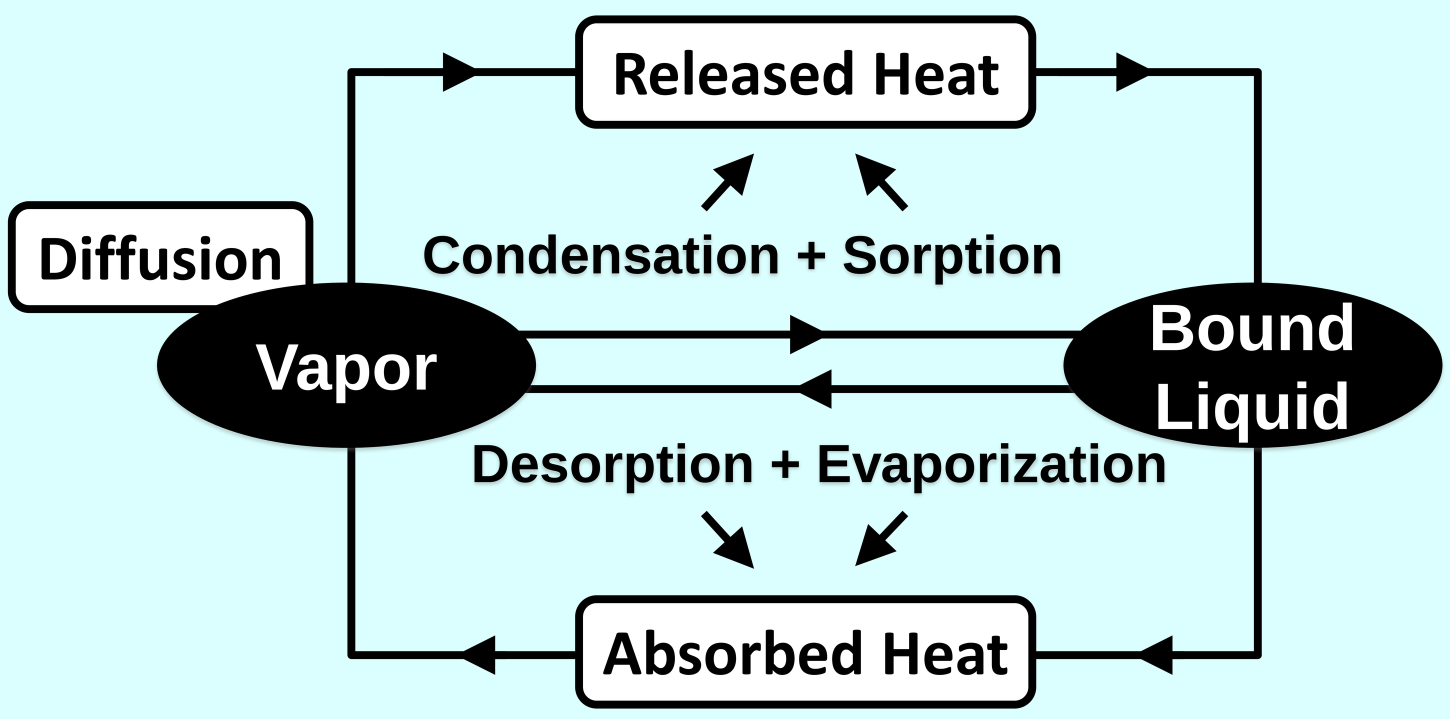


Figure 1. Coupled mass/heat transport in hygroscopic textile

Computational Methods

the COMSOL model accounts for **vapor-phase diffusion, heat transfer, liquid evaporation/condensation** and **sorption/desorption** through the **solid phase** (table 1). Complications due to **variable porosity** caused by swelling/shrinkage of the porous matrix are accounted for by the **source terms** in the transport equations [ref. 1 & 3].

Equation	Transient	Diffusion	Volume Source	Interface
mass conservation vapor	x	x	mass flux in/out fibre	PDE
mass conservation bound liquid	x	-	mass flux in/out fibre	PDE
energy conservation	x	x	heat flux (evaporization/condensation + sorption/desorption)	heat transfer in porous media

Table 1. Comsol model

Results

Temperature rise/fall across a wool textile due to heat/vapor transmission.

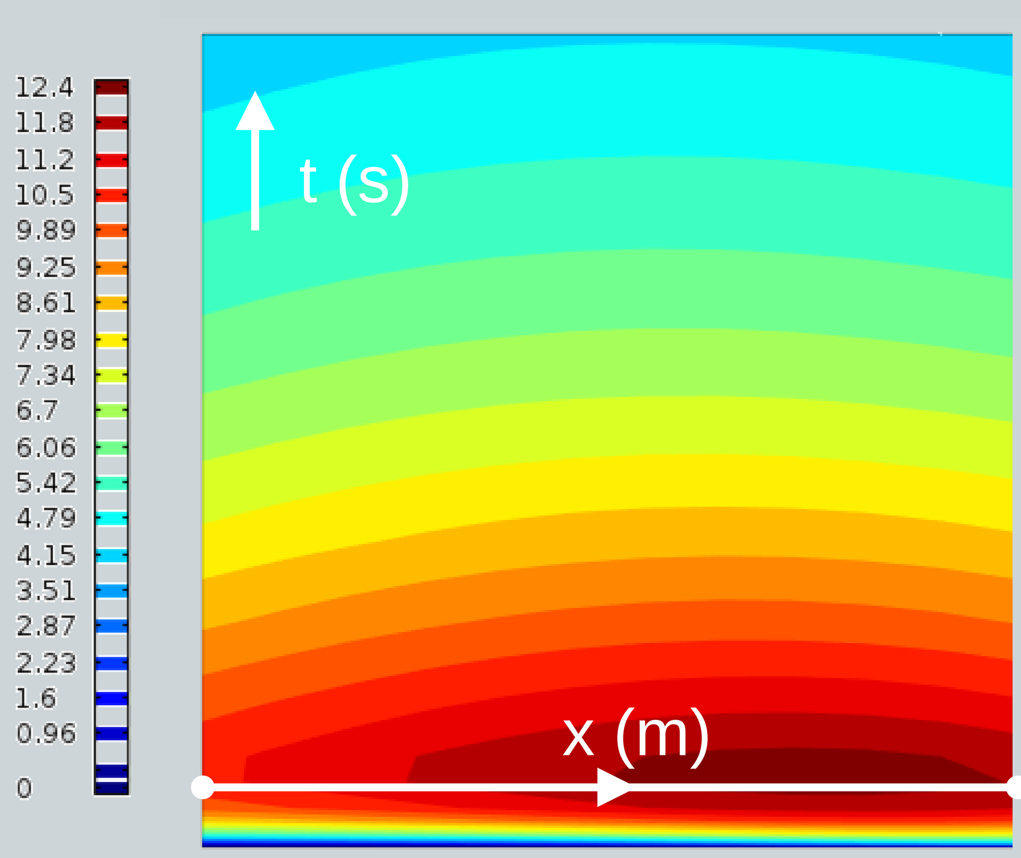


Figure 2. Contourplot temperature rise/fall

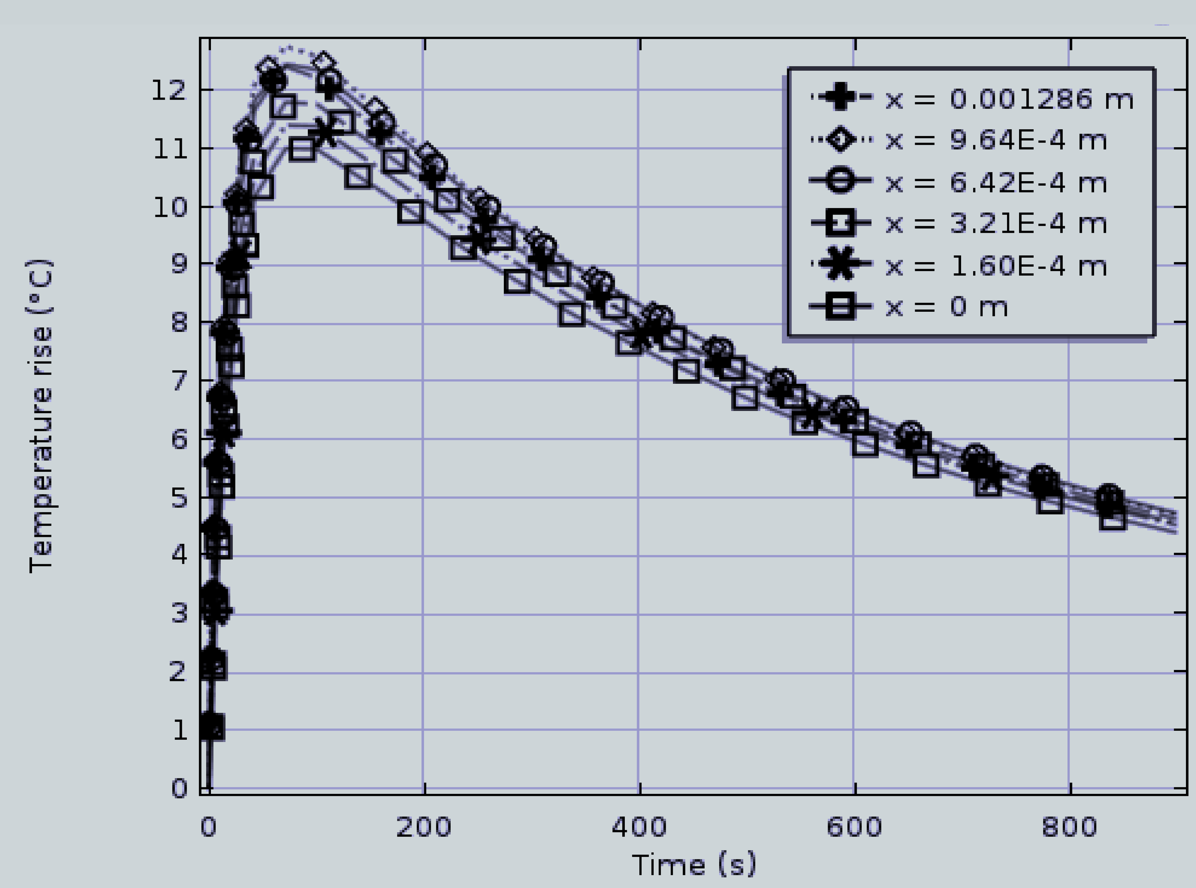


Figure 3. Curves temperature rise/fall across a wool fabric [ref. 1]

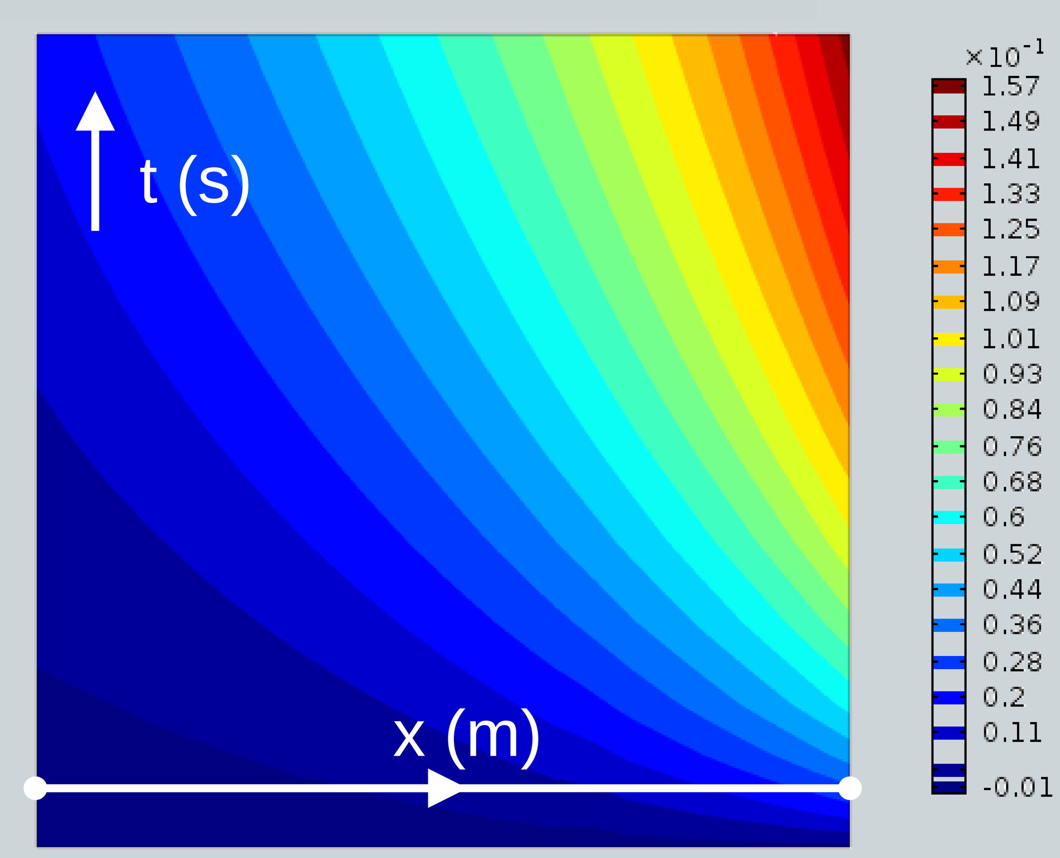
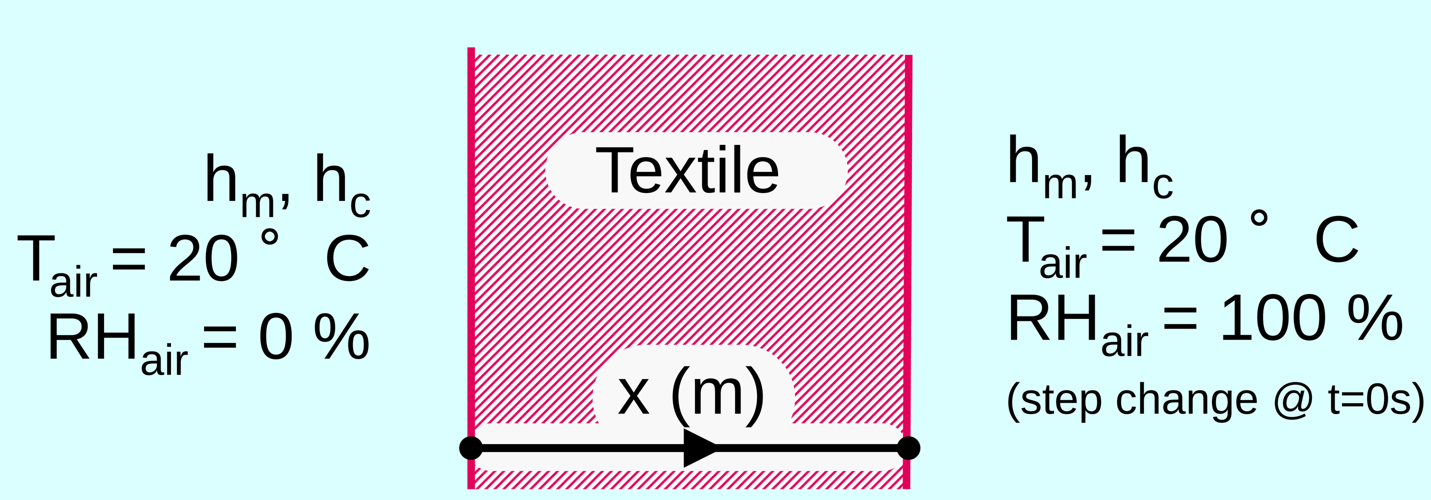


Figure 4. Contourplot bound liquid volume fraction

Test case

A wool fabric is subjected to a step change in relative humidity [ref. 1]:



h_m= convective mass transfer coefficient = 0.021 m/s
h_c = convective heat transfer coefficient = 21.8 W/(m^2K)

Figure 5. Definition test case

Conclusions

Coupled diffusion phenomena of heat and moisture in hygroscopic materials are successfully modeled. More fabrics and validation is underway.

References

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2. Soraia F. Neves, João B. L. M Campos, Tiago S. Mayor: Numerical simulation study on the heat and mass transfer through multi-layer textile assemblies, COMSOL Multiphysics Conference Milan (2012)
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