Design, Development, and Testing of a Resistive Adiabatic Calorimeter

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The design, construction, and evaluation of a resistive adiabatic calorimeter (RAC), in which the specimen is heated using the Joule effect, are described. The apparatus can be used to determine heat capacities of viscous substances and gel-type materials. The main structure of the calorimetric cell is constituted by a cylindrical jacket and two pistons. As well as for containing purposes, the pistons also function as electrodes for the sample. The outer cylinder (jacket) is surrounded by silicone oil, which is heated up to the desired temperature using an electrical resistance. The electrodes are also heated independently. Sixteen thermocouples, distributed in different zones than the cell, are used to control and monitor the temperature involved in the measurement. Data acquisition is done with a PCI card using a Lab-View program.

The energy supplied to the sample is based on principles of Ohm's law. An AC voltage in the kHz range is used, which establishes a current in the sample and induces heat dissipation through it. The dissipated power can be measured with enough accuracy to determine the heat capacity of the sample.

In order to achieve adiabaticity, the heat transfer from the sample to the electrodes and jacket is minimized by keeping the temperature of the sample, electrodes, and jacket, the same throughout the measurement period.

A theoretical model was developed in order to obtain the temperature distribution of the system, taking into account the geometry, heat sources, and thermophysical properties of the cell. The performance of the RAC was evaluated by comparing the heat capacity results to those obtained by DSC measurements made using a commercial calorimeter. In the case of maize starch, the heat capacity measured by the RAC was 1.55 kJ/kg·K at 298 K, which is close to the value obtained by DSC, 1.43 kJ/kg·K.