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COMPUTATIONAL MODELS OF HEAT AND MASS TRANSFER IN THE TEXTILE STRUCTURES

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INTRODUCTION

The aim of this study is to develop computational models of the heat and mass exchange processes that occur in modern composite textile structures of three-dimensional internal structure. The proposed finite element models enable the prediction of air permeability and heat transfer coefficients of textile structures in the early design stage. Furthermore, the finite element models were verified by comparing the sample variants of the calculated objects with the experimental measurements presented in the scientific literature. These models might be used in the development of protective clothing, airbags, fireproof seat covers, passive and active cooling systems, and others [1]. In order to facilitate the use of computational models for numerical analysis in manufacturing departments or test laboratories, the proposed finite element models were extended to the simulation apps using Comsol Multiphysics Application Builder.

COMPUTATIONAL METHODS

This research is based on our previous work [2-4]. In this study, we present an application of 3D computational models of heat and mass exchange in the active cooling system. Governing equations consist of a set of Navier–Stokes and energy equations. The boundary conditions that are applied in the ventilation model are presented in Figure 1. More details in literature [3,4].

Navier-Stokes equations were applied in the free flow spaces (air domain).

$$\rho(\mathbf{u}\cdot\nabla)\mathbf{u}=\nabla\cdot\left[-p\mathbf{I}+\mu\left(\nabla\mathbf{u}+(\nabla\mathbf{u})^{T}\right)-\frac{2}{3}\mu(\nabla\cdot\mathbf{u})\mathbf{I}\right]+\mathbf{F}$$

$$\nabla\cdot(\rho\mathbf{u})=0$$

Here ∇- the gradient operator, $\mathbf{u}$- fluid flow velocity, ρ - fluid mass density, p -fluid pressure, μ- fluid dynamic viscosity, $\mathbf{I}$- identity matrix.

Energy equation

$$\rho C_p \boldsymbol{u}\cdot\nabla T+\nabla\cdot\boldsymbol{q}=Q, \quad \boldsymbol{q}=-k\nabla T.$$

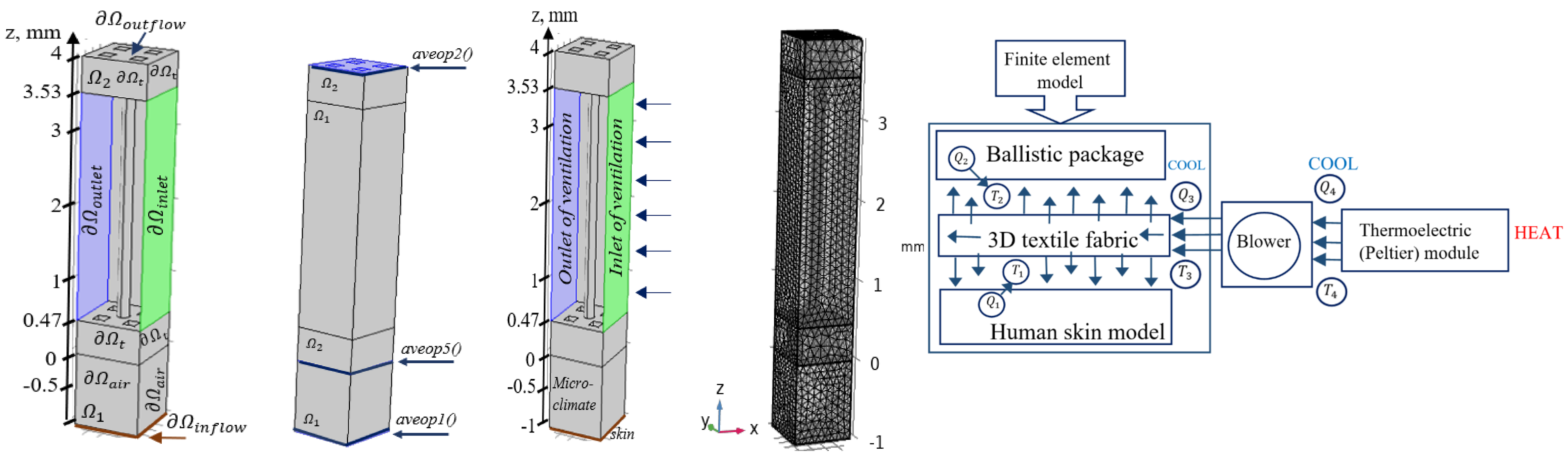


Figure 1. The heat and mass exchange scheme in the active cooler system

NUMERICAL RESULTS

In order to create a user-friendly environment, the developed models were extended using Comsol Multiphysics Application Builder [5]. The model tree (see Figure 2.) was simplified using the form editor and method editor for detail analysis. According to the literature [6], the most important properties of thermal comfort are air permeability, thermal resistance (or heat transfer coefficient). The main results that was evaluated are depicted in Figure 3.

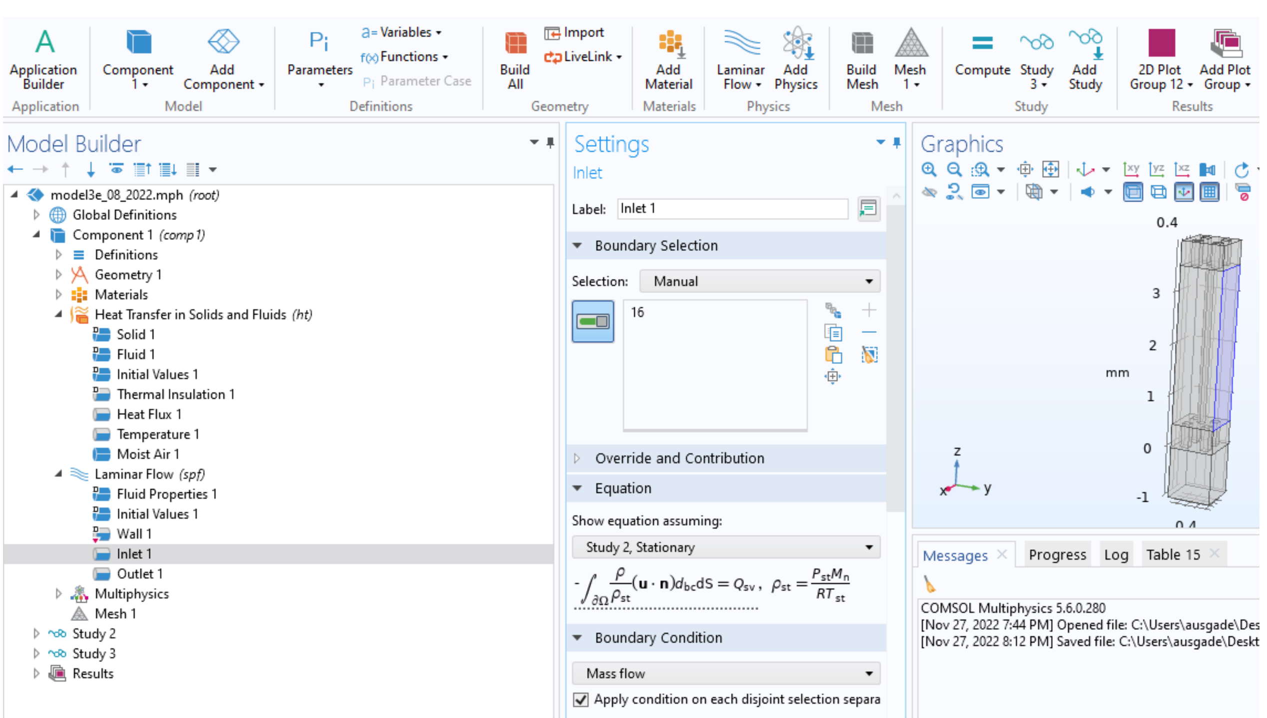
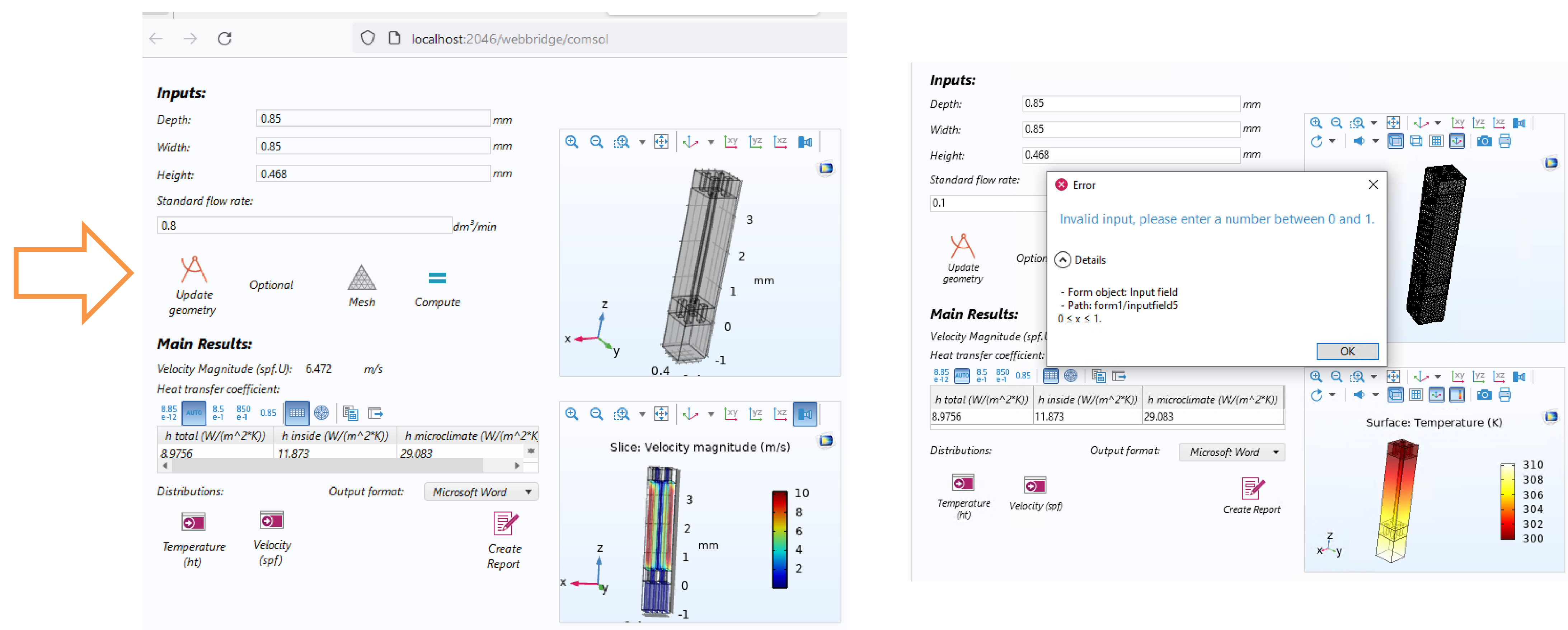


Figure 2. The ventilation model



CONCLUSIONS

The proposed methodology allows for predicting the air permeability (AP) and heat transfer coefficients. The prototype of apps might enable more users to access simulation in an organization (such as in manufacturing departments or test laboratories). For this reason, product designs and processes can be improved efficiently and effectively.

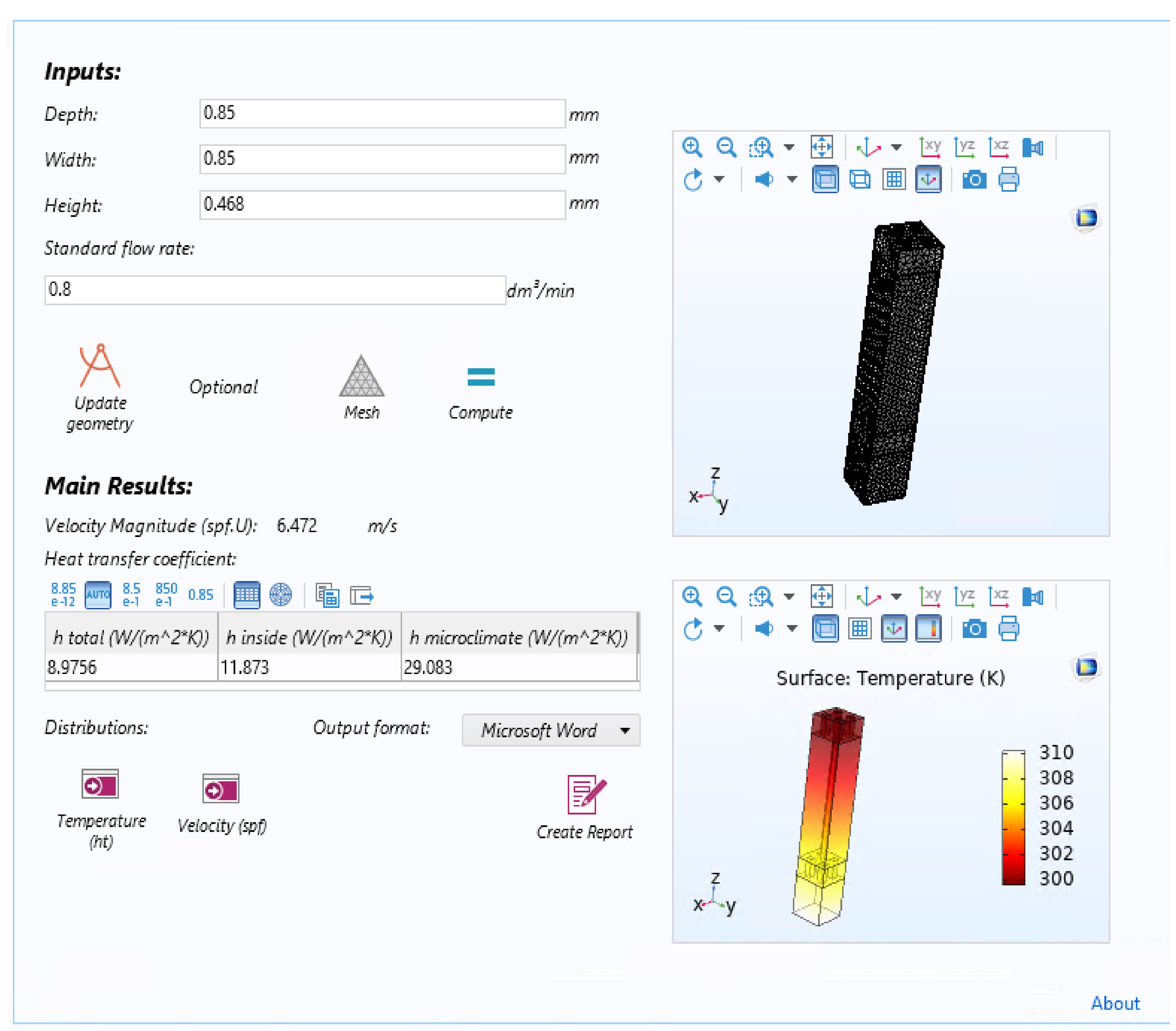


Figure 3. Ventilation model app

REFERENCES

[1] Y. Li, “The science of clothing comfort,” Textile Progress, vol. 31, no. 1–2, pp. 1–135, 2001

[2] A. Gadeikytė, D. Sandonavičius, V. Rimavičius, and R. Barauskas, “Finite Element Analysis of Heat and Mass Exchange Between Human Skin and Textile Structures,” Baltic Journal of Modern Computing, vol. 10, no. 2, pp. 159–169, 2022.

[3] A. Gadeikytė and R. Barauskas, “Investigation of influence of forced ventilation through 3D textile on heat exchange properties of the textile layer,” Journal of Measurements in Engineering, vol. 8, no. 2, pp. 72–78, 2020.

[4] A. Gadeikytė, “Multiscale models and algorithms for the simulation of heat and moisture transfer in textile,” Kaunas University of Technology, 2022.

[5] Comsol, Introduction to application builder.

[6] D. Tessier, Testing thermal properties of textiles. Elsevier Ltd., 2017