Chapter 4
Cold Thermal Energy Storage

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ABSTRACT

The chapter gives an overview of cold thermal energy storage (CTES) technologies. Benefits as well as classification and operating strategies of CTES are discussed. Design consideration and sizing strategies based on calculated load profile for design day is presented. Some recommendation concerning designing of CTES equipment are given. Special attention was paid to the analysis of specific features of heat transfer phenomena in ice storage tank including the assessment of the duration and the rate of ice formation and melting. The methodology of sizing components of the ice thermal storage system included in an air conditioning system for an office building situated in hot wet and dry climate are presented. Based on hourly cooling load calculation that was carried out using Carrier's Hourly Analysis Program, sizing of ice thermal storage system for different operating strategies included full, chiller priority and ice priority storage operation for the design day are presented. Finally, an analysis of some operational characteristics of the system are analyzed.

INTRODUCTION

Demands for energy savings and improved energy efficiency are becoming increasingly important. A very promising possibility is the storage of energy whose main objective is to bridge the gap between energy generation and consumption by overcoming the temporal shift between the energy produced and the need for it. This allows thermal storage systems to generate heating or cooling during periods when conditions are most favorable (e.g. the primary energy source is more available or less expensive), which can be independent of the instantaneous thermal load (ASHRAE, 1999).

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Cold Thermal Energy Storage (CTES) usually implies storage of cooling capacity in an appropriate medium at temperatures below the nominal temperature of the space or processing system. The main purpose of CTES utilization is to shift electric energy use from on-peak to off-peak hours (Abdul Galil, 2013; Dorgan & Elleson, 1993). During the off-peak hours electricity is used for charging the thermal storage in order to meet (fully or partially) the on-peak hours cooling load of the refrigeration facility or building. Cool storage can potentially reduce the on-peak energy consumption, peak demand, and most importantly, average cost of energy consumed (Elleson, 1997).

CTES, by itself, is not ultimately an energy savings technology; first of all it is a cost savings technology (Chvala, 2001). By shifting chilling operations to off-peak times, when demand and energy rates are reduced, significant money savings can be realized. The economics are more attractive when CTES is included into existing cooling system as a replacement of older cooling equipment. Energy savings also may be realized because CTES allows facilities to use more energy efficient chillers (Chvala, 2001).

A challenge common to all cold thermal energy storage technologies is to find an efficient and economical means of achieving the heat transfer necessary to alternately freeze and melt the storage medium (ASHRAE Handbook, HVAC Application, 1999). The high energy density of latent storage systems allows compact installations and makes factory-manufactured components and systems practical.

CTES is a proven technology which can be the most cost-effective, reliable system approach to cooling offices, schools, hospitals, malls and other buildings, and provides a steady source of low temperature fluids for process cooling applications. The implementation of CTES contributes to measures for environment protection helping to lower energy consumption and reduce greenhouse gas emissions.

The CTES systems may become an economically attractive alternative if one or more of the following conditions exist (Dincer & Rosen, 2001):

- Short period of cooling demand,
- Charges for peak power demand are high,
- Frequently varying cooling loads (loads are cyclical),
- Cooling demand and supply do not match,
- Economic incentives are provided to use off-peak energy,
- Energy supply is limited by the utility company, thus making it impossible to satisfy the maximum load directly,
- The capacity of an existing chiller is too low to provide peak load.
- Electricity production from Combined Heat and Power (CHP) plant.

BACKGROUND

Benefits of Cold Thermal Energy Storage (CTES)

A properly designed HVAC&R system with integrated cold thermal energy storage provides the following benefits: