Implementation of phase change material for the optimization of the heat accumulation system of Carnot Batteries

Among the main components of a thermodynamic energy storage system (Carnot Batteries), thermal reservoirs are those, which most influence the round-trip efficiency (RTE)[1]. In this sense, the heat storage and transfer processes must be maximized in terms of energy capacity and optimized in terms of accuracy of the working temperature range. This twofold objective can be achieved by implementing original transport and storage devices, which benefit from the advantages provided by certain phase change materials (PCM). Indeed, PCMs based on organic matter (oils) can transport and exchange a large amount of thermal energy due to their latent heat of fusion. These substances, when dispersed in an immiscible fluid such as water (oil-in-water emulsion), can function as a subsequent heat transfer fluid capable of supplying and subtracting a large amount of thermal energy within a well-defined temperature range. Out of this range, the sensible heat exchange mechanism takes over. Although recent developments have highlighted the advantages offered by such emulsified systems, working temperatures remain the limiting point, and the relevant applications are generally characterized by values below 90°C.

The objective of this PhD project is to formulate a new emulsified system based on PCM capable of operating at temperatures meeting the requirements of a Carnot Battery. More precisely, the PCM have to exchange the latent heat of phase transition (liquid-solid and vice versa) in a temperature range between 110 and 120°C. The new emulsion will be studied in all its specific aspects (such as: fraction of the components of the mixture, stability, thermal and pressure cyclic response, lifespan, thermo-chemical properties, supercooling, particle size distribution, viscosity, environmental issues, etc.) as well as heat transfer fluid[2,3]. The evaluation of the performances (in terms of heat transfer coefficient) of the new heat transfer fluid when compared to a conventional single-component fluid will assess the benefits of the implementation of the new phase change dispersion[4].

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