Methods and Setup for Calorimetric Analysis of Metallic Latent Thermal Energy Storage Systems

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Latent thermal energy storage systems are regarded as one possible solution to increase the range of battery electric vehicles in winter term conditions. Using a metallic Phase Change Material (mPCM) as for example the eutectic binary alloy $AlSi_{12}$ is beneficial due to its high energy density (950 kJ/kg when operating between 100 °C and 600 °C). Furthermore, its high thermal conductivity (up to 200 W/m·K) enables high thermal outputs. This is essential for vehicle application because of the necessity for short charging times and fast heat supply.

Besides the characterization of the storage material itself, methods for calorimetric analysis of complete storage systems are required. The methods should operate under conditions similar to real application e.g. size, heating and cooling rate, heat flow directions and thus arrangement of subcomponents for heat in- and output as well as realistic interfaces to subcomponents. Of special interest in later application of the methods is the influence of reactivity between storage material and container material on the stored and usable energy developing over time and cycling.

For these purposes a test setup was designed with the possibility to perform three proposed calorimetric procedures. For all methods the heat in the storage system is received from balancing heat put electrically into it, heat put into the setup components, and heat put out by losses or working fluid.
For the Adiabatic Method without working fluid, the power of electrical heat is measured as well as the heat put into the setup components. Heat losses are correlated to the surface temperature of the setup by calibration.
For the Heat balance method with working fluid, heat additionally is put out by a

working fluid, which is determined via massflow and temperature measurement of the fluid before and after passing the storage. For the Heat flow method with working fluid, the heat output of the storage (by loss and working fluid) is correlated to the temperature of the heat exchanging area.

These three methods were investigated via transient simulation regarding the resulting uncertainties for determining stored heat, heat capacity, heat of fusion and temperature of fusion arising by the method itself. As result the proposed methods can be rated regarding their suitability of characterizing latent thermal energy storage systems using mPCM.