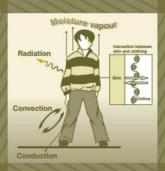
WOODHEAD PUBLISHING



Clothing biosensory engineering

Edited by Y. Li and A. S. W. Wo





Clothing biosensory engineering

Related titles:

Effect of mechanical and physical properties on fabric hand (ISBN-13: 978-1-85573-918-5; ISBN-10: 1-85573-918-6)

This new multiauthored collection addresses the effect of mechanical and physical properties on the way a fabric feels. It begins with concepts and understanding of fabric hand, covering development of fabric hand evaluation, the effect of fibre, yarn and fabric factors as well as finishing on hand, including the mechanical and physical properties. The latter part of the book goes on to cover statistical methods in evaluating hand and a comparison of hand evaluation in different cultures.

Friction in textiles (ISBN-13: 978-1-85573-920-8; ISBN-10: 1-85573-920-8)

The action of friction in fibres and textiles plays major roles in product performance, from the generation of the fibre through to the way a garment responds to wear. This book addresses both the beneficial and detrimental processes of friction, with chapters on fibre structure, measurement techniques, static electrification, shrink proofing and felting, surface modification treatments, friction in fabrics and fibres and its role in textile processing.

Clothing appearance and fit; Science and technology (ISBN-13: 978-1-85573-745-7; ISBN-10: 1-85573-745-0)

This comprehensive book provides a critical appreciation of the technological developments and scientific understanding related to clothing appearance and fit. It bridges recent active research and development in beauty and fashion design, with garment evaluation technology, drape and human anthropometrics and sizing. It includes many industrial standards, techniques and practices that will make it an essential reference for researchers, academics, professionals and students in clothing and textile academia and industry.

Biomechanical engineering of textiles and clothing (ISBN-13: 978-1-84569-052-6; ISBN-10: 1-84569-052-4)

Many modern consumers are demanding apparel products with higher added values in terms of functional performance to satisfy various aspects of their biological and psychological needs during wear. Naturally, engineering apparel products for biological and psychological health has become an integrated part of the concept of bioengineering. Biomechanical engineering of textiles and clothing addresses the issues of designing and producing textiles and clothing for optimum interaction with the body. It covers fundamental theories, principles and models behind design and engineering for the body's biomechanics. Contact problems arising between textiles/clothing and the body are discussed along with the mechanics of fibres, yarns, textiles and clothing. Material properties will also be covered in relation to mechanical performance.

Details of these books and a complete list of Woodhead's titles can be obtained by:

- visiting our website at www.woodheadpublishing.com
- contacting Customer Services (e-mail: sales@woodhead-publishing.com; fax: +44 (0) 1223 893694; tel.: +44 (0) 1223 891358 ext. 30; address: Woodhead Publishing Ltd, Abington Hall, Abington, Cambridge CB1 6AH, England)

If you would like to receive information on forthcoming titles in this area, please send your address details to: Francis Dodds, (address, tel. and fax as above; e-mail: francisd@woodhead-publishing.com). Please confirm which subject areas you are interested in.

Clothing biosensory engineering

Edited by Y. Li and A.S.W. Wong



The Textile Institute



CRC Press Boca Raton Boston New York Washington, DC

WOODHEAD PUBLISHING LIMITED

Cambridge England

Published by Woodhead Publishing Limited in association with The Textile Institute

Woodhead Publishing Limited, Abington Hall, Abington Cambridge CB1 6AH, England

www.woodheadpublishing.com

Published in North America by CRC Press LLC, 6000 Broken Sound Parkway, NW, Suite 300, Boca Raton, FL 33487, USA

First published 2006, Woodhead Publishing Limited and CRC Press LLC © 2006, Woodhead Publishing Limited The authors have asserted their moral rights.

This book contains information obtained from authentic and highly regarded sources. Reprinted material is quoted with permission, and sources are indicated. Reasonable efforts have been made to publish reliable data and information, but the authors and the publishers cannot assume responsibility for the validity of all materials. Neither the authors nor the publishers, nor anyone else associated with this publication, shall be liable for any loss, damage or liability directly or indirectly caused or alleged to be caused by this book.

Neither this book nor any part may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, microfilming and recording, or by any information storage or retrieval system, without permission in writing from Woodhead Publishing Limited. The consent of Woodhead Publishing Limited does not extend to copying for

general distribution, for promotion, for creating new works, or for resale. Specific permission must be obtained in writing from Woodhead Publishing Limited for such copying.

Trademark notice: Product or corporate names may be trademarks or registered trademarks, and are used only for identification and explanation, without intent to infringe

British Library Cataloguing in Publication Data A catalogue record for this book is available from the British Library.

Library of Congress Cataloging in Publication Data A catalog record for this book is available from the Library of Congress.

Woodhead Publishing ISBN-13: 978-1-85573-925-3 (book) Woodhead Publishing ISBN-10: 1-85573-925-9 (book) Woodhead Publishing ISBN-13: 978-1-84569-146-2 (e-book) Woodhead Publishing ISBN-10: 1-84569-146-6 (e-book) CRC Press ISBN-10: 0-8493-9095-8 CRC Press order number: WP9095

The publishers' policy is to use permanent paper from mills that operate a sustainable forestry policy, and which has been manufactured from pulp which is processed using acid-free and elementary chlorine-free practices. Furthermore, the publishers ensure that the text paper and cover board used have met acceptable environmental accreditation standards.

Typeset by SNP Best-set Typesetter Ltd., Hong Kong Printed by TJ International Limited, Padstow, Cornwall, England

Contents

	Editor contact details	xiii
	Preface	XV
1	Introduction to clothing biosensory engineering YI LI, Institute of Textiles and Clothing. The Hong Kong Polytechnic University, Hong Kong and ANTHONY S.W. WONG, School of Nursing, The Hong Kong Polytechnic University, Hong Kong	1
1.1	Consumer trends	1
1.2	Definition of sensory comfort	3
1.3	Human-clothing-environment system	4
1.4	Clothing biosensory engineering	6
1.5	Acknowledgements	7
1.6	References	7
2	Psychology and sensory comfort	9
	YI LI, Institute of Textiles and Clothing, The Hong Kong Polytechnic	
	University, Hong Kong and ANTHONY S.W. WONG, School of Nursing,	
	The Hong Kong Polytechnic University, Hong Kong	
2.1	Perception of comfort	9
2.2	Psychological research techniques	9
2.3	Comfort sensory descriptors	11
2.4	Psychophysics	13
2.5	Scales of measurement	15
2.6	Scales to measure direct responses	16
2.7	Wear trial techniques	22
2.8	Conclusion	24
2.9	Acknowledgements	24
2.10	References	24

Co		

vi

3	Neurophysiology of sensory perceptions YI LI, Institute of Textiles and Clothing, The Hong Kong Polytechnic University, Hong Kong and ANTHONY S.W. WONG, School of Nursing, The Hong Kong Polytechnic University, Hong Kong	28
3.1	Senses and comfort	28
3.2	Neurophysiological basis of sensory perceptions	29
3.3	Perception of sensations related to mechanical stimuli	32
3.4	Perception of thermal and moisture sensations	42
3.5	Perception of texture	48
3.6	Perception of fabric hand	50
3.7	Acknowledgements	54
3.8	References	54
4	Physiology of thermal comfort	60
	YI LI, Institute of Textiles and Clothing, The Hong Kong Polytechnic	
	University, Hong Kong and ANTHONY S.W. WONG, School of Nursing, The Hong Kong Polytechnic University	
4.1	Introduction	60
4.2	Thermal comfort	61
4.3	Thermophysiology of the human body	64
4.4	Thermoregulation of the human body	66
4.5	Dynamic thermal interaction between the body and	
4.6	clothing	68 70
4.0	Nomenclature	71
	Acknowledgements	7.7
4.8	References	71
5	Physics of thermal comfort	74
	YI LI, Institute of Textiles and Clothing, The Hong Kong Polytechnic	
	University, Hong Kong and ANTHONY S.W. WONG, School of Nursing, The Hong Kong Polytechnic University, Hong Kong	
5.1	Introduction	74
5.2	Heat and moisture transfer	74
5.3	Dynamic heat and moisture transfer in fabric	76
5.4	Moisture exchange between fiber and air	79
5.5	Boundary conditions	83
5.6	Physical properties of fibers and fabrics	84
5.7	Method of solution	84
5.8	Moisture sorption of wool fabrics	86
5.9	Behavior of fabrics made from different fibers	86
5.10	Acknowledgements	90
5.11	References	90

	Contents	vii
6	Thermal and moisture sensations Yi Li, Institute of Textiles and Clothing, The Hong Kong Polytechnic University, Hong Kong and ANTHONY S.W. WONG, School of Nursing, The Hong Kong Polytechnic University, Hong Kong	93
6.1	Introduction	93
6.2	Coolness to the touch	93
6.3	Warmth to the touch	99
6.4	Dampness sensation	104
6.5	Clamminess and moisture buffering during exercise	107
6.6	Environmental buffering	110
6.7	Acknowledgements	112
6.8	References	112
7	Tactile sensations	116
	YI LI, Institute of Textiles and Clothing, The Hong Kong Polytechnic University, Hong Kong and ANTHONY S.W. WONG, School of Nursing, The Hong Kong Polytechnic University, Hong Kong	
7.1	Introduction	116
7.2	Fabric prickliness	116
7.3	Fabric itchiness	120
7.4	Fabric stiffness	121
7.5	Fabric softness	127
7.6	Fabric smoothness, roughness and scratchiness	131
7.7	Garment fit and pressure comfort	141
7.8	Acknowledgements	147
7.9	References	147
8	Dimensions of sensory comfort perceptions YI LI, Institute of Textiles and Clothing, The Hong Kong Polytechnic University, Hong Kong and ANTHONY S.W. WONG, School of Nursing, The Hong Kong Polytechnic University, Hong Kong	151
8.1	Individual sensations involved in the perception of	
	sensory comfort	151
8.2	Identification of sensory factors	152
8.3	Thermal-wet comfort	159
8.4	Tactile comfort	160
8.5	Clothing pressure comfort	161
8.6	Acknowledgements	164
8.7	References	164

tents

viii

9	Overall comfort perception and preferences ANTHONY S.W. WONG, School of Nursing, The Hong Kong Polytechnic University, Hong Kong and Yı Lı, Institute of Textiles and Clothing, The Hong Kong Polytechnic University, Hong Kong	167
9.1 9.2	Introduction Influences of different factors toward overall comfort	167
9.3	perception Calculation of subjective preference on clothing	169
9.4	Relationship between overall comfort perception and	10,
	preference	171
9.5	Acknowledgements	175
9.6	References	175
	Had sained the contract from the sain	
10	Prediction of clothing sensory comfort	178
	ANTHONY S.W. WONG, School of Nursing, The Hong Kong Polytechnic	
	University, Hong Kong and Yi Li, Institute of Textiles and Clothing,	
	The Hong Kong Polytechnic University, Hong Kong	
10.1	Introduction	178
10.2	Prediction of fabric hand	178
10.3	Predictability of sensory comfort	180
10.4	Predictability of subjective preferences	181
10.5	Prediction of sensory factors	183
10.6	Prediction of clothing sensory comfort on the basis of	102
10.7	subjective measurements	183
10.7	Prediction of clothing sensory comfort on the basis of fabric physical properties	184
10.8	Application of hybrid models in the prediction of clothing	104
10.0	sensory comfort	185
10.9	Acknowledgements	187
10.10	References	187
11	Thermal properties	189
	J.Y. Hu, Yi Li and K.W. YEUNG, Institute of Textiles and Clothing,	
	The Hong Polytechnic University, Hong Kong	
11.1	Introduction	189
11.2	Heat production and heat loss	189
11.3	Thermal comfort	191
11.4	Thermal insulation	192
11.5	Thermal conductivity	194
11.6	Cool/warm feeling	194
11.7	Thermal manikin	198

	Contents	ix
11.8	Other apparatus for fabric thermal functional evaluation	201
11.9	Acknowledgements	203
11.10	References	203
12	Water vapor transfer	206
	J.Y. Hu, Yi Li and K.W. YEUNG, Institute of Textiles and Clothing, The Hong Polytechnic University, Hong Kong	
12.1	Introduction	206
12.2	Moisture phase changes	206
12.3	Water vapor transfer	208
12.4	Water vapor transfer with temperature gradient	213
12.5	Comparison of water vapor transfer with and without	
	temperature gradient	214
12.6	Conclusion	215
12.7	Acknowledgements	215
12.8	References	215
13	Liquid moisture transfer	218
	J.Y. HU, YI LI and K.W. YEUNG, Institute of Textiles and Clothing,	
	The Hong Polytechnic University, Hong Kong	
13.1	Introduction	218
13.2	Absorbency	218
13.3	Wettability	220
13.4	Waterproof	221
13.5	Contact angle	223
13.6	Moisture management	223
13.7	Experimental	229
13.8	Acknowledgements	233
13.9	References	233
14	Coupled heat and moisture transfer	235
	S.X. WANG and YI LI, Institute of Textiles and Clothing,	
	The Hong Kong Polytechnic University, Hong Kong	
14.1	Introduction	235
14.2	Simulation of coupled heat and moisture transfer	235
14.3	Moisture transfer with temperature gradient	238
14.4	The role of phase change material (PCM) fabrics	238
14.5	Effect of PCM fabrics	245
14.6	Measuring the thermal and moisture buffering effects	
	of fabrics	248
14.7	Acknowledgements	250
148	Deferences	250