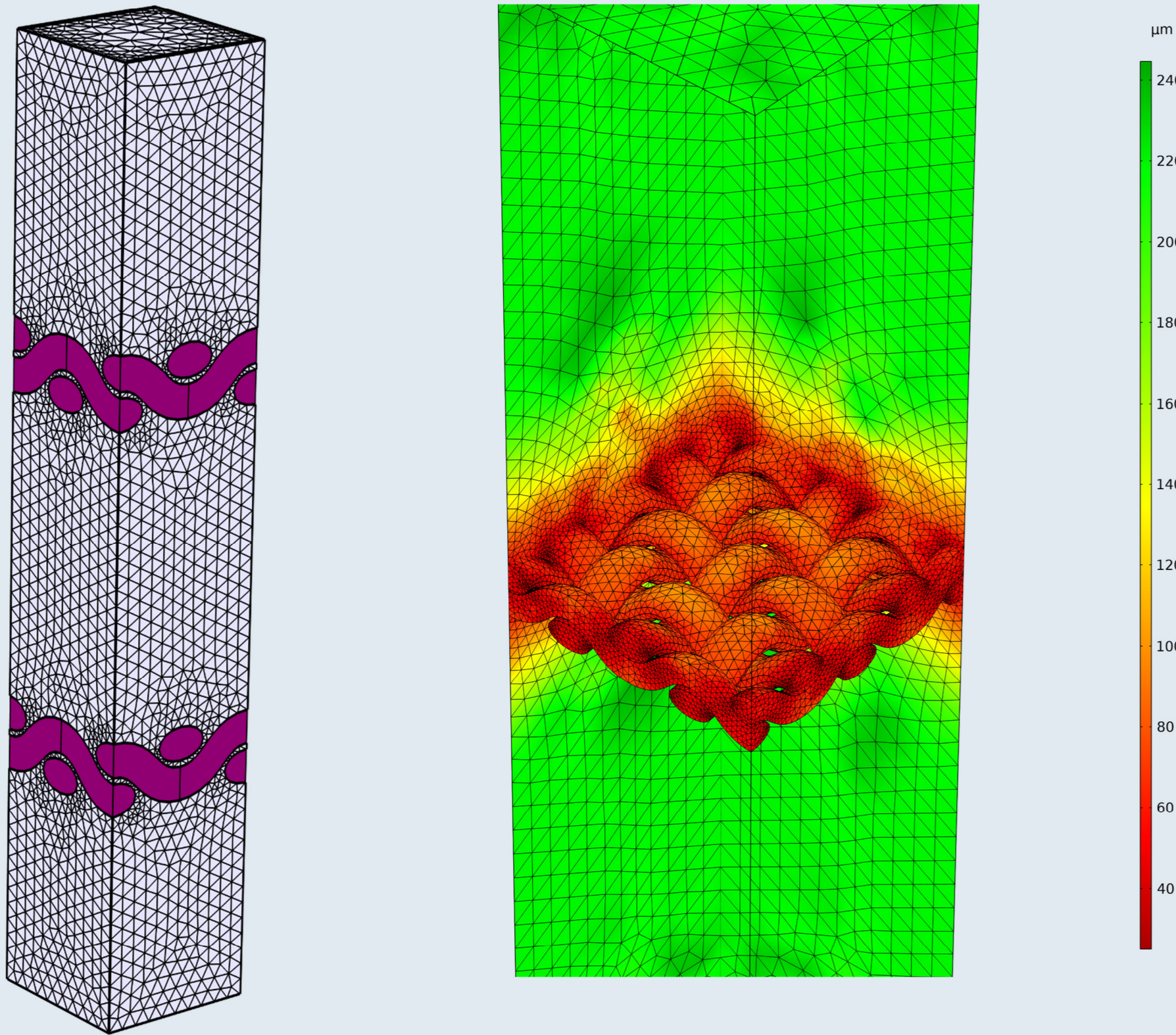


Numerical Simulation of Thermal Resistance and Heat Transfer Coefficients of Textile Structures

The intention of this study is to investigate heat and mass exchange between the human body and textile structures with additional ventilation. The forced ventilation model at a micro-scale was developed.

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Introduction

One of the challenges for protective clothing designers is to ensure thermal comfort to the wearer. In order, to reduce the thermal barrier between the protective clothing and the body, ensuring an optimal microclimate, a number of clothing systems have been developed in the world [1]. These systems might be divided into passive and active cooling systems. In this investigation, we propose a computational model of the air ventilation principle (active cooling) on a micro-scale.

Figure 1. illustrates the heat and moisture exchange in an active cooling system. Developed models facilitate the evaluation of average temperature and temperature distributions through different through-thickness positions along the axis Oz. Also, allows us to determine thermal comfort properties such as thermal resistance and heat transfer coefficients which might be applied in macro-scale models.

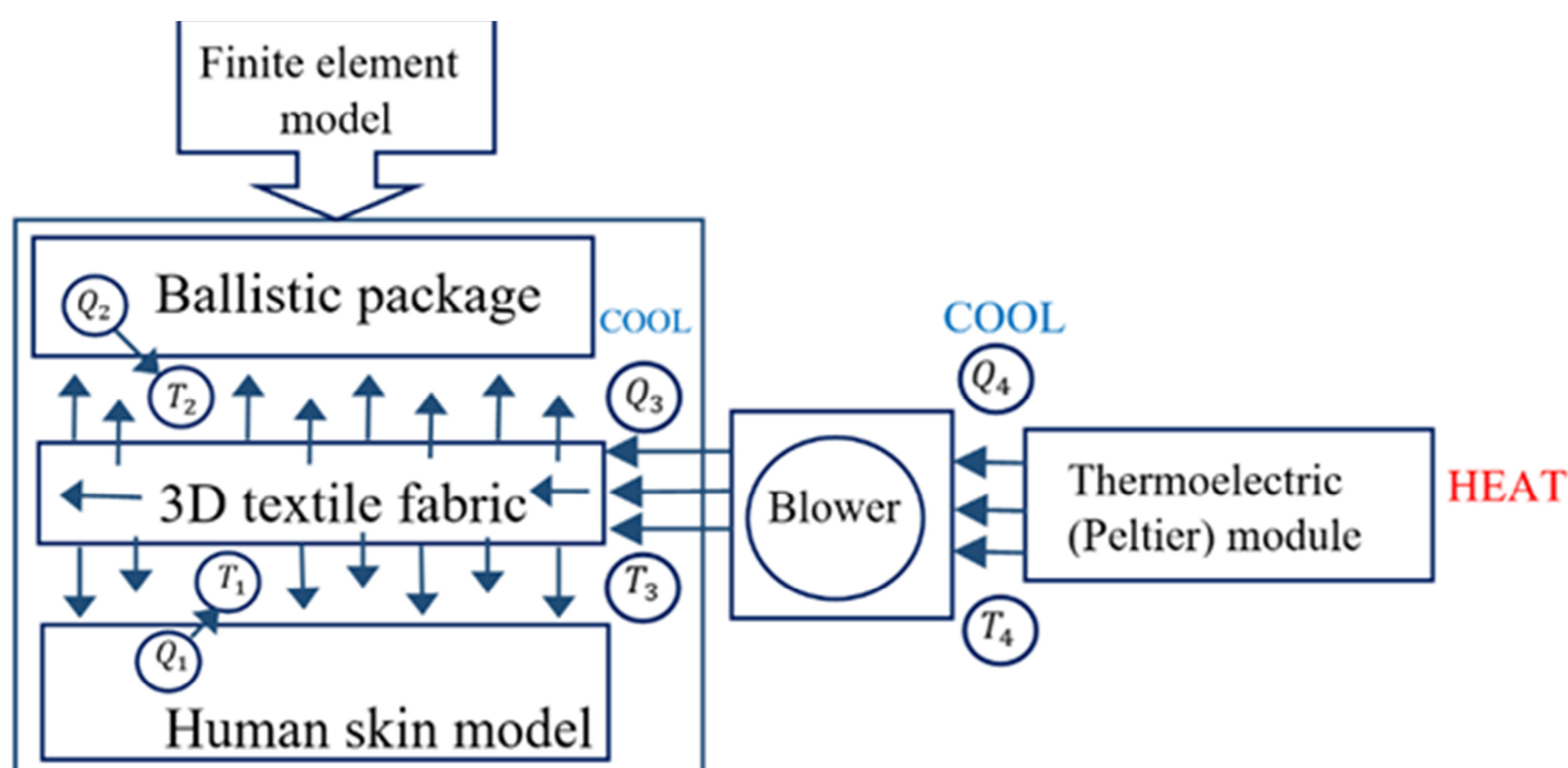


FIGURE 1. Principal scheme of heat and moisture exchange in the active cooler system [1].

Methodology

Forced ventilation model assumptions: the fluid flow is a laminar incompressible flow. It should be noted, the computational model is applicable in the range of small flow rates. The heat exchange occurs due to conduction, convection, and the flow is non-isothermal flow. These assumptions cover **Navier-Stokes and Energy equations**. Detailed explanation of governing equations and boundary conditions is based on the research carried out by the authors of this poster [2].

The optimal mesh size selection and the size of a unit cell were taken into consideration. It should be highlighted that the forced ventilation problem is not straightforward. **One of the challenges is that air pressure and air flux density decrease by passing through numerous cells** and it is unknown the actual pressure on the outlet boundary condition. For this reason, different sizes of a unit cell should be taken into account.

Results

It was found that the average temperature in a microclimate is 30.81 [degC] when inlet standard flow rate is 0.000014716 [m³/s]. Also, it was obtained that the effective heat transfer coefficient is 25.60 [W/(K*m²)].

Limitations. The proposed model might be improved using a turbulent flow regime.

The computer simulation of heat and mass transfer through textile structures with additional ventilation were done using COMSOL Multiphysics® [3] and MATLAB® software.

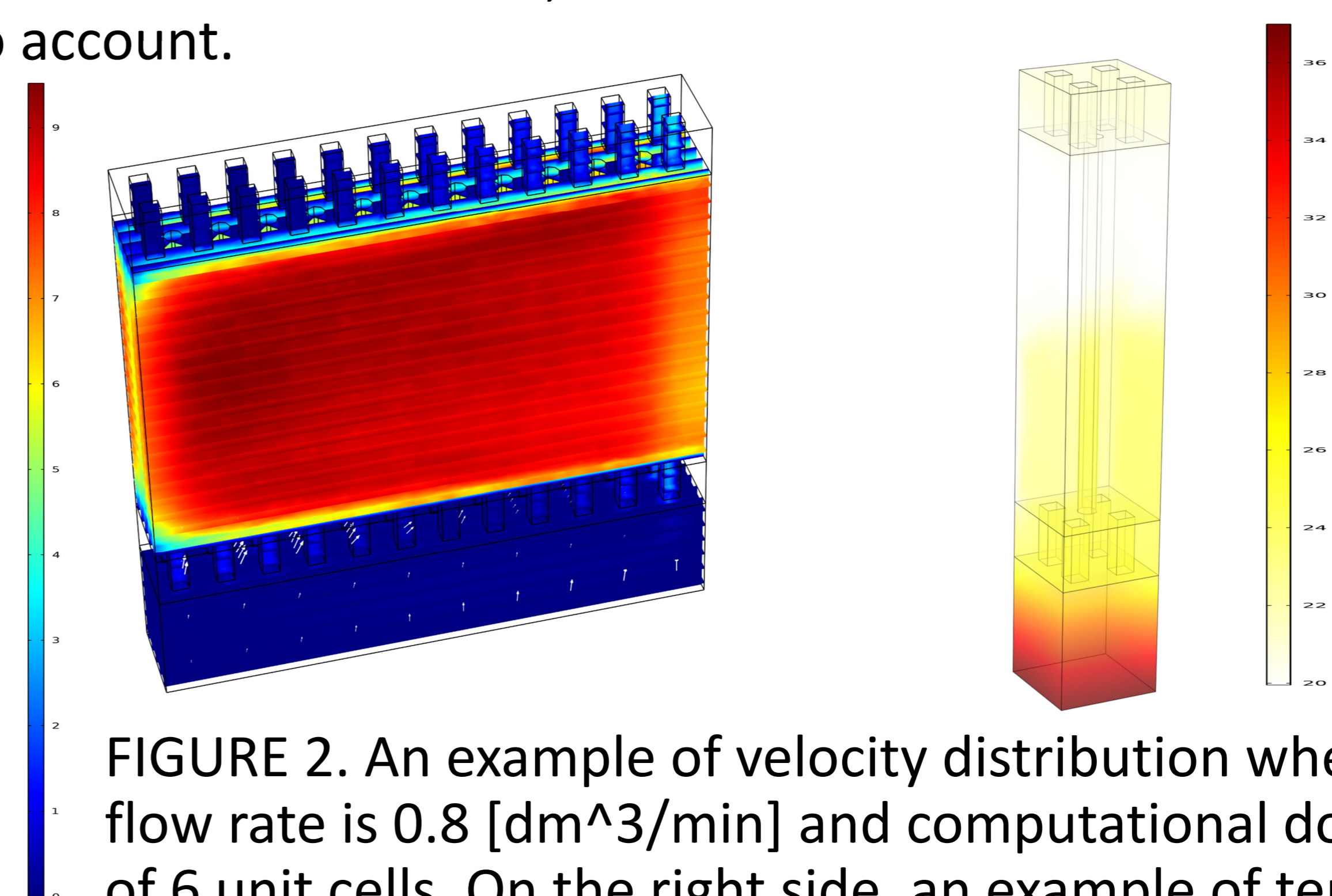


FIGURE 2. An example of velocity distribution when inlet mass flow rate is 0.8 [dm³/min] and computational domain consists of 6 unit cells. On the right side, an example of temperature distribution when inlet standard flow rate is 0.000014716 [m³/s] and outlet flow rate is 0.000014552 [m³/s].

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