Modeling Effective Thermal Conductivity of Porous Materials Including Radiation

Graduate

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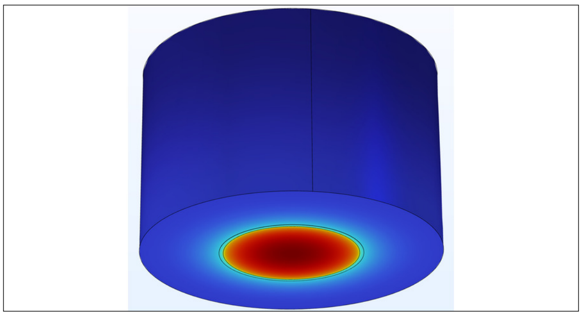
Initial Situation: Fire protection systems represent an indispensable foundation for the safety of people, buildings, and infrastructures. In the event of an emergency, they must reliably prevent fires from spreading uncontrollably and critical structures from failing. A particularly effective strategy is the use of intumescent materials, which expand into a foam when exposed to fire and thereby form an insulating protective layer. This layer significantly reduces heat transfer, prolongs the stability of load-bearing components, and can thus play a crucial role in limiting damage and saving lives.

Approach / Technology: The Hot-Disk TPS-2500s was used to characterize the material, complemented by methods such as the Transient Hot Bridge, Differential Scanning Calorimetry, and Thermogravimetric Analysis. This allowed for a comprehensive determination of both the thermophysical and thermomechanical properties of the fire protection material. Based on these measurement data, different modeling approaches were applied and compared to calculate the effective thermal conductivity. Furthermore, the thermal conductivity was formulated as temperature-dependent in order to better understand the material's behavior under real fire conditions. In addition, selected modeling approaches also considered the influence of thermal radiation occurring in the porous material.

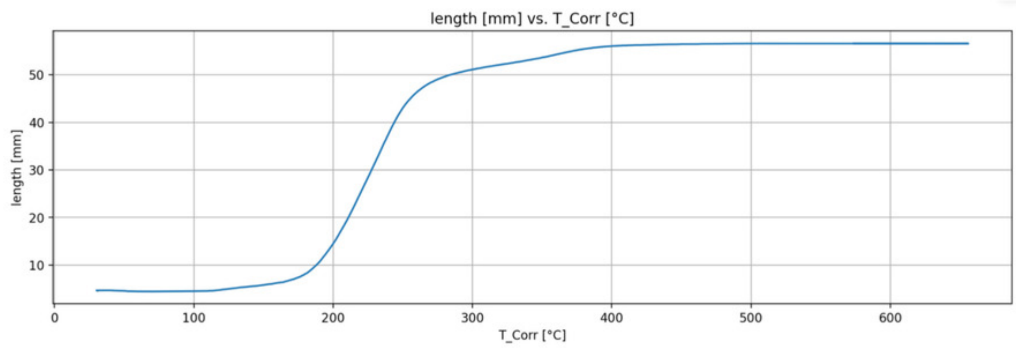
Result: The investigations show that the initial material and the resulting ash in the intumescent process exhibit significant differences in thermal conductivity, density, and porosity. Simulations and measurements confirm a consistent picture of the material behavior. The results provide valuable foundations for the optimization of fire protection systems and open up perspectives for future material developments.

Result of a Hot-Disk simulation for the validation of the measurement data
Own presentment



Microscopy image of an intumesced sample
Own presentment

Expansion behavior of the fire protection material under increasing temperature
Own presentment



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