

Handbook of yarn production

Handbook of yarn production

Technology, science and economics

Peter R. Lord



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 Ltd
Abington Hall, Abington
Cambridge CB1 6AH, England
www.woodhead-publishing.com

Published in North America by CRC Press LLC
2000 Corporate Blvd, NW
Boca Raton FL 33431, USA

First published 2003, Woodhead Publishing Ltd and CRC Press LLC
© 2003, Woodhead Publishing Ltd
The author has asserted his moral rights.

Originally published in 1979 by the author under the title *The economics, science and technology of yarn production*, this is a new, completely revised version of the book.

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 author and the publishers cannot assume responsibility for the validity of all materials. Neither the author 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 the publishers.

The consent of Woodhead Publishing and CRC Press 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 or CRC Press 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 1 85573 696 9

CRC Press ISBN 0-8493-1781-9

CRC Press order number: WP1781

Typeset by Replika Press Pvt Ltd, India
Printed by TJ International, Cornwall, England

Contents

<i>Acknowledgments</i>	<i>ix</i>
1 Review of yarn production	1
1.1 Historical basis	1
1.2 Present day conditions	8
1.3 Future of the means of textile production.....	9
1.4 Modern production systems.....	10
References	17
2 Textile products and fiber production	18
2.1 Textile materials (fabrics, fibers, and filaments).....	18
2.2 Natural fibers (types and production)	22
2.3 Man-made fibers (polymer extrusion and yarn production)	38
References	54
3 Common principles	56
3.1 Introduction	56
3.2 Twist in strands	56
3.3 Twist insertion	61
3.4 Confined and non-confined systems	67
3.5 Twist evenness	68
3.6 Tension control	69
3.7 Drawing	70
3.8 Consequences of roller errors on the textile product	76
3.9 Control of irregular flow in drawing or drafting	77
3.10 Doubling	83
3.11 Effects of shear	84
3.12 Integration of sub-processes	86
References	87
4 Filament yarn production	88
4.1 Introduction	88
4.2 Texturing filament yarns	89

4.3	Real twist texturing	90
4.4	False twist texturing	92
4.5	Draw-texturing	102
4.6	Stuffer box texturing	104
4.7	Air-jet texturing	106
4.8	Other texturing techniques	110
4.9	Industrial filaments	113
4.10	Silk filaments and staple yarns	113
4.11	Morphology and dyeing	114
	References	114
5	Carding and prior processes for short-staple fibers	116
5.1	Introduction	116
5.2	Opening line	118
5.3	Bale preparation	119
5.4	The first stage of blending and opening	121
5.5	The process of disintegration of fiber clumps	122
5.6	Condensation	123
5.7	The process of cleaning	125
5.8	Intimate blending	129
5.9	Fiber flow	133
5.10	Carding	136
5.11	Waste control	149
5.12	Safety	153
	References	154
6	Sliver preparation	155
6.1	Introduction	155
6.2	Drawframe	155
6.3	Combing	159
6.4	Creel blending	164
6.5	An industrial case study	165
	References	167
7	Short-staple spinning	168
7.1	Ring spinning	168
7.2	Open-end spinning	185
	References	203
8	Long-staple spinning	205
8.1	Introduction: Effects of lengthening the staple	205
8.2	Wool fibers and their preparation	206
8.3	Worsted systems	213
8.4	The woolen system	220
8.5	Bast fiber spinning processes	231
	References	232

9	Post-spinning processes	234
9.1	Winding	234
9.2	Yarn joining	245
9.3	Ply yarns	250
9.4	Automation	253
9.5	Two-for-one twisting	255
9.6	Customer concerns	257
	References	259
10	Staple systems and modified yarn structures	260
10.1	Yarns of complex structure	260
10.2	Processes using modified twist	261
10.3	Compact spinning	261
10.4	Air-jet spinning	263
10.5	Sirospun yarns and process	268
10.6	Hollow spindle spinning	270
10.7	Self-twist spinning	271
10.8	Twisted self-twist yarns and processes	274
	References	275
11	Quality and quality control	276
11.1	Quality	276
11.2	Quality control	278
11.3	Yarn evenness	291
11.4	End-breaks and quality	298
	References	300
12	Economics of staple yarn production	301
12.1	Yarn economics	301
12.2	Productivity	303
12.3	Quality and economics	306
12.4	Cost minimization	308
12.5	Operational factors	313
12.6	International competition	315
	References	316
	Appendices	317
1.	Calculations I: Elementary theory	317
2.	Calculations II: Worked examples	329
3.	Advanced topics I: Air conditioning and utilities	341
4.	Advanced topics II: Testing of textile materials	350
5.	Advanced topics III: Staple yarn structures	373
6.	Advanced topics IV: Textured yarn structures	383
7.	Advanced topics V: Blending of staple fibers	389
8.	Advanced topics VI: Drafting and doubling	407
9.	Advanced topics VII: Yarn balloon mechanics	427
10.	Advanced topics VIII: Topics in rotor spinning	453
Index		465

Acknowledgments

Grateful acknowledgments are made to the many friends and colleagues who have read various parts of this script and given very helpful and constructive criticism. These include Charles Chewning, David Clapp, Philip Dabbs, Yehia E1 Moghazi, Wally Johnson, W Oxenham, Jon Rust and W C Stuckey.

Acknowledgments are also made to UMIST, NC State University, Cotton Incorporated, the many different commercial organizations in a variety of fields with whom I have been associated and the many people involved. It has been a great experience and pleasure. Much of what I have to say in this book has its origins in the many discussions and shared fieldwork experiences. This embraces too large a number of people to name individually but I take the opportunity to express my thanks to all of you. I hope that by sharing these experiences, I will repay the help that I have received during my career in this fascinating field.

I would be remiss in not acknowledging the wonderful forbearance of my wife Mavis during these last years. Only someone that cared so much could have tolerated the late arrivals for meals, the relegation of important social responsibilities and the overwhelming obsession with the project. I dedicate the work to her in celebration of our 56th wedding anniversary.