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A simplified method on thermal performance capacity evaluation of counter flow cooling tower

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ABSTRACT

The thermal performance capacity of a wet cooling tower is dominated by weather conditions, particularly ambient wet-bulb temperature. In this paper, the tower performance was predicted by a simplified model which was characterized by specification of a mass evaporation rate equation. The purpose of this study was to present a calculation that was accurate and simple to implement, and could be applied to evaluate acceptance tests for new towers, to monitor changes in tower performance as an aid in planning maintenance, and to predict tower performance under changed operating conditions. The results were validated and showed good agreement with experimental measurements. The results were also presented in simple formats that were easy to use and understand. These allowed reduction of test data and comparison of test results to design data. The method held a practical advantage for predicted tower thermal performance capability to which it was best suited when both flow rate and temperature of inlet water were near design conditions since it required neither the measurement of air flow rate nor the calculation of tower characteristic ($h_{mass}A/L$). The expected results of this study will make it possible to incorporate cooling tower design and simulation to evaluate and optimize the thermal performance of power plants for example.

1. Introduction

Cooling towers have many applications in the fields of air-conditioning, refrigeration and power plants. In the case of power generation plants or sugar mill plants, the cooling tower requirements are relatively large and it has been the practice in recent years especially in Thailand to fabricate increasingly larger cooling towers. For large towers or towers with special requirements that are not Cooling Technology Institute (CTI) certified, in-situ testing is the only way to guarantee that the towers will perform as required. For this purpose, it is quite common to use the Merkel theory such as that of CTI [1] or ASME [2] for the computation of tower characteristic ($h_{mass}A/L$) or Number of Transfer Units (NTU). The problems usually encountered in analysis of cooling towers for large process plants included measurement of many test data with high accuracy instruments, analysis of test data and comparison of test results to design point. This is an expensive and time-consuming process that should be undertaken only after due consideration.

The thermal capacity of a cooling tower is obtained by performing the test. The test data should be evaluated by comparing correctly with the design conditions that were instructed according to the CTI cooling tower acceptance test code [1]. Incidentally, these data are not only useful in the determination of thermal capacity of the tower according to design conditions during the test run period but can also be used to determine the operating characteristics in the change in atmospheric conditions, especially temperatures. Notable examples of techniques based on this approach are the work of Fujita and Tezuka [3], Peterson and Backer [4] and Lucas et al. [5]. They demonstrated that the cooling tower characteristic curve predicted from the Merkel principle is simple in terms of formulation and can provide reliable estimate of cooling tower performance at off-design. By this method, the tower operating conditions are determined directly using the slope of the cooling tower characteristic curve.

Even though the method has been applied to predict the overall thermal evaluation of cooling towers, there are some concerns about simplifying assumptions of the Merkel theory such as the neglecting of the reduction of waterflow rate by evaporation and the saturated water vapor (or 100% relative humidity) of air at the tower exit. The method tends to underestimate the heat rejected by the cooling tower but can be used if only the water outlet temperature is of importance [6]. Kloppers and KrÖger also proposed a technique to get accurate prediction by including the water loss due to evaporation in the energy equation. The effect of

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