

# Determination of Optimum Height for Counter Flow Cooling Tower

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## ABSTRACT

A model for counter flow cooling tower is present with treatments to recover the simplifications in the literature. The Bošnjakovic formula, mutative water and air properties are used to relax the constraints. The finite volumes of water and moist air are defined separately in opposite flow directions. Mass and energy balances are evaluated for control volume; heat and mass transfer are considered between control volumes. The model is validated with experimental data from literature. The model determines the cooling tower optimum height, evaporation rate and distribution of air and water temperatures, humidity, water flow and Lewis factor along the tower height. It is concluded that: the height is affected by the inlet air humidity; the heat transfer mode is dominated by evaporation, and Lewis factor ranges from 0.91 to 0.924.

**Key Words:** Cooling Tower, Height, Evaporation Rate, Lewis Factor, One Dimensional

## 1 INTRODUCTION

A cooling tower is heat rejection equipment. Its main function is to extract waste heat from warm water to the atmosphere. Heat rejection in cooling tower is specified as convection between the fine droplets of water and the surrounding air, and also as evaporation which allows a small portion of water to evaporate into moving air, the process involves both heat and mass transfer.

Cooling towers are widely used in the power generation units, refrigeration and air conditioning industries [1]. Cooling towers can be classified by the movement of water and air as counter-flow and cross-flow types. Moreover, they can also be classified by means of air flow into mechanical draft and natural draft types.

A lot of work has been done for modeling cooling towers mathematically in the past century. Walker [22] proposed a basic theory of cooling tower operation. Merkel [15] developed the first practical theory including the differential equations of heat and mass transfer, which has been well received as the basis for most work on cooling tower modeling and analysis [1-10,5-18-14].

In Merkel's model, the Lewis factor is assumed as unity, this assumption may cause Merkel's model to underestimate the effective tower volume by 5-15% [20]. The influence of the Lewis factor diminishes when the inlet ambient air is relatively hot and humid [8]. For

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an unsung hero of various industries quietly ensuring the smooth functioning of processes and systems that rely on efficient thermal management Whether you are an engineer a student or simply someone intrigued by the inner workings of these towering structures this book aims to provide an in depth exploration of cooling towers and their pivotal role in our modern world In an era marked by rapid technological advancements and the relentless pursuit of progress the effective management of heat has become an indispensable aspect of numerous industrial operations Cooling towers have emerged as essential tools in this endeavor finding their place in power plants manufacturing facilities data centers and countless other domains These towering giants stand tall resolutely undertaking the task of dissipating excess heat and maintaining optimal temperatures thereby ensuring the smooth functioning of critical equipment The purpose of this book is to unravel the mysteries surrounding cooling towers and offer a comprehensive understanding of their design principles operational intricacies and the multitude of applications they serve Through the following chapters we will delve into the different types of cooling towers their underlying components and the diverse heat transfer mechanisms that drive their operation We will explore the fundamental principles of thermodynamics and fluid dynamics that govern their performance and examine the factors influencing their efficiency and environmental impact While this book strives to present a holistic overview of cooling towers it is important to acknowledge that the field of thermal management is a dynamic and ever evolving discipline Advancements in technology emerging environmental concerns and shifting regulatory landscapes continue to shape the industry prompting engineers and researchers to push the boundaries of efficiency sustainability and innovation Thus it is crucial to approach this subject with an open mind recognizing that the knowledge shared here is just a snapshot in the ongoing journey of discovery As we embark on this exploration of cooling towers let us celebrate the spirit of ingenuity that has led to their creation and evolution Let us marvel at the intricate designs and engineering prowess that enable these structures to operate efficiently effectively and often silently in the background May this book serve as a guiding light illuminating the fascinating world of cooling towers and inspiring further curiosity and innovation in the pursuit of optimal thermal management I extend my deepest gratitude to the experts engineers and researchers whose tireless efforts have contributed to the knowledge and advancements in the field of cooling towers Their dedication and expertise have laid the foundation for this book and their collective wisdom continues to shape the future of thermal management Lastly I would like to express my appreciation to you the reader for embarking on this intellectual journey I hope that this book serves as a valuable resource igniting your passion for understanding cooling towers and empowering you to contribute to the fascinating realm of thermal management Together let us delve into the captivating world of cooling towers and unlock the secrets held within their towering structures

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