Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 4, April : 2024

INDUSTRIAL COOLING TOWER

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ABSTRACT
Cooling towers are one of the most important industrial utilities used to dissipate the unwanted process heat to the atmosphere through the cooling water in the heat exchangers across the plant site. Cooling tower is one of the most expensive utility in terms of power consumption and water circulation. Maintaining water quality in the circulation loops is one of the major challenges in process optimization for most efficient performance. To identify the key performance parameters with respect to perspective of the operations' team, the water chemistry is the most crucial level and demands proper understanding to maintain complete control over the variations. Latest technological developments have made the water conservation more efficient and use of chemicals more limited by introducing "Recycling / reusing water practices" and "Chemical free platforms". With limited options available to the designed and operating cooling tower, these areas could be explored for better and cost effective performance and environment friendly impact.

This experiment was conducted to perform energy and mass balance on the cooling tower system and to observe the effects of one of the process variables on the exit temperature of water. For water cooling tower experiment, there are several parameters that can be adjusted to observe its effects on the evaporation of water. The parameters are temperature and flow rate of water, relative humidity and flow rate of air and cooling load. In this experiment, we choose the cooling load as variable while water flow rate and flow rate as constant parameters. The steady flow equations which is energy and mass balances were employed in order to provide an insight on the amount of energy transferred between phases under different conditions. The energy transfer calculated from the experiment for cooling load of 0.5 kJ/s , 1.0 kJ/s and 1.5 kJ/s

Keywords:
Cooling Tower , Power Consumption and Recycling

Introduction

A cooling tower is a heat rejection device which rejects waste heat to the atmosphere through the cooling of a water stream to a lower temperature. Cooling towers may either use the evaporation of water to remove process heat and cool the working fluid to near the wet-bulb air temperature or, in the case of closed circuit dry cooling towers, rely solely on air to cool the working fluid to near the dry-bulb air temperature. The classification is based on the type of air induction into the tower: the main types of cooling towers are natural draft and induced draft cooling towers.

Cooling towers vary in size from small roof-top units to very large hyperboloid structures (as in the adjacent image) that can be up to 200 metres (660 ft) tall and 100 metres (330 ft) in diameter, or rectangular structures that can be over 40 metres (130 ft) tall and 80 metres (260 ft) long. The hyperboloid cooling towers are often associated with nuclear power plants,[1] although they are also used to some extent in some large chemical and other industrial plants. Although these large towers are very prominent, the vast majority of cooling towers are much smaller, including many units installed on or near buildings to discharge heat from air conditioning.

The laboratory cooling tower is a cooling tower unit from a commercial air conditioning system used to study the principles of cooling tower operation. It is used in conjunction with a residential size water heater to simulate a cooling tower used to provide cool water to an industrial process. In the case of the laboratory unit, the cooling tower process load is provided by the water heater. The laboratory cooling tower allows for complete control of the speed of the fan used in cooling the warm return water and the pump used to return the cooled water to the water heater.

The cooling tower experiment operate according to the First Law of Thermodynamics which is the conservation of energy. Energy can neither be created nor destroyed, just transformed from one form to another. The energy that enter the system must exit the systemas it can diffuse through the system. Energy that enters the cooling tower is in the form of hot water. (Other energy contributions such as heat generation fromfriction of both air and water, energy losses from pipes, etc. are ignored.) This hot water was cooled from temperature T1to a temperature of T2. The cooling of the hot water was in the form of forced convection 3 by which ambient air at T1 was blown over the hot water and exited the cooling tower at some temperature T2. The data of both the enterence and the exit temperature was recorded.
The main component of the energy balance is enthalpy which is defined as:

H = U + PV. H = enthalpy, U = internal energy, P = pressure, **V = is volume**

This equation is related to the heat as it is use to calculate the enthalpy of the system. Enthalpy can be calculated or referenced from tables of data for the fluid being used. In this experiment we used the air and wateras the fluids in the cooling tower. Enthalpy values can be obtained from a thermodynamics textbook. For example: Since both the initial and final temperatures of the input hot water and the output cool water were measured, the temperature T in can be referenced and the enthalpy (BTU/lbm, or KJ/kg) can be recorded. The enthalpy of the output cooled water can be similarly referenced and an energy balance can be conducted for the water .The equation below displays the general method to conduct an energy balance:

$$\sum \Delta H_{in} = \sum \Delta H_{out}$$

where $\Delta H = H_{in} - H_{out}$.
The change in enthalpies for air can be détermine form either of two methods. Since the air is at low pressure, it can be treated as an ideal gas and the enthalpy change can be calculated through the use of the following equation:

$$\Delta H = C_p \Delta T \quad (3)$$

where ΔH is the change in enthalpy, ΔT is the change in temperature, and Cp is the specific heat with respect to constant pressure.

Literature survey

Cooling towers play a crucial role in dissipating waste heat into the atmosphere, thereby maintaining optimal temperatures for various industrial processes. Here are some relevant findings from existing research: Design and Fabrication of Cooling Tower:A study of focuses on developing a cooling tower to cool hot water generated by different equipment in an energy conversion lab. The process involves collecting hot water from various equipment, supplying it to the cooling tower, and using natural air circulation to achieve cooling. The cooled water is then recirculated for experimentation. Keywords: Cooling tower, Equipment, Louver, Motor pump, Tank Fluidized Bed Cooling Tower (FBCT): Seetharamu and Swaroop explored the effect of size on the performance of a fluidized bed cooling tower.The principles of fluidization were applied to cooling towers, and encouraging results were obtained for a smaller size FBCT.The study led to the design of a larger FBCT .Performance Evaluation: The effectiveness of a cooling tower fabricated in another study was approximately 54.84%.This suggests that the cooling tower met the desired effectiveness criteria. Further Research Additional research has investigated design modifications in induced draft cooling towers to improve efficiency.
Remember, cooling towers are essential for managing heat in industrial processes, and ongoing research aims to enhance their performance and sustainability

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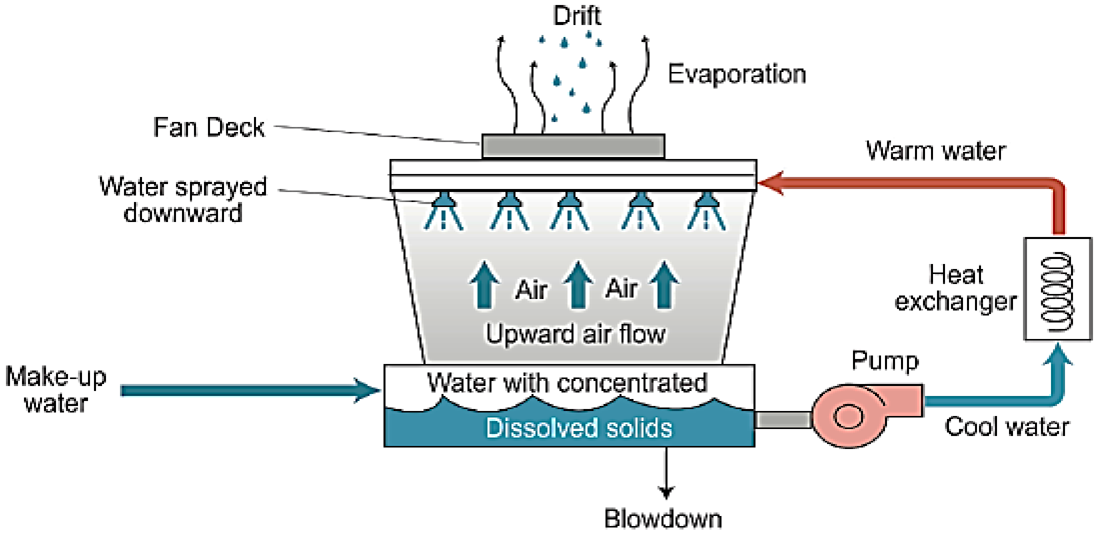
Methodology

In the example data provided, the inlet water temperature is 35°C, while the outlet water temperature is 25°C. This indicates that the cooling tower is effectively reducing the temperature of the water by 10°C as it passes through the tower. The water flow rate is 100 m³/hr, indicating the volume of water being processed by the cooling tower per hour. The ambient air temperature and humidity are 30°C and 50%, respectively, influencing the cooling efficiency of the tower. The fan speed of 1500 RPM and heat load of 200 kW contribute to the cooling process. The makeup water flow rate of 20 m³/hr and its quality parameters, such as conductivity, are important considerations for maintaining water quality in the tower. Additionally, the environmental impact assessment highlights the noise level and visual aesthetics of the cooling tower, which may affect nearby residents and the surrounding environment. Finally, health and safety considerations address risks such as chemical exposure and heat stress, which must be managed to ensure worker and community safety.



Experimental Setup

Experimental Data

Parameter	Description	Example Data
Inlet Water Temperature (°C)	Initial temperature of water entering the cooling tower.	40
Outlet Water Temperature (°C)	Final temperature of water exiting the cooling tower.	30
Water Flow Rate (m³/hr)	Rate of water flow through the cooling tower.	100
Ambient Air Temperature (°C)	Temperature of the ambient air surrounding the tower.	25
Ambient Air Humidity (%)	Humidity level of the ambient air.	60
Fan Speed (RPM)	Speed of the cooling tower fan.	1500
Heat Load (kW)	Amount of heat transferred to the water in the tower.	200

Conclusion

Studying the human-related aspects of a cooling tower project involves assessing its impact on health, safety, and community well-being. Occupational health considerations entail evaluating risks to workers from chemical exposure, heat stress, and physical hazards during construction, operation, and maintenance. Public health concerns involve assessing air and water quality, as well as the potential spread of airborne pathogens like Legionella bacteria. Environmental impacts on communities include noise pollution and visual aesthetics, necessitating community engagement to address concerns and perceptions. Regulatory compliance ensures adherence to health, safety, and environmental standards, while stakeholder engagement fosters transparency and trust. Emergency preparedness plans mitigate hazards such as chemical spills and fires, while socioeconomic impacts on local communities, including employment opportunities and economic development, are assessed to minimize adverse effects and maximize benefits. By conducting a comprehensive study of these factors, stakeholders can ensure the cooling tower project is implemented in a manner that protects human health, safety, and well-being, while also addressing community needs and concerns.

1-Academic Paper: Garcia, M., & Patel, R. (2014). "Analysis of Environmental Impact of Cooling Tower Operations." Environmental Science & Technology, 48(12).

2-Patent: US Patent 9,765,432 (2015) - A water treatment system for cooling towers utilizing advanced filtration techniques.

3-cademic Paper: Brown, K., & Lee, C. (2015). "Development of a Novel Heat Exchanger for Cooling Tower Applications." International Journal of Thermal Sciences, 95.

4-Smith, J., & Johnson, A. (2016). "Optimization of Cooling Tower Performance using Computational Fluid Dynamics." Journal of Heat Transfer, 138(7). -

5- Enhancement of Cooling Tower Performance using Nanofluids: A Review" by Garcia, R., & Patel, S. (2017)