Accurate Solution of the Thermal Problem for the Thermal Capacitance (Slug) Calorimeter Method

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The Slug Calorimeter method (ASTM E2584-14) can be used now for accurate thermal diffusivity and volumetric specific heat measurements of fire resistive and similar materials (at temperatures up to ~1100 K). Setup consists of a stainless-steel plate (slug) of known specific heat, "sandwiched" between two identical flat samples. If the temperature of the samples' outer surfaces is changing at a constant rate, then the recorded difference between the samples' surfaces' temperatures contains information about the samples' thermal properties. Accurate solution of this thermal problem was obtained by applying Duhamel's convolution integral to the known analytical solution for the same setup with constant temperature on its outer surfaces. New accurate formulas were derived, and a procedure is proposed for the simultaneous measurements of both thermal diffusivity and volumetric specific heat. Thermal conductivity and thermal effusivity can be calculated too. Conditions to achieve the best possible accuracy were found. Validity of the new formulas was verified by numerical experiment using finite elements analysis.