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THERMAL PERFORMANCE ANALYSIS OF PHASE CHANGE MATERIAL THERMAL ENERGY STORAGE PROTOTYPE

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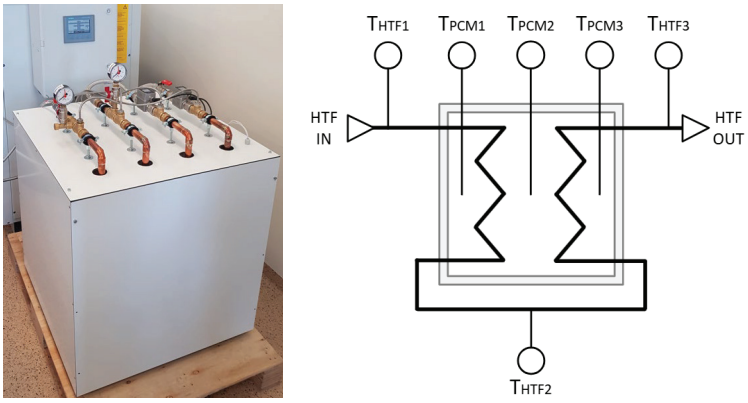
Abstract – Latent heat thermal energy storage (TES) plays an important role in increasing the energy density of the storage systems. Phase change materials (PCMs) are used as a latent heat storage medium; however, because of the low thermal conductivity of most PCMs, it is important to ensure effective heat transfer between heat transfer fluid (HTF) and PCM. The study presents experimental analysis of thermal performance of high energy density PCM-based TES prototype (PCM TES). The PCM TES prototype consists of a thermally insulated storage tank, a compact fin-and-tube type heat exchanger, and an organic PCM RT58 (93 kg). The unit is designed for use in heating and domestic hot water preparation systems in the temperature range of 40–60 °C. The PCM TES charging and discharging experiments were performed using an experimental setup that consists of buffer tanks with an electric heater and cooler for the preparation of hot and cold HTF (water), a mixing valve with actuator and electronic constant temperature controller, flowmeters, circulating pumps, expansion vessels, 6 temperature sensors (Pt100), process control and monitoring system. Several parameters have been analysed, including HTF temperature and mass flow rate, PCM temperature, PCM charging and discharging time, heat transfer rate of the heat exchanger, stored and released thermal energy. The experiment showed that the heat transfer rate during the charging process at a mass flow rate of 0.1 kg/s and an average inlet temperature of hot water of 72 °C decreases from 20.9 kW to 3.4 kW with an average of 9.3 kW. During the discharging process at a mass flow rate of 0.1 kg/s and an average cold water inlet temperature of 16 °C the heat transfer rate decreases from 19.2 kW to 2.2 kW with an average of 10.6 kW. The amount of heat absorbed and released in the PCM temperature range 20–70 °C is 7.48 kWh and the duration of the charging and discharging is 48 min and 44 min, respectively.

Keywords – Heat exchange; latent heat; Phase Change Material (PCM); Thermal Energy Storage (TES)



PCM TES prototype and experimental setup