Thermal Characterization of Hydration-Dehydration behavior of MgO Composites as Candidates for High-Temperature Waste Heat Storage

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Abstract

The recent energy transition in Germany and the subsequent growing in importance of renewable energy sources have brought new opportunities but equally some challenges regarding efficient energy storage systems due to the fluctuating nature of this type of energy sources. Concerning waste heat utilization, conventional thermal storage systems are mostly designed for the storage of sensible or latent heat [1]. For the case of high-temperature applications involving thermochemical storage, the reaction system MgO-Mg$(OH)_2$ appears as a potential candidate due to its good reaction reversibility, low cost, availability, non-toxicity and high energy density [2]. However, this system exhibits very low thermal conductivity, which is a major drawback if coupled for instance, to industrial waste heat sources. This in practice incurs in high investment costs due to the design of special heat exchangers with larger surfaces. An additional burden by the utilization of heat storage systems based on metal oxides is the large density variation, which induces agglomeration of particles thus compromising cyclability. Earlier and current research on the MgO-Mg$(OH)_2$ system focuses mainly on kinetic aspects of the hydration-dehydration process [3,4] but there is very little knowledge regarding thermal conductivity, enthalpy of reaction and cycle stability of MgO composites.

In a previous screening at Fraunhofer UMSICHT of several commercial MgO materials, two were identified as promising candidates for thermochemical storage but only one was chosen for the production of composites. A potential way to overcome the burdens mentioned above appears to be the development of composites with higher thermal conductivities without a significant loss of energy density through the addition of expanded graphite (EG).

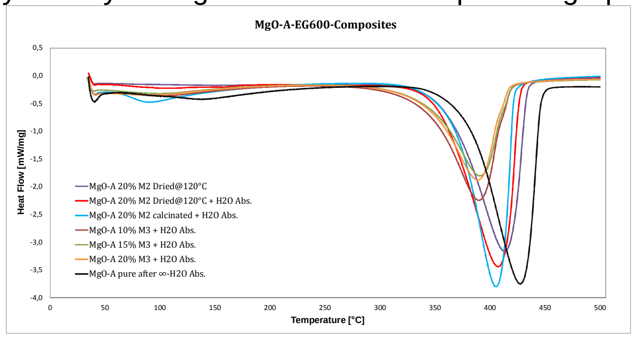

Figure 1: Thermogram of different MgO-EG samples produced by two methods: M2 (manual mixing) and M3 (ball mill)

In order to understand the hydration-dehydration behaviour of the MgO-Mg$(OH)_2$ system alone or in combination with adequate dopants, which may enhance both kinetics and thermal conductivity, it is necessary a deep characterisation of the thermal properties of such composites by using techniques such as TG, DSC and HotDisc. The characterisation results obtained from samples produced by three different methods will enable in the upcoming future the development of tailor-made composites with materials with high thermal conductivity and stability, such as expanded graphite (EG) for applications in the temperature range below 500°C.

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