Renewable and Waste-Heat Utilisation Technologies

Understand the science and engineering behind conventional and renewable heat loss recovery techniques with this thorough reference guide. This book provides you with the knowledge and tools necessary to assess the potential waste-heat recovery opportunities that exist within various industries and select the most suitable technology. In particular, technologies that convert waste heat into electricity, cooling or high-temperature heating are discussed in detail, alongside more conventional technologies that directly or indirectly recirculate heat back into the production process. Essential reading for professionals in chemical, manufacturing, mechanical and processing engineering who have an interest in energy conservation and waste-heat recovery.

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Thermal Energy Recovery, Conversion, Upgrading and Storage

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CAMBRIDGE
UNIVERSITY PRESS

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Shaftesbury Road, Cambridge CB2 8EA, United Kingdom

One Liberty Plaza, 20th Floor, New York, NY 10006, USA

477 Williamstown Road, Port Melbourne, VIC 3207, Australia

314–321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi – 110025, India

103 Penang Road, #05–06/07, Visioncrest Commercial, Singapore 238467

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a department of the University of Cambridge.

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www.cambridge.org
Information on this title: www.cambridge.org/9781108480772
DOI: 10.1017/9781108691093

First published 2023

A catalogue record for this publication is available from the British Library.

ISBN 978-1-108-48077-2 Hardback

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Acronyms

Roman Symbols

A	heat-transfer area, m^2
c	velocity, m/s
c_p	specific-heat capacity, J/(kg K)
C	cost, $
C_0	total investment cost, $
C_{c}	cost of electricity, $/kWh
C_{g}	cost of natural gas, $/kWh
$C_{\mathrm{o\&m}}$	operation and maintenance costs, $/kWh
d_{h}	hydraulic diameter, m
D	diameter, m
D_{s}	specific diameter
$\mathcal{D}$	thermal diffusivity, m^2/s
e_{th}	thermal effusivity, $J/m^2/s^{1/2}/K$
f	friction factor
F	Martinelli parameter
g	acceleration due to gravity, m/s^2
h	enthalpy, J/kg
k	thermal conductivity, W/(m K)
L	length, m
LCOE	levelised cost of electricity, $/kWh
m	mass, kg
$\dot{m}$	mass-flow rate, kg/s
n	operating hours per annum
N_{s}	specific speed
Nu	Nusselt number
NPV	net-present value, $
P	pressure, Pa
ΔP	pressure drop, Pa
P_{r}	reduced pressure
PB	payback period, years
PP	heat-exchanger pinch point, K
Pr	Prandtl number

q	heat transfer per unit mass, J/kg, vapour quality
Q	heat transfer, J
$\dot{Q}$	heat-transfer rate, J/s, volumetric flow rate m^3/s
r	discount rate, %
Re	Reynolds number
s	entropy, J/(kg K)
S	annual savings, $
SIC	specific investment cost, $/kW
t	time/year
T	temperature, K
ΔT_{k}	endo-reversible heat-pump temperature difference, K
ΔT_{log}	log-mean temperature difference, K
ΔT_{sh}	amount of superheat K
w	specific work, J/kg
W	work, J
$\dot{W}$	power, W
U	internal energy, J, overall heat-transfer coefficient $W/(m^2\ K)$
x	fluid composition
X	exergy, J
$\dot{X}$	exergy rate, J/s
z	height, m

Greek Symbols

α	heat-capacity ratio, heat-transfer coefficient, $W/(m^2\ K)$
β	heat-conductance ratio
ε	heat-exchanger effectiveness
η	thermal efficiency/isentropic efficiency
θ	non-dimensional heat source temperature drop
μ	dynamic viscosity, Pa s
ρ	density, kg/m^3
ϕ	coefficient of performance (power-driven)
ψ	coefficient of performance (heat-driven)
ω	rotational speed, rad/s

Subscripts

0	dead state
c	cold
ch	chiller
ci	cold-fluid inlet
cp	cold-fluid pinch
co	cold-fluid inlet
cr	critical point
e	expander
ev	evaporator
h	hot

hi	hot-fluid inlet
hp	hot-fluid pinch, heat pump
ho	hot-fluid outlet
i	inner
l	saturated liquid
min	minimum
max	maximum
n	net
o	outer
p	pump
ph	preheat
s	conditions after isentropic expansion
sh	superheater
v	saturated vapour
wf	working fluid
′	saturation conditions

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