Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 205 (2017) 175–182

Procedia Engineering

www.elsevier.com/locate/procedia

10th International Symposium on Heating, Ventilation and Air Conditioning, ISHVAC2017, 19-22 October 2017, Jinan, China

Experimental Investigation of Evaporative Condensed Refrigerating System by Variation of Heat Transfer Tube Types

Yingde Yin[1,2,3, *], Dongsheng Zhu[1,2,3], Jinfei Sun[1,2,3], Li Xiuzhen[1,2,3], and Tu Aimen[1,2,3]

1Guangzhou Institute of Energy Conversion, Chinese Academy of Sciences, Guangzhou, China 510640
2Key Laboratory of Renewable Energy, Chinese Academy of Sciences, Guangzhou, China 510640
3Guangdong Key Laboratory of New and Renewable Energy Research and Development, Guangzhou, China 510640

Abstract

This paper presents an experimental investigation of heat transfer enhancement in an evaporative condenser, where the tubes are remodeled with round, elliptical and twist types. The result shows that the heat transfer coefficients of the elliptical and the twisted tubes are higher than that of the round one of 10.2%-18.0% and 14.6%-28.9%, respectively. And then the evaporative-cooled chiller is introduced to a demonstration project to replace the initial water-cooled one. The tests for cold source system with the evaporative-cooled chiller show that the energy-conservation rate is 16.3% and the water-conservation rate is 39.7%, better than that of cold source system with the water-cooled chiller.

Peer-review under responsibility of the scientific committee of the 10th International Symposium on Heating, Ventilation and Air Conditioning.

Keywords: Heat transfer enhancement; Evaporative condenser; Chiller; Cold system

1. Introduction

The enhanced heat transfer, which has been developed since 1960s as a new energy-save technique, can greatly improve the performance of heat exchangerincluding [1]: (1) remodeling the heat exchanger's structure by the enhanced heat transfer element, (2) improving the fluid's physical property, (3) increasing the contact area by filling, and (4) surface disposal of heat transfer coil [2].

Recently, the topic of enhanced heat transfer of an evaporative condenser has been widely investigated. For examples, Armbruster [3] and colleagues studied the process of non-saturated evaporation in slick horizontal tubes

* Corresponding author. Tel.: +86-20-37029707; fax: +86-20-37029709.
E-mail address: yinyd@ms.giec.ac.cn

1877-7058
Peer-review under responsibility of the scientific committee of the 10th International Symposium on Heating, Ventilation and Air Conditioning.
10.1016/j.proeng.2017.09.950

experimentally. Wittek [4] introduced the non-linear trait of evaporative condensation, and oriented the enhanced heat and mass transfer. Hisham [5] studied the performance of an evaporative condenser and the result showed that the system efficiency was in the range of 97-99%, whereas it was 88-99% for air cooled condenser. Hasan [6] studied the naked tube and finned round evaporative cooled heat exchanger at same operating conditions, and the performance presented that at the condition of certain tube binds, and the heat transfer rate of finned round tubes was larger than that of naked tubes. Ala Hasan [7] compared the performance of elliptical tube and round tube evaporative cooled heat exchanger. There are three main types of condensers used in refrigerating/cooling systems, namely, air-cooled, water-cooled, and a combination of the two formers as evaporative-cooled. Air-cooled condensers are mainly used in small and medium sized refrigeration cooling system [8-9]. Water-cooled condensers are for the large sized and for the heat pumps, where the heat transfers to circulating cooling water and then is conducted to atmosphere through a cooling tower[10]. Although, water-cooled condensers are more compact and have a higher heat transfer coefficient than air-cooled condensers, they have higher initial costs and need water pump to circulate the water to cooling tower [11-12]. Evaporative-cooled condensers combine the advantages of air-cooled and water-cooled condenser by utilizing both sensible and latent heat transfer between the air and water. The cooling can be accomplished by the evaporation of the water into the air stream with smaller fans and motors. In addition, the requirements of the evaporative-cooled condensers for water pumping and chemical treatment are also lowered [13].

Several researchers conducted experiment and application of evaporative cooling system [14-26].However, the investigation of heat transfer enhancement in evaporative condenser by remodeling the tube type is rarely reported. Our research group [27-29] has been engaged in heat transfer enhancement of evaporative condensers by numerical simulation and experimental testing for several years. We have inspected and analyzed the effect factors (including cooling water spray density, wind speed, air temperature and wet bulb air relative humidity) on the evaporator condenser's heat transfer enhancement. Recently, we focused on the evaporative cooling system with evaporative condensers. In this paper, three kinds of tubes (round, elliptical and twisted) were employed to enhance the cooling capacity of evaporative condenser by changing the parameters of air flow velocity (u_f) and water spraying density (Γ).In order to verify the advantages of the evaporative-cooled chiller, the performance was compared with the water-cooled chiller in a demonstration project for application.

2. Experimental part

2.1. Experimental apparatus

In order to investigate the enhanced heat transfer performance of the tubes, we built a tested bench in evaporative condensed refrigerating system (Figure 1). According to the fluid circulation path, it can be divided into three parts: (1) the refrigerant circulation, (2) the cooling water circulation, (3) the chiller water circulation.

The heat exchange coil is the key of an evaporative condenser because the coil's physical property strongly affects the heat and mass transfer of the heat exchanger improving the physical property of heat transfer tube by variation of tube types or tube surface characteristics plays important role in enhancing the heat and mass transfer of the evaporative condensers.

Nomenclature

K Total heat transfer coefficient, $W\cdot m^{-2}\cdot K^{-1}$
u_f Air velocity, $m\cdot s^{-1}$
Γ Sprinkling density, $kg\cdot m^{-1}\cdot s^{-1}$
COP Coefficient of performance