Thermophysical Properties Characterization of Insulating Materials

J. Blumm
NETZSCH-Gerätebau GmbH, Wittelsbacherstr. 42, 95100 Selb/Bavaria, Germany

1. Introduction

In the last decades, measurement of thermophysical properties such as thermal conductivity or thermal resistance have become increasingly important for the determination of heat transfer properties of industrially-relevant materials. One example is the optimization of heat transfer in thermal insulations used in the construction of houses. Reduction of the thermal conductivity of materials employed can significantly reduce the energy consumption of the entire building. Methods and instruments are required to measure not only the thermal conductivity at room temperature but also the temperature dependence.

For decades plate-type systems such as guarded hot plate systems are established as standard methods for the analysis of insulating materials. Large possible sample sizes,a wide temperature range and high accuracy are only some of the advantages of this method. Long measurement times and high preparation efforts, on the other hand, must be considered in the application of absolute measurement techniques.

2. Heat Flow Meter Technique

Nowadays the heat flow meter technique (figure 1) is more and more frequently used for the characterization of insulating materials. The sample is positioned between two plates which are kept at different temperatures. Additionally, two heat flow sensors are mounted on the surface of the plates. By measuring the heat flow, the temperature difference between the plates and the sample thickness (with an integrated LVDT-system) the thermal conductivity can be determined. Employment of state-of-the-art technologies for the design of such instruments allows easier test preparation and significantly faster testing times compared to other techniques. Presented in figure 2 is a photo of the NETZSCH HFM 436 Lambda Series heat flow meter systems available for the measurement of the thermal conductivity of e.g. insulating materials. The HFM 436 Lambda series instruments allow temperature-dependent measurements between -20 and 100°C. The systems are suitable for materials with thermal conductivities between approx. 0.005 and 0.5 W/(m·K). Depending on the instrument version, square samples of 30 cm x 30 cm and up to 10 cm thickness or 60 cm x 60 cm and up to 20 cm thickness can be analyzed. Therefore, it is the optimum tool for testing low-conducting inhomogeneous materials such as fibers or foam insulations.

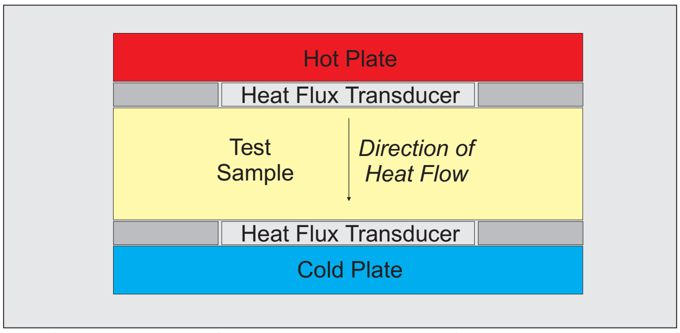

Fig.1 Schematic Design of a Modern Heat Flow Meter System

Fig. 2 NETZSCH Heat Flow Meter Systems HFM 436/3 and HFM 436/6

3. Test Speed

Crucial for the application of such instruments for quality control is the measurement time required for the determination of the thermal conductivity of a material. Due to the special setup of the unit and the use of two heat flux transducers, testing times of less than 20 minutes can be realized. Presented in figure 3 is the stabilization time of the measured thermal conductivity of a glass fiber insulation versus time. The sample was put into the unit at 11:23. After 15 minutes, the measured result of the thermal conductivity stabilized within +-0.5%. Even after waiting several hours, the measured value remained unchanged. This example clearly demonstrates the fast testing speeds possible with the new generation of heat flow meter systems .

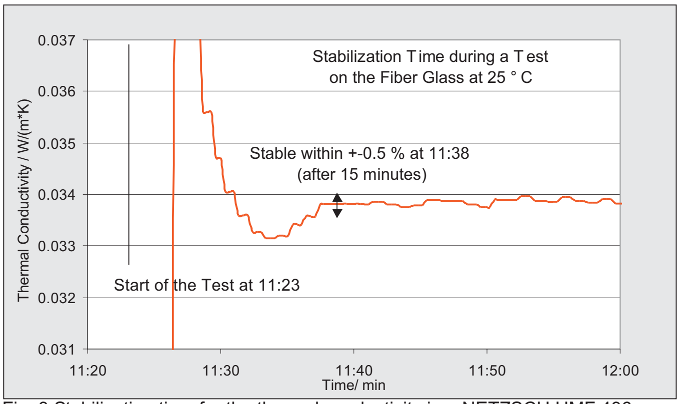

Fig. 3 Stabilization time for the thermal conductivity in a NETZSCH HMF 436

4. Accuracy

Figure 4 shows a comparison of the measured thermal conductivity of an insulation plate measured with two different heat flow meters HFM 436 and a guarded hot plate system NETZSCH GHP 456. The guarded hot plate system (absolute measurement technique) allows measurement results to higher temperatures. In the overlapping region all results agree within 2.5%. This example clearly demonstrates the good reliability and accuracy of the HFM 436 systems.

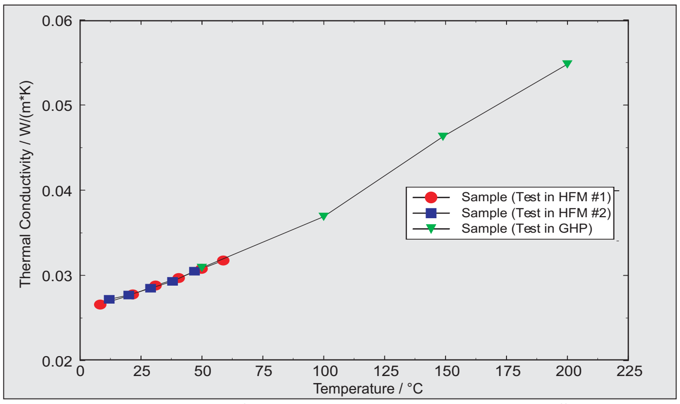

Fig. 4 Thermal conductivity of an Insulating Board measured with different techniques

5. Application

The NETZSCH HFM 436 series instruments can be employed for a wide range of insulating materials such as glass or mineral fibers, polystyrene or elastomer foams or powders. Figure 4 shows the measurement results for a black elastomer foam measured three times with the HFM 436 between 12 and 47°C. For each test, the sample was removed from the instrument, turned and put into the system again. It can be seen that even under such conditions the system allows a reproducibility of the results better than 1%.

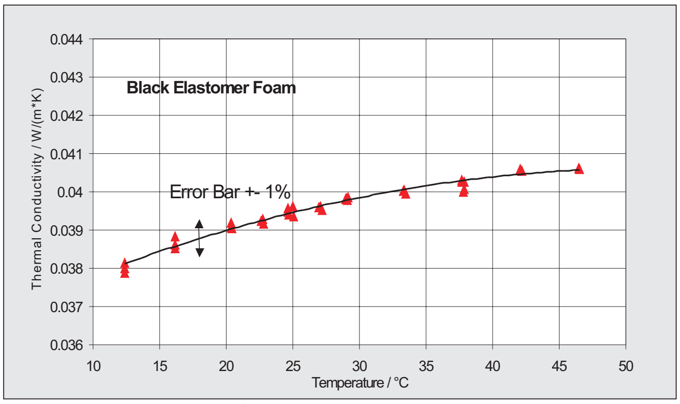

Fig. 5 Thermal conductivity of a Black Elastomer Foam measured 3 times with the HFM 436, carrying out a new preparation for each test