Abstract

An experimental study was conducted of three different solutes (ethylene glycol, sodium chloride and potassium carbonate) dissolved in water to lower the freezing temperature of water yet allow the formation of solid as a thermal storage medium in a reservoir. The bottom face of the rectangular reservoir contained two evaporator plates that are part of a R134a vapor-compression refrigeration cycle. In addition to pure water, the solutions (followed by their freezing point) are 14 wt% ethylene glycol (-5 °C), 24 wt% ethylene glycol (-10 °C), 6 wt% NaCl (-4 °C), 10 wt% NaCl (-7 °C), 15 wt% K_2CO_3 (-7 °C), and 20 wt% K_2CO_3 (-10 °C). The system is designed so that a layer of solid will form on the evaporator plate (provided the temperature of the refrigerant is sufficiently low). After a user-defined growth time, the refrigerant is switched to the other evaporator, and the solid is eventually released from the dormant plate. The objective is to accumulate solid in the reservoir during an active growth period, and then shut off the compressor, and use the ice as a thermal storage medium. The 14% (-5 °C) ethylene glycol, 6% NaCl (-4 °C), and 10% NaCl (-7 °C), solutions achieved their freezing point temperatures. The other solutions obtained temperatures below the freezing point of pure water, but did not achieve their freezing points. The vapor-compression based reservoir effectively formed solid for all solutions. The ice formed with the ethylene glycol was malleable, while that of the sodium chloride and potassium carbonate were rigid. The solid generation proves the viability of using the reservoir for thermal storage. A coefficient of performance was defined and estimated, and found to be relatively insensitive to evaporating temperature (at a value of approximately 0.5). Characterizing mass growth and melting behavior for fluids that achieved theoretical freezing temperature is the next logical study.