

## CONTENTS

	Page No.
Contents	I
Certificate	II
Acknowledgement	III
Abstract	IV
Nomenclature	V
List of Figures	IX
List of Tables	X
<b>1. INTRODUCTION</b>	
1.1 Function and Mechanism of a Cooling Tower	1
1.2 Description of Induced Draft Cooling Tower	2
1.3 Motivation	4
1.4 Objectives of the project	4
<b>2. LITERATURE REVIEW</b>	
2.1 Summary of Literature review	5
2.2 Conclusion of Literature review	10
<b>3. FORMULATION OF MATHEMATICAL MODEL</b>	
3.1 Merkel Method	11
3.2 System Description and Model Formulation	13
3.2.1 Energy equation	14
3.2.2 Draft equation	15
3.2.3 Pressure equation	18
3.2.4 Fan Power equations	18
3.2.5 Formulation for three zones of the cooling tower	19
3.2.6 Formulation for Exergy Analysis	21
<b>4. RESULTS AND DISCUSSIONS</b>	
4.1 Solution Procedure	24
4.2 Initial Conditions	28
4.3 Results and Discussions	30
4.4 Parametric Study	31
<b>5. CONCLUSION AND RECOMMENDATIONS FOR FUTURE WORK</b>	
5.1 Conclusion	43
5.2 Recommendations for Future Work	44
<b>References</b>	45
<b>Appendix (A) : Thermo-Physical Properties</b>	47

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## **CERTIFICATE**

This is to certify that the major project entitled “**Analysis of an Induced Draft Counter Flow Cooling Tower**” which is being submitted by Shri **GAURAV AGGARWAL**, is the authentic record of student’s own work carried by him out under our guidance and supervision for partial fulfilment of the award of the degree of Master of Engineering in Thermal Engineering, Department of Mechanical Engineering, Delhi College of Engineering, University of Delhi.

The matter embodied in this project has not been submitted for the award of any other degree.

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## **ABSTRACT**

Induced draft counter flow cooling towers are widely used in power plants and air conditioning installations to reduce the temperature of circulating water so that it may be reused in condensers and other heat transfer equipments. The performance prediction of induced draft cooling towers requires the understanding of the fluid dynamics and heat and mass transfer mechanism between hot water and ambient air.

In the present work, a simple and efficient mathematical model has been developed in which energy equation, draft equation and pressure equation are solved. The main initial conditions required in the model are inlet air/water conditions, geometric parameters and fan parameters. The model predicts outlet air conditions, inlet mass flow ratio, evaporation loss, fan power requirements and various performance evaluation parameters like thermal efficiency, exergy destruction and second law efficiency.

It was observed that wet bulb temperature of inlet air plays a significant role on parameters such as evaporation loss, fan shaft power, thermal efficiency, exergy destruction and second law efficiency.

**Key words:** Induced draft cooling tower, draft equation, first and second law analysis.

## NOMENCLATURE

<b>A</b>	area (m <sup>2</sup> )
<b>a</b>	surface area per unit volume, m <sup>2</sup> /m <sup>3</sup>
<b>B</b>	breadth of cooling tower, m
<b>c<sub>p</sub></b>	specific heat at constant pressure, J/kg K
<b>D</b>	diffusion coefficient
<b>d</b>	differential element ; droplet
<b>G</b>	mass velocity, kg/m <sup>2</sup> s
<b>H</b>	height, m
<b>h</b>	heat transfer coefficient, W/m <sup>2</sup> K ; enthalpy, J/kg
<b>h<sub>d</sub></b>	mass transfer coefficient, kg/m <sup>2</sup> s
<b>i</b>	enthalpy, J/kg
<b>i<sub>ma</sub></b>	enthalpy of dry air at wet bulb temperature, J/kg
<b>i<sub>masw</sub></b>	enthalpy of saturated air at the local bulk water temperature, J/kg
<b>K</b>	loss coefficient
<b>L</b>	length, m
<b>m</b>	mass flow rate, kg/s
<b>M</b>	Merkel method, also molecular mass, kg/mole
<b>N</b>	rotational speed, r/min
<b>NTU</b>	number of transfer units
<b>P</b>	power, W
<b>p</b>	pressure, N/m <sup>2</sup>
<b>q</b>	heat transfer rate, W
<b>R</b>	characteristic gas constant J/kg K
<b>R<sub>y</sub></b>	characteristic flow parameter, m <sup>-1</sup>
<b>r</b>	rounding, m
<b>s</b>	entropy, J/kg K
<b>t</b>	temperature, °C or K
<b>U</b>	overall heat transfer coefficient, W/m <sup>2</sup> K
<b>V</b>	volume, m <sup>3</sup> , also volume flow rate, m <sup>3</sup> /s

<b>v</b>	velocity, m/s
<b>W</b>	width of cooling tower, m
<b>w</b>	humidity ratio, kg water vapor/kg of dry air
<b>X</b>	exergy, W
<b>x</b>	mole fraction
<b>z</b>	elevation, m

### **GREEK SYMBOLS**

<b><math>\rho</math></b>	air density, kg/m <sup>3</sup>
<b><math>\Delta</math></b>	differential
<b><math>\eta</math></b>	efficiency
<b><math>\mu</math></b>	dynamic viscosity, kg/sm
<b><math>\theta</math></b>	relative humidity
<b><math>\sigma</math></b>	surface tension, N/m
<b><math>\Psi</math></b>	specific exergy, J/kg

### **DIMENSIONLESS GROUPS**

<b><math>Le_f</math></b>	dimensionless Lewis factor, $h/(c_p h_d)$
<b><math>Me</math></b>	Merkel number, $h_d a_{fi} L_{fi} / G_w$
<b><math>Sc</math></b>	Schmidt number, $(\mu / \rho D)$

### **SUBSCRIPTS**

<b>a</b>	air
<b>abs</b>	absolute
<b>av</b>	mixture of dry air and water vapor
<b>C</b>	Chebyshev method
<b>c</b>	casing of fan

<b>ct</b>	cooling tower
<b>ctc</b>	cooling tower contraction
<b>d</b>	destruction,diameter(m)
<b>da</b>	dry air
<b>db</b>	dry bulb
<b>de</b>	drift eliminator
<b>dif</b>	diffuser
<b>e</b>	e-NTU method, effective
<b>evap</b>	evaporated
<b>F</b>	fan
<b>F/ dif</b>	fan/ diffuser
<b>fd</b>	frictional and drag
<b>fi</b>	fill
<b>fr</b>	frontol
<b>fs</b>	fill support
<b>H</b>	height,m
<b>h</b>	hot
<b>ll</b>	second law
<b>i</b>	inlet
<b>il</b>	Inlet louvers
<b>m</b>	mean, or mass transfer
<b>max</b>	maximum
<b>min</b>	minimum
<b>norz</b>	normalized
<b>o</b>	outlet
<b>pl</b>	plenum chamber
<b>r</b>	reference
<b>rz</b>	rain zone
<b>s</b>	saturation
<b>sp</b>	spray
<b>T</b>	total

<b><i>th</i></b>	thermal
<b><i>up</i></b>	upstream
<b><i>v</i></b>	vapor
<b><i>w</i></b>	water
<b><i>wb</i></b>	wet bulb
<b><i>wd</i></b>	water distribution system
<b><i>wv</i></b>	water vapor



## LIST OF FIGURES

### **Chapter 1**

Figure 1.1	Induced draft counter flow cooling tower	3
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### **Chapter 3**

Figure 3.1	Induced draft counter flow cooling tower with geometry	13
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### **Chapter 4**

Figure 4.1	Information flow diagram	25
Figure 4.2	Flowchart of computer program	27
Figure 4.3	Air outlet temperature v/s wet bulb temperature of inlet air	32
Figure 4.4.	Inlet mass flow rate ratio v/s wet bulb temperature of inlet air	33
Figure 4.5	Evaporation loss v/s wet bulb temperature of inlet air	33
Figure 4.6	Actual fan shaft power v/s wet bulb temperature of inlet air	34
Figure 4.7	Thermal efficiency v/s wet bulb temperature of inlet air	35
Figure 4.8	Exergy destruction v/s wet bulb temperature of inlet air	36
Figure 4.9	Second law efficiency v/s wet bulb temperature of inlet air	37
Figure 4.10	Air outlet temperature v/s droplet diameter	38
Figure 4.11	Inlet mass flow rate ratio v/s droplet diameter	39
Figure 4.12	Evaporation loss v/s droplet diameter	39
Figure 4.13	Actual fan shaft power v/s droplet diameter	40
Figure 4.14	Thermal efficiency v/s droplet diameter	40
Figure 4.15	Exergy destruction v/s droplet diameter	41
Figure 4.16	Second law efficiency v/s droplet diameter	41

## LIST OF TABLES

### **Chapter 4**

Table 4.1	Initial conditions supplied to the computer program.	28
Table 4.2	Output results of the induced draft cooling tower.	30
Table 4.3	Effect of variation in wet bulb temperature of inlet air.	31
Table 4.4	Effect of variation in droplet diameter in the rain zone.	38