Available online at www.ijapie.org

INTERNATIONAL JOURNAL OF ADVANCED PRODUCTION AND INDUSTRIAL ENGINEERING

IJAPIE-2018-10-427, Vol 3 (4), 32-34

IJAPIE
Connecting Science & Technology with Management.

A Journal for all Products & Processes.

Numerical Analysis of Forced Draft Parallel Flow Shower Cooling Tower with Varying the Water to Air Mass Flow Ratio

[1]M. Zunaid*, [2]Qasim Murtaza, [3]Samsher, [4]Afzal Husain
([1,2,3]Department of Mechanical Engineering, DelhiTechnologicalUniversity, New Delhi, India
[4]Department of Mechanical Engineering, Sultan Qaboos University, Oman)
Email: mzunaid3k@gmail.com

Abstract : *The performance of conventional cooling tower deteriorated due to decomposition of salt from water on fill. Therefore a forced draft parallel flow shower cooling tower (SCT) has been developed to overcome these difficulties. In SCT inlet hot water temperature are reduces when it come in contact of inlet air. This study presents three dimensional (3-D) computational fluid dynamics (CFD) analysis of forced draft parallel flow SCT to predict its exit conditions by varying the inlet water to air mass flow ratio (RLG). The model has validated with experimental results. It has been observed that thermal efficiency of SCT decreases with increasing the inlet RLG.*

Keywords: *CFD, SCT, RLG,3-D.*

---

1. INTRODUCTION

Conventional cooling tower (CCT) used to cool the inlet hot water using evaporation and sensible heat transfer. The performance of CCT is reduced due to accumulation of salt from water on fill (Qureshi et al. [1]). To increase the efficiency of CCT, it is necessary to clean or remove fill which is time-consuming and costly. Therefore SCT has been developed to overcome these difficulties. SCT produces smaller size water droplets when these droplets come in contact of air causing simultaneous heat and mass transfer. G. Gan et al. [2] have suggested that CFD can be used for determining the performance and optimum design of closed wet cooling tower. Cui et al. [3] concluded that the droplet temperature variation and efficiency of the cooling tower are directly proportional to the diameter of the water droplet.

Suresh Kumar [4] showed the variance in droplet size distribution with respect to different projection angles. He also observed the variation of projection angle as a function of air inlet velocity. Muangnoi et al. [5] numerically and experimentally studied water-jet cooling tower, they found that exit water temperature raises with rise the inlet droplet diameter. Wang [6] investigate the performance of the cooling tower and found that 7 ºC drop in water temperature attained at 20 m/s air velocity. Reuter et al. [7] use CFD model for determining the effect of CCT geometry on the air flow pattern and decided that the inlet diameter to height ratio has a major impact on inlet losses. N. Williiamson et al. [8] have established one dimensional and two dimensional CFD models and compared them under the design variables. They have reported a difference of less than 2% between there results. He also observed that water mass flow rate and droplet size has major impact on heat transfer among all the parameters considered. Zunaid et al. [9] studied 2-D multi droplet SCT and concluded that thermal efficiency of SCT increases with increase the inlet water temperature. Zunaid et al. [10] found that thermal efficiency of SCT decreased with increase the RLG.

In the present work, CFD analysis of 3-D SCT has been done by help of Ansys Fluent. Numerical analysis of SCT has been done to decide the outcome of variation in inlet RLG on exit parameters of SCT. An experimental study has also been carried out for study performance of SCT under variable conditions. The results from experimental analysis have been used for validating the numerical results.

2. EXPERIMENTAL FACILITY

3-D down draft parallel flow SCT shows in Fig. 1. The water from the storage tank supplied to the nozzle by the help of a reciprocating pump. Nozzle breaks the water into the small droplets for maximizing the surface area so as to increase the energy transfer between the water and air. The atmospheric air and water spray droplets were entered at the top of the tower. The air come in contact with the water spray droplets at the upper part of SCT and due to sensible and evaporative heat transfer between air and droplets temperature of exit water decreased. Thus exit water at the lower temperature can be used for industrial application.

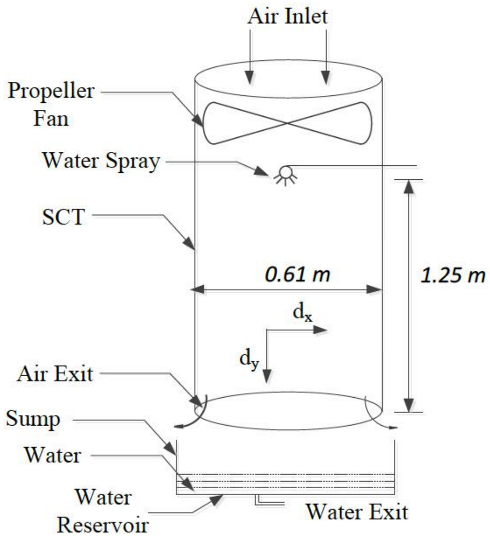

Fig. 1 Parallel flow downdraft evaporative SCT

3. RESULT AND DISCUSSION

A. Model Validation

The investigational data of a SCT has been used for model validation. Comparison of outlet water droplet temperature obtained from the experiment and those obtained from the CFD are shown in Table 1. It can be seen that error in predicted water is less than ±10%.

Table 1 Comparison between experimental and model predicted results

S. No.	Change in experimentally observed exit water temperature (˚C)	Change in model predicted exit water temperature (˚C)	Change in error in exit water temperature (%)
1	13.60	14.94	8.97
2	13.10	13.83	5.28
3	12.30	13.25	7.17
4	14.70	15.96	7.89
5	15.20	16.18	6.06
6	15.40	16.30	5.52
7	16.10	15.35	4.89
8	18.50	17.60	5.11
9	17.30	16.15	7.12

B. Parametric Study

After validation, a numerical study has been done to decide the effect of variation in inlet parameters on the outlet water droplet temperature of SCT. Initial conditions used for CFD are droplet diameter 250 µm, water temperature 56℃, DBT of air 36℃; relative humidity of air 65%, and the ratio of mass flow rate of water to air varies from 0.5 to 2.0. The tower height was 1.25 m and tower diameter was 0.61 m. Inlet droplet velocity was 20 m/s, inlet air volume flow rate was 400 m3/h, and droplet angle of projection at inlet was 45̊. The reference temperature and relative humidity are same as inlet condition and acceleration due to gravity is 9.81 m/s2.

C. Effect of Variation of Inlet RLG

In this study, RLG varied from 0.5 to 2.0, and constant inlet parameters of SCT are air DBT (36 ˚C), air relative humidity (65%), water droplet diameter 250 µm, and water temperature (56 ˚C). Table 2 shows as RLG increases exit air DBT, air specific humidity, droplet temperature (Fig. 2) and makeup water required increases because of the mass of water at the inlet increases. Maximum and minimum water droplet temperature reduction is 16.46 ˚C and 9.46 ˚C which obtained at 0.5 and 2 RLG respectively. Table 2 also shows as RLG increases the thermal efficiency of SCT decreases (Fig. 3) because the mass flow rate of inlet water increases with increasing the RLG.

Table 2 Effect of variation in inlet RLG

RLG	a ,out T (˚C)	a ,out ω (kgw/kga)	d ,out T (˚C)	d ,l m (kg/s)	th η (%)
0.5	39.55	0.0452	39.54	0.0025	65.60
1	42.74	0.0555	42.73	0.0037	52.89
1.25	43.85	0.0595	43.84	0.0042	48.47
1.5	44.75	0.0628	44.74	0.0046	44.88
2	46.55	0.0663	46.54	0.0047	37.70

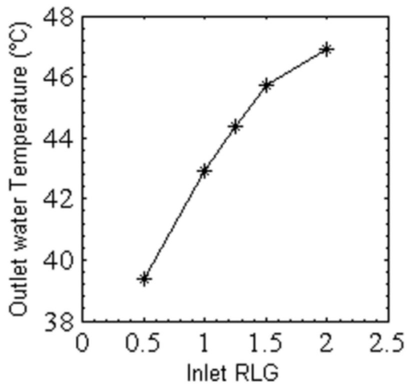

Fig. 2 Outlet water temperature with variation in inlet RLG

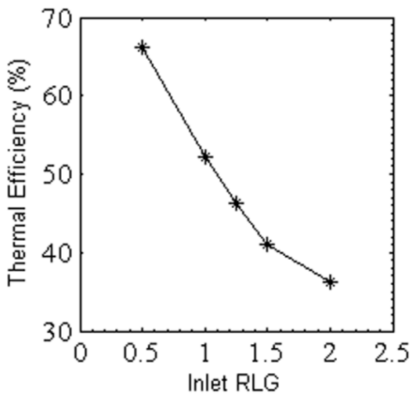

Fig. 3 Thermal efficiency with variation in inlet RLG

4. CONCLUSIONS

A 3-D CFD analysis of SCT used to find out the exit conditions of SCT with varying inlet RLG. The maximum cooling of water droplets and maximum thermal efficiency of SCT achieved by minimum RLG.

REFERENCES

[1] Bilal A Qureshi, Syed M Zubair "A Complete Model Of Wet Cooling Towers With Fouling In Fills", Elsvier, Applied Thermal Engineering, King Fahd University Of Petroleum And Minerals, Saudi Arabia,9 March 2006.

[2] G. Gan, S.B. Riffat, L. Shao, P. Doherty, "Application Of CFD To Closed Wet Cooling Towers", Applied Thermal Engineering, University of Nottingham,16 March 2000.

[3] Cui, H., Li, N., Peng, J., Cheng, J. and Li, S., "Study on the dynamic and thermal performances of a reversibly used cooling tower with upward spraying", Energy, Vol. 96, (2016), 268-277.

[4] Sureshkumar, R., Kale, S.R. and Dhar, P.L., "Heat and mass transfer processes between a water spray and ambient air–I. Experimental data", Applied Thermal Engineering, Vol. 28, No. 5, (2008), 349-360.

[5] Muangnoi, T., Asvapoositkul, W. and Hungspreugs, P., "Performance characteristics of a downward spray water-jet cooling tower", Applied Thermal Engineering, Vol. 69 No.1, (2014),165-176.

[6] Wang, W., Zhang, H., Liu, P., Li, Z., Lv, J. and Ni, W., 2017. The cooling performance of a natural draft dry cooling tower under crosswind and an enclosure approach to cooling efficiency enhancement. Applied Energy, 186, pp.336-346.

[7] H.C.R. Reuter, D.G. Kroger "Computational Fluid Dynamics Analysis Of Cooling Tower Inlets", Journal Of Fluid Engineering, University Of Stellenbosch, South Africa, August 23 2011.

[8] N. Williamson ,M. Behnia, S. Armfield, "Comparison Of A 2D Axisymmetric CFD Model Of A Natural Draft Wet Cooling Tower And 1D Model", Elsevier, International Journal Of Heat And Mass Transfer, The University Of Sydney, Australia, 4 March 2008.

[9] Zunaid, M., Murtaza, Q., & Gautam, S. (2017) 'Energy and performance analysis of multi droplets shower cooling tower at different inlet water temperature for air cooling application', Applied Thermal Engineering, Vol. 121, pp. 1070-1079.

[10] Zunaid, M., (2018) 'Energy and Exergy Analysis of Shower Cooling Tower with Variation in Inlet Air Dry Bulb Temperature for Industrial Application', International Journal for Research in Applied Science & Engineering Technology, Vol. 6, No. 3, pp. 583-588.