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「社会構想マネジメントを先導する グローバルリーダー養成プログラム」

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東京大学大学院
工学系研究科

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Physiologically-Based Models of Human Thermal and Respiratory Systems and Their Application in Engineering and Medical Sciences

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The focus of this presentation is the development of physiologically-based computatonal models of the human thermal and respiratory systems and their application in engineering and medical sciences. The models allow the determination of temperature, blood flow rate, content of oxygen, carbon dioxide and carbon monoxide in different tissues of the human body, depending on the ambient conditions and the physical activity levels. The human body was divided into 15 segments: head, neck, trunk, arms, forearms, hands, thighs, legs and feet. Each segment contains an arterial compartment and a venous compartment which represent the large vessels. The blood in the small vessels is considered together with the tissues – muscle, fat, skin, bone, brain, lung, heart and viscera. The gases – O2, CO2 and CO – are transported by the blood and stored by the tissues dissolved and chemically reacted. Metabolism takes place in the tissues, where oxygen is consumed generating carbon dioxide and heat. The skin exchanges heat with the environment by conduction, convection, radiation and evaporation. The respiratory tract exchanges heat by convection and evaporation. In the lungs, mass transfer happens by diffusion between an alveolar compartment and several pulmonary capillary compartments. Some important geometrical features were included: 3D heat conduction, the use of elliptical cylinders to adequately approximate body geometry, the careful representation of tissues and important organs. The models were validated by comparing their results with experimental data and the agreement was excellent. These models were used to predict the behaviour of the human body under different hazardous environmental conditions such as thermal stress, decompression accident in airplanes, compartment fire, urban atmospheric pollution, with very interesting results. Other developments include the use of the human thermal system model embebbed in a commercial CFD software to be used in thermal comfort and air quality simulations. These models were also used for the exergy analysis of human body performance under physical activities and for the assessment of the thermal comfort conditions.

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