International Journal of Thermal Sciences 50 (2011) 2050–2061

Contents lists available at ScienceDirect

International Journal of Thermal Sciences

journal homepage: www.elsevier.com/locate/ijts

Influences of wind-break wall configurations upon flow and heat transfer characteristics of air-cooled condensers in a power plant

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ARTICLE INFO

Article history:
Received 13 December 2010
Received in revised form
4 May 2011
Accepted 4 May 2011
Available online 8 June 2011

Keywords:
Air-cooled condenser
Flow and heat transfer characteristics
Wind-break wall
Hot plume recirculation
Wind speed and direction

ABSTRACT

Wind-break wall is considered to be an effective way to weaken the inlet flow distortions and hot plume recirculation of air-cooled condensers in a power plant. It is of use to investigate the effects of wind-break wall configurations on the thermo-flow performances of air-cooled condensers. The physical and mathematical models of the air-side fluid and heat flows for the air-cooled condensers in a representative 2 × 600 MW direct dry cooling power plant are established with three different configurations of the wind-break wall. The volumetric flow rate and heat rejection of the air-cooled condensers are calculated and compared on the basis of the simulation results of air velocity and temperature fields at various ambient wind speeds and directions. The results show that the thermo-flow performances of the air-cooled condensers are improved by the extensions of the inner and outer walkways and elevation of the wind-break wall, especially at the wind directions ranging between 0° and 90°. The improvement thanks to the width increase of the inner or outer walkway is superior to that resulting from the elevated wind-break wall.

1. Introduction

Direct dry cooling technology has been gaining rapid development in thermal power plants throughout the countries that are short of water resources in the recent decade [1,2]. The air-cooled condenser (ACC) in a power plant consists of an array of the condenser cells. For each condenser cell, the finned tube bundles are arranged in the form of an A-frame fitted with an axial flow fan below. The ambient air is impelled by the fans to flow through the finned tube bundles, removing the thermal duty of the exhaust steam from a turbine. Ambient wind is considered to be one of the key issues for the ACC performance.

Many studies have found that air-cooled condensers work fairly bad in a wide range of specific climates, especially with large wind speeds and adverse wind directions. By using computational fluid dynamics (CFD) methods, Duvenhage and Kroger [3] investigated the effects of wind on the fan performance and recirculation in air-cooled condensers and found that cross wind significantly reduces the air flow rate in the upwind condenser cells, and that the wind along the longitudinal axis cause increased hot plume recirculation. The trend is similar to that obtained from the experimental measurements by Cooling Tower Institute of America. van Rooyen and Kroger [4] numerically studied the air flow field about and through a particular air-cooled condenser, in which the performance of the fan is modeled with the aid of the numerical approach – actuator disc model. It is found that the reduction in fan performance is the main reason for the poor ACC performance while recirculation of hot plume air only reduces performance by a small amount. Wang et al. [5] obtained the overall velocity and temperature fields of air in a power plant by numerical simulation, finding that wind effects and fan suction induce plume recirculation. Installation of a side board below or above the fan platform was suggested to avoid such recirculation. Hotchkiss et al. [6] studied the effects of the cross flow on the performance of the axial flow fans in air-cooled condensers by using actuator disk fan model. The investigation revealed that the adverse effect of the off-axis inflow on fan static pressure rise was attributed to two factors, increased kinetic energy per unit volume at the fan exit and greater dissipation through the fan itself. Off-axis inflow was found to affect fan-blade loading characteristics with implications for blade fatigue. By also using actuator disk model, Meyer [7] numerically investigated the effect of the inlet flow distortions and found that the inlet flow losses of the periphery fan are dominated by the flow separation occurring around the lip of the fan inlet section. These flow losses can be reduced by the installation of a walkway at the edge of the fan platform or by the

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1290-0729/$ – see front matter
doi:10.1016/j.ijthermalsci.2011.05.004