

HEAT AND MASS TRANSFER IN TEXTILES

Second Edition



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Editor

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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_a	activation energy of movement of bound water
H	enthalpy (J/kg)
h_e	Heat transfer coefficient
h_m	mass transfer coefficient
Δh_v	enthalpy of vaporization (J/kg)
Δh_{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
$n&$	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

γ	Pore volume density function
λ	latent heat of evaporation
λ_{eff}	effective thermal conductivity
μ	Viscosity
ν	Fluid velocity
ρ	Density
σ	surface tension
τ	tortuosity factor of capillary paths
ψ	relative humidity
ω	averaging volume
ε	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
β	Liquid phase
γ	Gas phase
σ	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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