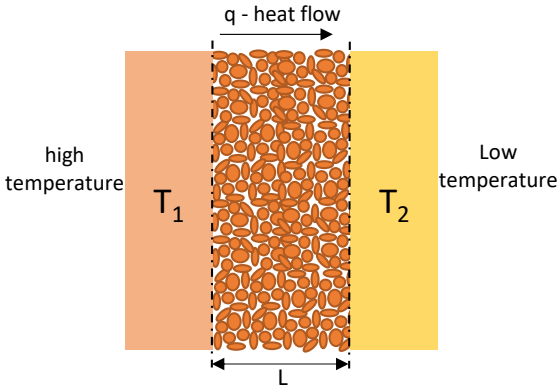
Basic knowledge: physical properties of bulk solids V; Thermal conductivity

The thermal conductivity of a bulk solid is its ability to conduct heat through the bulk. It is not to be confused with the thermal conductivity of the soilds that are in the bulk. A high thermal conductivity means the material is allowing an efficient heat conduction, while a low thermal conductivity means that the material is well insulating.

As you can imagine, the thermal conductivity of the bulk will be much lower than the one from the solids itself. That's because the solids are only touching each other at a small fraction of the surface, and the void space between the solids is filled with another medium (such as air) which will act as insulation if stationary.



k…thermal conductivity

In principle, the thermal conductivity is defined as followed (which is also known as the Fourier's law):

$$q = -k\frac{T_1 - T_2}{L}\left(\frac{W}{m\,K}\right)$$

q…heat flux
T1…Temperature
T2…Temperature
L …thickness of material

Determining the thermal conductivity of bulk solids can be done in steady state or transient. As you can imagine, transient measurements are more complicated. In both cases, the experimental setup is quite advanced. While the preparation of the test with solid material isn't that complicated, the preparation of a sample – as well as the measurement method for bulk solids – is more difficult. Various physical properties need to be considered such as bulk density, particle size distribution and moisture. All of these, as well as time consolidation, will have impact on the thermal conductivity measurement (for more information on thermal conductivity measurement, please check out my previous post).

Consequently, it is extremely important to perform such measurements with the sample in a way that it is representative for the application where you need to calculate the heat flux via the determined thermal conductivity. This means if you need to calculate heat flux through a vertical layer as shown in the above sketch, then the measurement should also be vertical.

Thermal conductivity is a figure you cannot take blindly. Talk to experts in the field who will be able to help you find or determine the right figure relevant for your application.

Next time, we will learn more about particle size distribution.

As always, please do not hesitate to message me with questions/comments.

Gerald Marinitsch, has broad and comprehensive background in management, mechanical and process engineering and since 2014 is working with a team of experts at Solex on heat exchangers for bulk solids.

'*After several years of working with bulk solids heat exchangers, I realized that bulk solids knowledge is not widely spread throughout the engineering society. Consequently, I decided to summarize some basic knowledge in a series of articles* '

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