Impact of tower spacing on the performance of multiple natural draft dry cooling towers under no wind conditions

M. Khamooshi[1], T.N. Anderson[1] R.J. Nates[1]

1Department of Mechanical Engineering, Auckland University of Technology, Auckland, New Zealand

*mehrdad.khamooshi@aut.ac.nz

1. INTRODUCTION

Natural draft dry cooling towers (NDDCT) are an important part of concentrated solar power (CSP) plants in that they dictate the flow of air over the condenser. Under no wind conditions, airflow in the NDDCT is driven by natural convection resulting in a relatively uniform temperature and pressure distribution in the condenser. By expanding CSP plants, additional cooling towers are needed to increase the cooling capacity of the plant and hence the layout of multiple cooling towers could influence the thermo-flow characteristics of these NDDCTs. Despite this previous studies have tended to focus on a single isolated cooling tower. In their work Lu et al. [1, 2] focused on improving the design of a small NDDCT with a tower aspect ratio of 1.25 using numerical simulations of a single NDDCT with and without the wind. In addition, they showed that windbreaks resulted in significant variation in the system performance. However, the question of how multiple small cooling towers interact with each other under the no-wind condition appears to have been overlooked.

2. APPROACH

The present work aims to examine the effect of spacing on the performance of two cooling towers and their interaction with each other at the no wind condition. To achieve this a series of steady-flow, three-dimensional computational fluid dynamics (CFD) simulations were undertaken. A tower similar to [1, 2] with height of 20 m and base diameter (D) of 12.525 m was modelled in an open cylindrical domain with a height of 90 m and diameter of 280 m, and boundary conditions as shown in Figure 1. The domain was discretised in space using a structured prismatic mesh with an element size of 0.3 m in the tower and heat exchanger and the Realizable k-ε turbulence model was used to simulate the turbulent field. No slip and adiabatic conditions were assigned to the tower wall and ground and the heat exchangers were modelled as a cylindrical porous media with a radiator on its top surface. Tower spacing's from 2D-D/10 were chosen for investigating the effect of tower spacing on the heat rejection of the cooling towers.

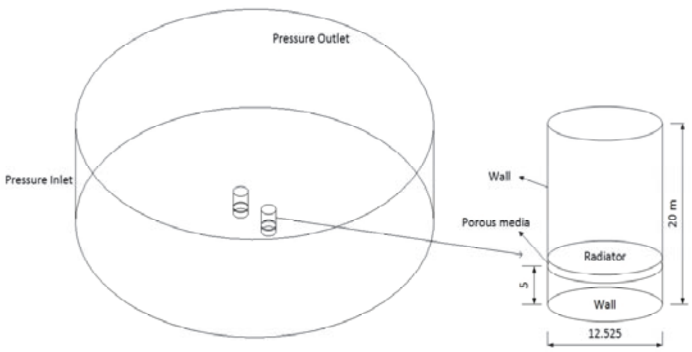

Figure 1. Model geometry, computational domain and boundary conditions

3. RESULTS

Figure 2 shows that the combined heat rejection decreases with reduced tower spacing. As the heat transfer occurs due to natural convection, it would be very sensitive to small changes in inlet conditions. Exploring this further, as the tower spacing decreases, the velocity vectors in Figure 3 become asymmetrical in nature. This implies that there is a weaker driving force between the walls of towers at low tower spacing, which results in lower air flow rates into both towers i.e. the towers begin to fight for the available air resulting in air circulating under the bottom of the heat exchanger as shown in Figure 3b. The net result of this behaviour is that the total heat rejected by the heat exchangers is reduced.

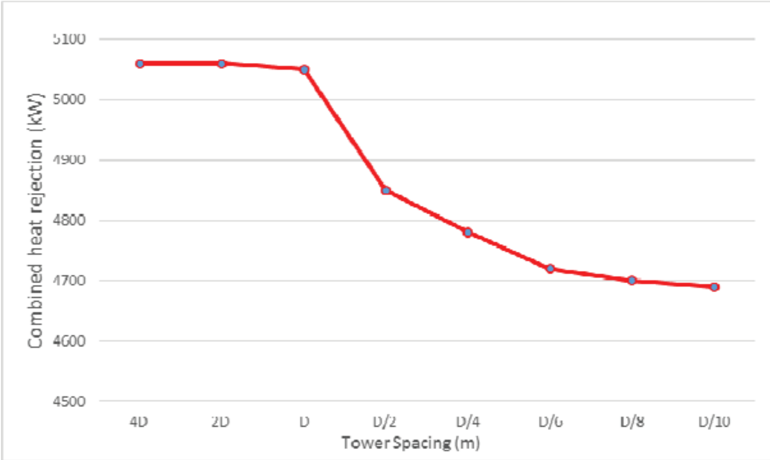

Figure 2. Combined heat rejection of NDDCTs at different tower spacing.

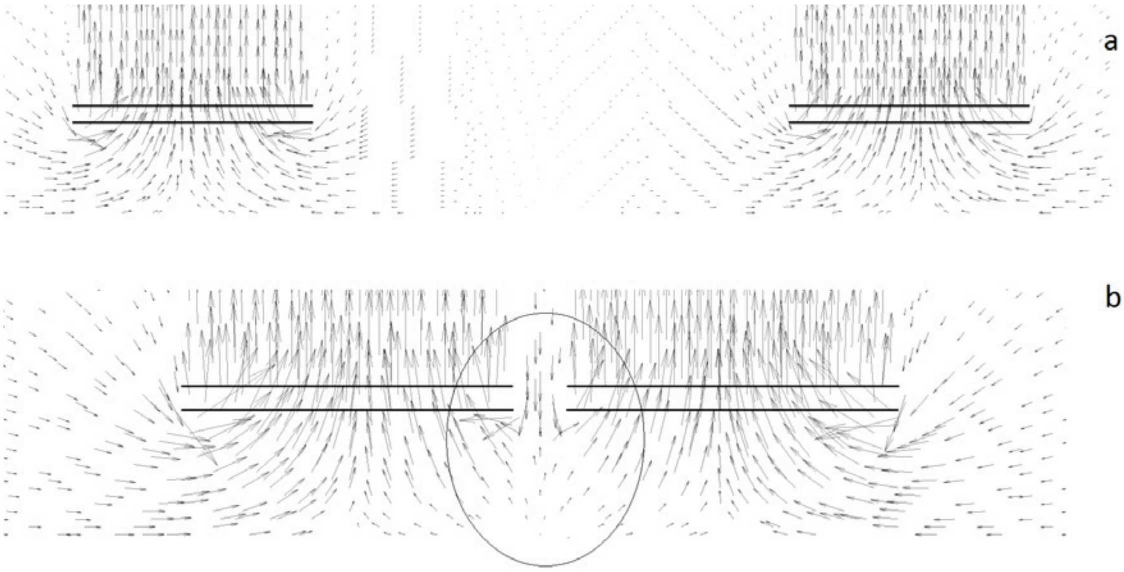

Figure 3. Velocity vectors at central vertical cross section with the tower spacing of a) 2D, b) D/10

4. CONCLUSIONS

The results show that with a tower spacing greater than or equal to the tower diameter NDDCT's act individually. However, a reduction in spacing beyond this reduces the scavenging area between two towers and limits the air supply for both towers. This results in non-uniform temperature and velocity distribution. The interaction between towers at low tower spacing reduces the performance of both towers, and the combined heat rejection decreases by 4-8%.

REFERENCES

1. Lu, Y., et al., *Experimental study of crosswind effects on the performance of small cylindrical natural draft dry cooling towers.* Energy Conversion and Management, 2015. **91**: p. 238-248.
2. Lu, Y., et al., *Windbreak walls reverse the negative effect of crosswind in short natural draft dry cooling towers into a performance enhancement.* International Journal of Heat and Mass Transfer, 2013. **63**: p. 162-170.