

# **HEAT AND MASS TRANSFER IN TEXTILES**

***Second Edition***



**Editor  
A. K. Haghi**



**ISBN: 978-1-61804-025-1**



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Published by WSEAS Press

[www.wseas.org](http://www.wseas.org)

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All papers of the present volume were peer reviewed by two independent reviewers. Acceptance was granted when both reviewers' recommendations were positive.

See also: <http://www.worldses.org/review/index.html>

ISBN: 978-1-61804-025-1



World Scientific and Engineering Academy and Society

## Preface

Dear readers,

The study of heat transfer is one of the important fields of engineering science. Heat transfer problems are of great practical significance in textile chemistry engineering, clothing and thermo physics. Despite the importance of the subject, it is hard to find a book on thermal analysis of textiles. Textile fabrics have been improved to assist in thermal and moisture regulation to and from human body through engineering of fibers, yarns and fabric construction, and developing fabric finishes. The book is written for both engineering students and engineers practicing in areas involving heat diffusion problems. In chapter 1, the basic concepts and fundamentals of heat transfer are presented. Chapter 2 is devoted to heat convection drying of textiles. In chapters 3 and 4, heat conduction and heat radiation in drying process of textiles are presented, respectively. Chapter 5 deals with heat and mass transfer in textiles with particular reference to clothing comfort. The book was compiled and written this book for those who wish to acquire a basic knowledge of the many common heat and moisture transfer concepts in textiles. It aims to provide a good basis for engineers employed in the textile industry and following a course of study in further education. As this book is intended to be essentially a practical guide, a detailed discussion of the theoretical side of the subject should be outside its scope. A considerable literature exists and the reader who wishes to make a further study of this aspect of the subject is referred to the bibliography at the end of this book. However, for a proper appreciation of what is involved to heat and mass transfer in textiles, certain basic theories and concepts should be understood.

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## Nomenclature

A	Area
a,b,c	Constants
$c_p$	constant pressure specific heat
$C_A$	moisture content of air in fabric pores
$C_a$	water-vapor concentration in the air filling the inter-fiber void space
$C_e$	moisture content of extent air
$C_F$	moisture content of fibers in a fabric
$C_f$	water-vapor concentration in the fibers of the fabric ( $\text{kg } m^{-3}$ )
$C_p$	specific heat
$D$	diffusion coefficient
$D_b$	bound water conductivity
$D_{eff}$	effective diffusivity
$E_d$	activation energy of movement of bound water
H	enthalpy (J/kg)
$h_e$	Heat transfer coefficient
$h_m$	mass transfer coefficient
$\Delta h_v$	enthalpy of vaporization (J/kg)
$\Delta h_{vap}$	latent heat of evaporation
J	species diffusion flux
$J_L$	free water flux
K	Permeability
$K_0$	single phase permeability of porous material
$K_r$	relative permeability
$k$	thermal conductivity
$k_{eff}$	effective thermal conductivity
$m$	Ratio of diffusion coefficients of air and water vapour
$m'$	mass source per unit volume
$\dot{m}$	evaporation rate, mass transfer rate
M	molecular weight
P	pressure
$P_c$	capillary pressure

$P_s$	saturation pressure
$q$	convective heat transfer rate
$Q$	enthalpy of desorption from solid phase
$R$	Radius
$R$	gas constant, Fiber regain
$S$	Pore saturation
$T$	Time
$T$	Temperature
$T_e$	external air temperature
$U$	moisture content

### Greek symbols

$\gamma$	Pore volume density function
$\lambda$	latent heat of evaporation
$\lambda_{eff}$	effective thermal conductivity
$\mu$	Viscosity
$\nu$	Fluid velocity
$\rho$	Density
$\sigma$	surface tension
$\tau$	tortuosity factor of capillary paths
$\psi$	relative humidity
$\omega$	averaging volume
$\varepsilon$	volume fraction ( $m^3$ of quantity / $m^3$ )

### Subscripts

0	Initial
C	capillary, critical
Eq	Equilibrium
G	Gas
Ir	Irreducible
Ms	maximum sorptive
V	Vapour
W	Water
$\beta$	Liquid phase
$\gamma$	Gas phase
$\sigma$	Solid phase
Bl	Bound liquid
Ds	Dry solid

## Nomenclature

Lv	Liquid-to-vapor
Ls	Liquid-to-solid
Sat	Saturation
Sv	Solid-to-vapor
V	Vapor

## Superscripts

G	intrinsic average over the gaseous phase
L	intrinsic average over the liquid phase
*	vapour saturated
-	average value

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