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A numerical simulation study on the thermal performance of ventilated clothes

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In warm climates and particularly during activities involving high level of exertion, the body depends strongly on sweat evaporation to maintain its thermal balance [1]. However, if this mechanism for heat loss is hampered, e.g. by the use of protective clothes, moisture can accumulate near the skin, decreasing the driving force for evaporation, which results in lower rate of sweat evaporation and increased risk of thermal discomfort of the user. Yet, this scenario can be avoided by imposing some degree of convection in the clothing microclimates in order to ensure the continuous removal of sweat released by the body [2]. This can be achieved by integrating a fan-based solution in the clothing structure.

In order to study the performance of a fan-based cooling solution for clothing products, a numerical study on the coupled heat and mass transport phenomena was conducted. Energy, momentum and continuity equations describing the transport processes across the several domains of the system (i.e. microclimate between skin and clothing, multi-layer clothing assembly and surrounding environment) were solved using a FEM-based approach. The model takes into account the diffusion and convection of water vapour in the clothing porous and in the microclimate, the sorption/desorption of water vapour in the fibres, the phase change of water, as well as the heat conduction through the simulation domains [3]. The model was used to study of the influence of the imposed air flow rates, properties of the clothing layers as well as their relative position, over the water distribution within the clothing layers and the overall heat/mass transport from the body. The results indicate that the characteristics of the clothing structures (e.g. porosity and tortuosity) play a very important role in the total mass/heat removal.

The approached described here can be used to study, predict and optimise the thermal performance of products used near the body (clothing, footwear, gloves, headgear, etc.)

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