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Surface Water Source Heat Pump Air Conditioning System Simulation and Operation Performance Analysis

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Abstract

This paper established a heat pump system model containing heat pump unit model, AC load model and heat exchanger model utilizing the mass and energy balance and the structure's designing method. This paper also developed the surface water source heat pump air conditioning system simulation program by Visual Basic, and verified the simulation by the actual engineering project. In addition, this paper explored the impact of the surface water temperature and heat exchanger structure on the heat pump air conditioning system operation. The results shows that one degree drop of the surface water temperature leads to 2.3 per cent increase of performance coefficient and a 100m added length of the closed-loop surface water heat exchanger tube leads to 0.08 per cent increase of performance coefficient.

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Keywords: Surface water source heat pump system;Simulation model;Operation performance

1. Introduction

The operation performance of water source heat pump is significantly affected by the temperature of surface water, and it plays a decisive role for the energy-savings of the whole heat pump system. In order to analyze the system

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operation, a reliable simulation for the heat pump system can be conducted on the basis of a relatively simple calculation model.

Currently, a lot of heat pump simulation models have been developed, these models can be approximately divided into two types based on the complexity and the extent of experience: formula fitting model and deterministic model [1]. For the formula fitting model, several equations are fitted according to the performance parameters of sample provided by the manufacturers. These equations do not contain the specific structural parameters of the unit, so it has some limitations. For the deterministic model, models of each component are established on the basis of the laws of thermodynamics and heat and mass transfer principles, then each component model are connected to constitute a complete heat pump model by certain relationship. The deterministic model method is suitable for the design and optimization of the system. The formula fitting model of the heat pump was researched by Hamilton and Miller [1] in 1990, the authors carried out formula fitting for the every component, and a system model was formed based on the thermodynamic relations among components. The typical deterministic model called steady-state model of reciprocating heat pump unit was proposed by Bourdouxhe [2] in 1994,in this model, characteristics of the each component of the unit is determined through several specific formula, the model requires only minimal parameters and experimental data. In 2001, Ding Guoliang et al. conducted a detailed simulation for each component, and established a neural network prediction model of heat pump performance [3].

At present, the heat pump models have been mostly established based on the product sample parameters provided by the manufacturers, the reliability and the authenticity of the data is not guaranteed, so the fitting model is not very convincing. In terms of heat pump air conditioning system, the researches for air conditioning system model with surface water as heat source are few. So this paper established the model of heat pump air conditioning system based on the deterministic model and analyzed the impact of surface water temperature and structure parameters of heat exchanger in surface water on the system performance by the system model.

2. Methods

2.1. Heat pump circuit and heat pump component thermodynamic model

The circuit of the refrigerant is shown in Fig.1. This part utilized the laws of thermodynamics and heat and mass transfer principles to establish the system component models with the structure's parameters identified.

Compressor model was established according to the steady-state simulation model [4], while using the empirical formula to calculate the volumetric efficiency of open refrigeration compressors. A simplified formula introduced by the literature [5] was applied in horizontal shell and tube condenser modeling and design calculations involving structural parameters. In the condenser, cooling water goes in the tube and the gaseous refrigerant in the shell. Throttle model was based on the assumption that enthalpy of the refrigerant stays the same before and after throttling. In the horizontal dry shell and tube evaporator model, the refrigerant in the tube boils from the state of wet saturated steam to the state of dry saturated steam and the water outside the tube flows bypassing the fold baffles. The convective heat transfer coefficient inside and outside the tube referred to this paper[6].Refrigerant physical parameters was calculated using polynomial fitting method known as Cleland computational model of refrigerant thermal properties[7].

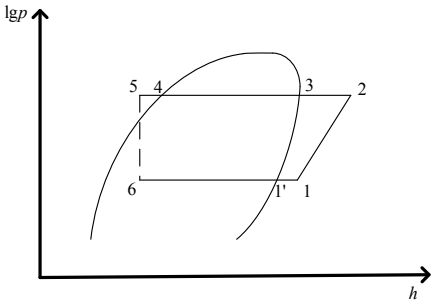

Fig. 1. p-h diagram of refrigeration cycle