

cooling tower performance

BASIC THEORY AND PRACTICE

Total Heat Exchange

An open-circuit cooling tower, commonly called a cooling tower, is a specialized heat exchanger in which two fluids (air and water) are brought into direct contact with each other to affect the transfer of heat. In a "spray-type" cooling tower shown in **Figure 1**, this is accomplished by spraying a flowing mass of water into a rain-like pattern, through which an upward moving mass flow of cool air induced by the action of a fan.

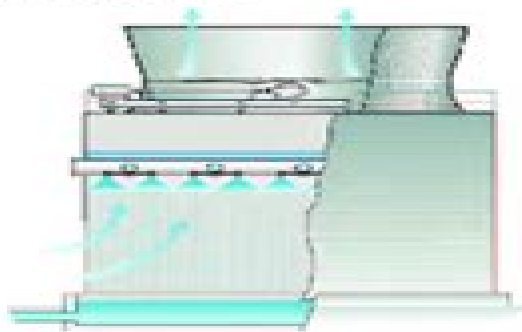


FIGURE 1

Ignoring any negligible amount of sensible heat exchange that may occur through the walls (casing) of the cooling tower, the heat gained by the air must equal the heat lost by the water. Within the air stream, the rate of heat gain is identified by the expression $G(h_2 - h_1)$, where:

- G = mass flow of dry air through the cooling tower — lb/min
- h_1 = enthalpy (total heat content) of entering air — Btu/lb of dry air
- h_2 = enthalpy of leaving air — Btu/lb of dry air

Within the water stream, the rate of heat loss would appear to be $L(t_1 - t_2)$, where:

- L = Mass flow of water entering the cooling tower — lb/min
- t_1 = Hot water temperature entering the cooling tower — °F
- t_2 = Cold water temperature leaving the cooling tower — °F

This derives from the fact that a Btu (British thermal unit) is the amount of heat gain or loss necessary to change the temperature of 1 pound of water by 1°F.

However, because of the evaporation that takes place within the cooling tower, the mass flow of water leaving the cooling tower is less than that entering it, and a proper heat balance must account for this slight difference. Since the rate of evaporation must equal the rate of change in the humidity ratio (absolute humidity) of the air stream, the rate of heat loss represented by this change in humidity ratio can be expressed as $G(H_2 - H_1)(t_2 - 32)$, where:

- H_1 = humidity ratio of entering air — lb vapor/lb dry air
- H_2 = humidity ratio of leaving air — lb vapor/lb dry air
- $(t_2 - 32)$ = an expression of water enthalpy at the cold water temperature — Btu/lb (the enthalpy of water is zero at 32°F)

Including this loss of heat through evaporation, the total heat balance between air and water, expressed as a differential equation, is:

$$Gdh = Ldt + GdH(t_2 - 32) \quad (1)$$

The total derivation of equation (1) can be found in *A Comprehensive Approach to the Analysis of Cooling Tower Performance* available from SPX Cooling Technologies.

Heat Load, Range and Gallons per Minute

The expression "Ldt" in equation (1) represents the heat load imposed on the cooling tower by whatever process it is serving. However, because pounds of water per unit time are not easily measured, heat load is usually expressed as:

$$\text{Heat Load} = \text{gpm} \times R \times 8.33 = \text{Btu/min} \quad (2)$$

Where:

- gpm = water flow rate through process and over tower — gal/min
- R = "range" = the difference between the hot and cold water temperatures — °F (see Figure 3)
- 8.33 = pounds per gallon of water

Cooling Tower Journal

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Cooling Towers Journal DiBiasio Publications, 2016-11-01 Blank 200 page journal **Cooling Towers** Nicholas P. Cheremisinoff, Paul N. Cheremisinoff, 1981 *Cooling Towers* G. B. Hill, E. J. Pring, Peter D. Osborn, 2013-10-22 *Cooling Towers Principles and Practice* Third Edition aims to provide the reader with a better understanding of the theory and practice so that installations are correctly designed and operated As with all branches of engineering new technology calls for a level of technical knowledge which becomes progressively higher this new edition seeks to ensure that the principles and practice of cooling towers are set against a background of up to date technology The book is organized into three sections Section A on cooling tower practice covers topics such as the design and operation of cooling towers types of cooling tower cooling tower components and construction materials practical aspects of tower selection industrial applications and water quality and treatment Section B is devoted to cooling tower theory and calculations These include psychrometry heat transfer theory and calculations calculations when selecting tower size for a given duty and the use of charts for calculation of cooling tower duties Section C on data and tables explains the basis of the SI system of units and includes meteorological tables and data as well as data on specific heat capacity of some common substances **Challenges of Power Engineering and Environment** Ke-fa Cen, Yong Chi, Jianhua Yan, 2009-03-27 This book is the proceedings of the International Conference on Power Engineering 2007 The fields of this book include power engineering and relevant environmental issues The recent technological advances in power engineering and related areas are introduced This book is valuable for researchers engineers and students majoring in power engineering *Wind Engineering 1983 3B* J.D. Holmes, 2012-12-02 *Wind Engineering 1983* Part B contains the proceedings of the Sixth International Conference on Wind Engineering held in Gold Coast Australia on March 21 25 1983 and in Auckland New Zealand on April 6 7 1983 under the auspices of the International Association for Wind Engineering The conference provided a forum for discussing topics related to wind energy and wind engineering from bluff body aerodynamics and mathematical models of wind loading to full scale measurement and modeling of buildings and other structures Comprised of 37 chapters this volume begins with a description of two probabilistic wind load models used in assessing the safety indices of structural members in cyclonic and non cyclonic regions of Australia The discussion then turns to the effect of uncertainties in wind load estimation on reliability assessments wind tunnel test program and risk analysis for structural design and application of wind engineering to low rise housing Subsequent sections focus on wind loading of chimneys and cooling towers bridges cables and transmission lines and offshore platforms The fundamentals of bluff body aerodynamics are also examined along with mathematical models of wind loading This monograph will be of interest to students practitioners and researchers concerned with wind energy and wind engineering *Insights and Innovations in Structural Engineering, Mechanics and Computation* Alphose Zingoni, 2016-11-25 *Insights and Innovations in Structural Engineering Mechanics and Computation* comprises 360 papers that were presented at

the Sixth International Conference on Structural Engineering Mechanics and Computation SEMC 2016 Cape Town South Africa 5 7 September 2016 The papers reflect the broad scope of the SEMC conferences and cover a wide range of engineering structures buildings bridges towers roofs foundations offshore structures tunnels dams vessels vehicles and machinery and engineering materials steel aluminium concrete masonry timber glass polymers composites laminates smart materials Steam Power Plant Engineering George Frederick Gebhardt,1908 *Structural Engineering and Industrial Architecture* Saeed Ghaffarpour Jahromi,Huseyin Bilgin,2023-11-30 Structural Engineering and Industrial Architecture collects the contributions presented at the 6th International Conference on Structural Engineering and Industrial Architecture ICSEIA 2023 Changsha China 24 26 February 2023 The book gathers cutting edge research and achievements on a wide range of topics including Civil Engineering Engineering Structure Environmental Protection Materials Architectural Environment Seismic Engineering The book is aimed at academics and engineering working or interested in the above mentioned areas **Progress in Applied Mechanics** Yeh Kai-Yuan,2012-12-06 Prof W Z Chien was born on 9 October 1912 and 1982 saw the 70th anniversary of his birth Some of his friends colleagues and former students prepared this special volume in honour of his outstanding contribution to the field of mechanics The volume does not contain contributions from all of his students and friends and for this we apologize Prof Chien s family have lived in Qufanguiao Village Hongshengli Wuxi County Jiangsu Province for generations Many members of his family have been teachers in this village When he was 14 years old his father died and for a time it appeared necessary to terminate his education but fortunately an uncle Chien Mu who later became a very famous historian in China came to his aid and he was able to continue his studies In 1931 he took entrance exams and was simultaneously admitted to five prestigious Chinese universities Of these he chose to enter Tsing hau University in Beijing with major work in physics He received his baccaulaurate in 1935 and taught at middle school for a time until he was awarded a Sino British scholarship to study abroad In the competition for this award three of the recipients were in the field of mechanics Prof C C Lin Prof Kuo Yung huai and Prof Chien Wei zang All three arrived in Toronto in August 1940 and entered the Depart ment of Applied Mathematics of the University of Toronto to study under Prof J L Synge International Sugar Journal ,1917 Alternative Energy and Shale Gas Encyclopedia Jay H. Lehr,Jack Keeley,2016-04-25 A comprehensive depository of all information relating to the scientific and technological aspects of Shale Gas and Alternative Energy Conveniently arranged by energy type including Shale Gas Wind Geothermal Solar and Hydropower Perfect first stop reference for any scientist engineer or student looking for practical and applied energy information Emphasizes practical applications of existing technologies from design and maintenance to operating and troubleshooting of energy systems and equipment Features concise yet complete entries making it easy for users to find the required information quickly without the need to search through long articles *Heating and Ventilating Engineer and Journal of Air Conditioning* ,1962 **American Engineer and Railroad Journal** ,1899 The Street railway journal ,1898

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