The applicability and application of evaporative cooling in countries around ‘The belt and road initiative’

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Abstract

Countries along ‘The Belt and Road Initiative’ (referred to ‘B&R’) mostly are tropical desert climate. The renewable energy of ‘dry air energy’ is abundant. There are natural conditions of evaporative cooling applications in those countries. In this paper, the applicability of evaporative cooling were studied in the background of ‘B&R’, and it provided theoretical guidance for application of evaporative cooling in countries along ‘B&R’. Climate, economy, culture and ‘dry air energy’ around ‘B&R’ were investigated and then applicability was analyzed. The operation mode of evaporative cooling in countries around ‘B&R’ was obtained using the dry bulb temperature and mean coincident wet bulb temperature in ASHRAE. It provided theoretical guidance for the application of evaporative cooling in ‘B&R’. And the suitable application form of evaporative cooling in ‘B&R’ were summarized which provides reference for design and application in ‘B&R’. It is found that as long as the architectural design is reasonable that evaporative cooling can fully meet indoor comfort requirement of most cities around ‘B&R’.

Keywords: evaporative cooling, countries around ‘B&R’, applicability and application, outdoor design parameters, operation mode

1. Introduction

In recent years, ‘B&R’ proposed by President Xi Jinping, has become ‘Chinese new name card’. It creates development opportunities of many countries in the world and forms a new pattern of mutual benefit and win-win [1]. Countries around ‘B&R’ especially the Silk Road Economic Belt mostly are the tropical desert climate, continental arid and semi-arid climate and weather are hot and dry, ‘dry air energy’ is abundant. The driving energy of evaporative cooling is ‘dry air energy’, which is green, economy, energy saving and renewable. So evaporative cooling is very suitable for countries along ‘B&R’.

Continue high temperature in these areas’ summer has brought a lot of inconvenience to people's production and life. And the initial investment is high if all use traditional mechanical refrigeration. Because the economy of those countries in ‘B&R’ is relatively backward, it is difficult to support high air conditioning costs. And mechanical refrigeration (CFCs) also causes pollution to the environment. As one of the earliest cooling mode of human, evaporative cooling is a main cooling way for countries along ‘B&R’ [2-4]. Since 1980s, this technology has attracted the attention of many scholars. Especially in the recent ten years of twenty-first century, the modern evaporative cooling technology has been rapidly developed and widely used. Professor Chen Peilin, Tongji University, according to different climatic conditions in different regions of our country, studied the application of evaporative cooling and outlet air temperature of indirect evaporative cooling [5]. The evaporative cooling team led by professor Huang Xiang, Xi’an Polytechnic University, has made a lot of research on the basic theory of evaporative cooling technology [6,7] and equipment development [8], having made gratifying achievements. But the research on theory and application of evaporative cooling in hot and dry areas of central Asia and west Asia are less. In this paper, based on the major
national strategy, the applicability and application of evaporative cooling in countries along ‘B&R’ is studied and provide some theoretical guidance.

2. Preliminary analysis of the applicability for evaporative cooling countries along ‘B&R’

Every technology applying in some place is based on its own unique geographical, climate and economic conditions. Firstly, the study of a technology’s applicability needs to consider if it is suitable to apply in those areas; secondly, it needs to research the economy, climate and other basic conditions of the region; then, it can be reasonably applied.

2.1. The ‘dry air energy’ condition in countries along ‘B&R’

Due to the theory that dry air can hold more water and the process when water vapor into gas needs to absorb heat, this is ‘dry air energy’. Two important index to evaluate the ‘dry air energy’ are the wet bulb temperature and the dry and wet bulb temperature difference. Taking into account the accuracy and rationality of study data, dry bulb temperature and mean coincident wet bulb temperature of evaporative cooling, the hourly meteorological parameters of the appendix:design condition for selected locations in 2009 ASHRAE Handbook-Fundamentals, are selected, as shown in fig 1.

As can be seen from figure1, the dry and wet bulb temperature difference is larger in countries of ‘B&R’, about 10°C~25°C, having abundant ‘dry air energy’ with evaporative cooling applications possible. Only a small part of coastal areas’ dry and wet bulb temperature difference is small. Meanwhile, the wet bulb temperature of those typical cities are mostly less than 23°C, which belongs to ventilation area or high adaptation area of evaporative cooling technology.

2.2. The ‘dry air energy’ condition in countries along ‘B&R’

According to fig 2 of the per capita GDP in 2014 for countries along ‘B&R’, only the United Arab Emirates, Israel, Saudi Arabia, Latvia and Italy are more than $15000. Other countries are all belong to the rise of economic development, and most of which are developing countries. Their economic development requires advanced technology, however, their own situation limit them. At the same time, it is not necessary to sacrifice environment when economy is develop. Therefore, with a view to economic, energy saving and green, the evaporative cooling is suitable to the national environment of those counties and should have good application prospects.

2.3. The climatic condition in countries along ‘B&R’

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As can be seen from figure 3, the climatic condition of the countries along ‘B&R’ is as follows: China, India, Pakistan, and Bangladesh are mostly hot and humid countries, and the average temperature is above 25°C, which is not suitable for evaporative cooling applications. In contrast, countries like Russia, Japan, and the United States have a moderate climate, with average temperatures between 10°C and 25°C, which is suitable for evaporative cooling applications.
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