Components of thermal conductivity over a large range of temperature of thermal insulation products

Alain Koenen, LNE

In the context of global warming and energy saving, the insulation of buildings and industrial plants become crucial. In 2019, the European Commission launch the Green Deal strategy which one aim is carbon neutrality of Europe. The improvement of thermal insulation product are then logically part of this strategy.
In this context, the thermal insulation of building equipment's and industrial installations is very important for the energy efficiency due the important temperature reached. It's well known that the thermal conductivity of insulation materials can be divided into three parts, solid, gas and radiative. When the temperature increases the impact of insulation become more important. The determination of each part can help to improve the thermal insulation product.

This paper proposes to identify the three components of the thermal conductivity from thermal conductivity curves obtained on a large range of temperature on fibrous insulation material.
The thermal conductivity curves are determined with a Guarded Hot Plate method, which has been standardized under the International Organization for Standardization (ISO 8302) and ASTM International (ASTM Test Method C 177). It determines steady-state thermal transmission properties of flat slab specimens having a low thermal conductivity. The standard test methods for the guarded hot plate utilize the one-dimensional steady-state thermal conductivity equation for the determination of thermal conductivity (λ):

$$\lambda = QL/(A.DT)$$

where Q is the time-rate of one-dimensional heat flow through the meter area of the guarded hot plate (W); A is the meter area of the apparatus normal to heat flow (m2); ΔT is the temperature difference across the specimen (K); and L the specimen thickness (m).

The gas part can be determined by the thermal conductivity curve of air. For product optically thick, the radiative part become preponderant and can be assessed with the value of extinction coefficient of Rosseland. The determination of this coefficient by optical method is subject to a large uncertainty and the measurement done by guarded hot plate means can be used for this. The solid part can be determined with thermal conductivity measurement at low pressure.