

Thermal technologies in food processing

**Edited by
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Notation

a	surface area	m^2
A	surface area	m^2
\mathbf{A}	coefficient matrix	$kg\ s^{-1}$
a, b	constants	
A_p	particle surface area	m^2
$Bi = hd/\lambda$	Biot number	
\vec{B}	magnetic flux density	
\mathbf{B}	flux density	$V\ S\ m^{-2}$
\mathbf{C}	capacity matrix	$J\ ^\circ C^{-1}$
C	concentration of bacteria in liquid food	number of bacteria m^{-3}
C_1, C_2	constants	
C_η	turbulence constant	
c	heat capacity (Chapter 6)	$J\ kg^{-1}\ ^\circ C^{-1}$
c, c_0	velocity of light, in vacuum (Chapter 10)	
c_a	specific moisture capacity of vapour phase	
c_p	specific heat capacity (constant pressure)	$J\ kg^{-1}\ K^{-1}$
\vec{D}	electric flux density	$V\ S\ m^{-2}$
\mathbf{D}	flux density	$V\ S\ m^{-2}$
D	decimal reduction time	min
D_{ref}	reference decimal reduction time	min
D_p	field penetration depth	m
D_e	diffusion coefficient	$m^2\ s^{-1}$
d	diameter	m
\vec{E}	electric field	
\mathbf{E}	electric field strength	$V\ m^{-1}$

F	F -value: integrated lethality (Chapter 7)	min
\hat{F}	volumetric average	s m^{-3}
\mathbf{f}	thermal load vector	W
f	frequency	GHz
f_i	volumetric body force	N m^{-3}
F_i	Cartesian component of particle force	N
F_o	Fourier number	
$G = SR/V - 1$	shape factor of the container	
g	acceleration due to gravity (Chapter 7)	m s^{-2}
g, h	constant (Chapter 10)	
H	static enthalpy (Chapter 6)	J kg^{-1}
\overline{H}	specific enthalpy (Chapter 7)	J m^{-3}
\vec{H}	magnetic field (Chapter 10)	
\mathbf{H}	magnetic field (Chapter 7)	A m^{-1}
h	surface heat transfer coefficient (Chapter 6)	$\text{W m}^{-2} \text{ }^\circ\text{C}^{-1}$
h	convective heat transfer coefficient (Chapter 7)	$\text{W m}^{-2} \text{ K}^{-1}$
h	Planck's constant	
h_{evap}	evaporation heat density	
h_i	enthalpy of phase i	
I_i	mass sink or source density of phase i	
i	imaginary unit	
\vec{j}	electric current density	
K	turbulent kinetic energy	$\text{m}^2 \text{ s}^{-2}$
\mathbf{K}	stiffness matrix	$\text{W }^\circ\text{C}^{-1}$
k	electrical conductivity	S m^{-1}
k	thermal conductivity (Chapter 7)	$\text{W m}^{-1} \text{ }^\circ\text{C}^{-1}$
k	Boltzmann's constant (Chapter 10)	
\vec{k}	wave vector	
k_t	reaction rate constant at temperature T	s^{-1}
L	characteristic length	m
M	molecular weight (Chapter 6)	kg mol^{-1}
M, M_i	moisture content, liquid moisture content (Chapter 10)	
m, n, o, p, q, r	exponents (Chapter 6)	
m	constant (Chapter 10)	
\mathbf{N}	shape function	
n	constant	
n_i	concentration of ion i	
n_\perp	outward normal to surface	
\vec{P}	polarisation	
p	pressure	Pa
Q	power dissipated per unit volume (Chapter 7)	W m^{-3}

Q	volumetric heat generation (Chapter 6)	$W m^{-3}$
\dot{Q}	rate of heat (Chapter 11)	$J s^{-1}$
$Q(R)$	radiant flux emitted per unit area unit increment of wavelength	$W m^{-2} \eta m$
\mathbf{Q}	source term vector	units s^{-1}
Q_{em}	electromagnetic heat production density	
q_R	radiative power flux density	
R	universal gas constant (Chapter 6)	$J mol^{-1} K^{-1}$
R	smallest characteristic dimension of a geometry (Chapter 7)	m
r	residual (Chapter 6)	
r	radial position of a can (Chapter 7)	m
r	reflected waves (Chapter 11)	
$\Re(x)$	real part of x	
S	heat transfer surface	m^2
S_ϕ	source of quantity ϕ	units $m^{-3} s^{-1}$
T	temperature	$^\circ C$ or K
T_{ref}	reference temperature	K
T_m	temperature of the heating medium	K
t	time (Chapters 6, 7, 10)	s
t	transmitted waves (Chapter 11)	
\mathbf{U}	velocity vector	$m s^{-1}$
\mathbf{u}	nodal temperature vector	
u	velocity in the vertical direction	$m s^{-1}$
u_j	Cartesian velocity component	$m s^{-1}$
V	volume	m^3
V	voltage (Chapter 7)	V
v	velocity in the radial direction	$m s^{-1}$
\vec{x}	local vector	
x_i, x, y, z	Cartesian coordinate (Chapter 6)	m
x, z	distance (Chapter 7)	m
Z	Z-value: slope of the lethality or cooking curve	K
Z_q	quality factor	K
z_i	valence of ion i	

Greek symbols

Ω	object domain	
Γ	boundary of object	
Γ	diffusivity of quantity ϕ	$kg m^{-1} s^{-1}$
α	absorbed waves	
α_M	mass diffusivity	
α_p	pressure diffusivity	
$\alpha = \lambda/\rho c_p$	thermal diffusivity	$m^2 s^{-1}$
$\chi = \epsilon - 1$	dielectric susceptibility	
δ_E	electric field attenuation length	

δ_p	pressure gradient coefficient/power attenuation length	
δ_T	thermal gradient coefficient	
ϵ	turbulent energy dissipation rate (Chapter 6)	$\text{m}^2 \text{s}^{-3}$
ϵ	emissivity (Chapter 11)	
ϵ	permittivity (Chapter 7)	F m^{-1}
$\epsilon = \epsilon' - i\epsilon''$	relative permittivity (Chapter 10)	
ϵ_c	convergence error	
ϵ'	dielectric constant (Chapter 7)	
ϵ''	dielectric loss factor (Chapter 7)	
ϵ_0	dielectric constant of vacuum	
ϵ_V	ratio of vapour flow to total moisture flow	
ζ	ratio of vapour diffusion to total moisture diffusion (Chapter 6)	
ζ	dimensionless axial length (Chapter 7)	
η	dynamic viscosity	$\text{kg m}^{-1} \text{s}^{-1}$
$\theta = T/T_{\text{ref}}$	dimensionless temperature (Chapter 7)	
ϑ	dimensionless temperature	
κ	damping constant	
λ	wavelength (Chapter 10)	
λ	thermal conductivity (Chapter 7)	$\text{W m}^{-1} \text{K}^{-1}$
μ	relative permeability (Chapter 10)	
μ	apparent viscosity (Chapter 7)	Pa s
μ_0	permeability of vacuum	
μ_i	mobility of ion i	
ϕ	transported quantity per unit mass	units kg^{-1}
ρ	density (charge, mass)	kg m^{-3}
σ	Stefan-Boltzmann constant (Chapters 6 and 11)	$\text{W m}^{-2} \text{K}^{-4}$
σ	conductivity (Chapter 10)	
σ	electrical conductivity (Chapter 7)	$\text{W m}^{-1} \text{K}^{-1}$
σ_S	electrical conductivity (solid)	$\text{W m}^{-1} \text{K}^{-1}$
σ_L	electrical conductivity (liquid)	$\text{W m}^{-1} \text{K}^{-1}$
σ_e	electrical conductivity (effective)	$\text{W m}^{-1} \text{K}^{-1}$
ω	circular frequency	

Subscripts

0	initial condition
∞	ambient condition