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Technical grade paraffin waxes as phase change materials for cool thermal storage and cool storage systems capital cost estimation

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Abstract

The present paper is confined to the discussion of technical grade paraffin waxes as phase change material (PCM) for cool storage and the cool storage systems capital cost investment. The objective of this study is to determine the potential for using cool storage systems. The thermal properties of technical grade paraffin waxes as PCM are investigated, and static and dynamic cool storage processes are discussed. The capital cost of the cooling storage system is estimated, which indicates the cooling storage system not only saves energy and other operation and maintenance costs, but also saves a significant fraction of the initial capital costs. Installing cool storage, at less cost than conventional nonstorage equipment, can often increase the cooling capacity of the existing system.

Keywords: Phase change materials; Cool storage; Melting and freezing point; Heat of fusion; Differential scanning calorimeter; Static and dynamic storage process; Capital cost

1. Introduction

Thermal energy storage (TES) is the temporary storage of high or low temperature energy for later use. It bridges the time gap between energy requirements and energy use. TES systems contribute to the effective use of energy: peak shift of electrical demands, heat recovery, solar energy utilization and seasonal storage [1].

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Nomenclature

C_{pw}	specific heat capacity of heat transfer medium (kJ/kg K)
C_{pi}	specific heat capacity of phase change materials (kJ/kg K)
ΔH	latent heat of phase change materials (kJ/kg)
m_w	mass of heat transfer medium (kg)
m_i	mass of phase change materials (kg)
Q	amount of heat storage (kJ/kg)
ΔT	temperature difference (K)

TES technologies play an important role in reshaping patterns of electricity use for heating and cooling. In the 1970s and 1980s, when electric utility companies recognized the need to reduce the peak demand on their generation and distribution systems, interest in cool storage for commercial applications grew. For many utilities, the air conditioning load drives the peak system demand on the hottest days of the year. Utilities realized that if cooling could be generated and stored during off peak periods for later use, more peak capacity would be available for other use, and off peak capacity would be more fully used. Therefore, many utility companies began to offer financial incentives in the form of specialized rates, peak demand charges, rebates and subsidies to encourage customers to shift their on peak energy consumption to off peak periods. This encouragement has resulted in rapid growth in the popularity of cool storage for air conditioning and process cooling.

Cool storage technology is an effective means of shifting peak electrical loads as part of the strategy for energy management in buildings. Usually, office building cooling load peaks at a level two or more times higher than the daily 24 h average load. With a conventional nonstorage system, the electric power demand is essentially proportional to the cooling load, thus contributing to peak power demand on the electric utility. By adding a means to use cool storage, the refrigeration system could be operated during the off peak night time hours when the cooling load is low. Daytime cooling could then be supplied by circulating the cooling medium rather than operating the compressor.

Cool storage also may be considered as a useful tool to reduce the size of refrigeration machinery and air conditioning by means of spreading the daytime load over a 24 h period. A cool storage system can meet the same total cooling load as a nonstorage system over a given period of time with a smaller chiller. Thus the total cooling capacity, distributed over the period, is matched more closely to the total cooling load encountered in the same period. Consequently, the reduction in size and cost of the cooling equipment can partially or completely offset the cost of the storage equipment.

Cool storage systems can be classified according to the type of thermal storage medium and the way of storage medium is used. The most common cool storage media are water, ice and other phase change materials (PCM), commonly known as eutectic salts. These media differ in their heat