Introduction of PCM Flux as a Dynamic High Temperature Latent Heat Storage Concept

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H. Pointner, W.-D. Steinmann, M. Eck

German Aerospace Center (DLR), Institute of Technical Thermodynamics, Stuttgart, Germany

Abstract

In times of a rising share of fluctuating renewables in the worldwide energy mix, there is a great need for energy storage units allowing harmonization of electricity production and consumption. Using phase change materials (PCM) to store heat for a flexible electricity generation with direct steam generating solar thermal power plants promises a good overall efficiency due to small temperature gradients that occur. This good efficiency, however, is associated with the need for expensive heat transfer structures (HTS) because of a poor thermal conductivity in PCMs. The required ratio of HTS and PCM to achieve an acceptable effective thermal conductivity is constant, and upscaling a storage unit is not expected to reduce costs significantly. With respect to the local fixation of the PCM, the system is defined as a static system. While discharging, the maximum heat flux decreases with time due to a growing and isolating layer of solidified PCM on the heat exchanger modules. One possibility to overcome this problem is the development of new dynamic concepts of PCM storage systems with moving PCM. In such systems, the isolating layer of PCM is slid away from areas with the highest heat transfer. The heat flux can thereby be controlled accurately by the PCM`s velocity.

In this paper, PCM Flux as a completely new PCM storage concept is presented. PCM Flux is compared to other dynamic concepts and to the state-of-the-art static PCM storage system regarding possible heat flux and performance. The comparison outlines the outstanding properties of PCM Flux. Simulations with a specifically developed finite difference method tool modeling the movement of PCM, aluminum and steel, show a fully controllable heat flux with a peak power of 10 kW/m² at a ΔT of 10K. Additionally, a negligible parasitics share of 0.13% arises in this storage system. The heat exchanger with its HTS only has to be designed for the nominal power output independent of the storage capacity. That is why the relative costs decline is inversely proportional to the storage size. The PCM Flux concept represents a PCM storage system with strict separation of power and capacity reducing the specific electricity costs of direct steam generating solar thermal power plants significantly.