

Textiles in automotive engineering

Walter Fung and
Mike Hardcastle



The Textile Institute



WOODHEAD PUBLISHING LIMITED

Textiles in automotive engineering

Textiles in automotive engineering

Walter Fung and Mike Hardcastle



The Textile Institute



WOODHEAD PUBLISHING LIMITED

Cambridge England

Published by Woodhead Publishing Limited in association with The Textile Institute
Abington Hall, Abington
Cambridge CB1 6AH, England
www.woodhead-publishing.com

Published in North and South America by
Technomic Publishing Company Inc
851 New Holland Avenue, Box 3535
Lancaster, Pennsylvania 17604 USA

First published 2001, Woodhead Publishing Ltd and Technomic Publishing
Company Inc

© 2001, Woodhead Publishing Ltd

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 the publishers.

The consent of Woodhead Publishing Ltd and Technomic Publishing Company Inc 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 Ltd or Technomic Publishing Company Inc 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 493 1

Technomic Publishing Company ISBN 1-58716-080-3

Cover design by The ColourStudio

Typeset by Best-set Typesetter Ltd, Hong Kong

Printed by T J International, Cornwall, England

Dedicated to my forebears, Taishan County, Guangdong Province, China

*Walter Fung
(Feng Qing Xiang)*

To Christine my wife whose unflappable character, cheerful disposition, patience and constant support have provided the inspiration for my contribution to this publication and many other enterprises.

Mike Hardcastle

Contents

	<i>Preface</i>	x
	<i>Acknowledgements</i>	xiii
1	Introductory survey	1
1.1	General survey	1
1.2	Material survey – fibres	8
1.3	Material survey – plastics	15
1.4	Material survey – natural and synthetic rubbers	18
1.5	Requirements from suppliers	19
1.6	References	22
1.7	Further reading	22
2	Interior design	24
2.1	Interior design	24
2.2	Further reading	42
3	Fabric structures and production methods	44
3.1	Introduction, fibres and yarn types	44
3.2	Fabric structures – wovens	54
3.3	Fabric structures – warp knitted	76
3.4	Fabric structures – weft knitted	86
3.5	Fabric structures – flat-bed knitting	94
3.6	Fabric structures – non-wovens	95
3.7	References	106
3.8	Further reading	106
4	Yarn and fabric processing	110
4.1	Introduction	110
4.2	Dyeing and finishing	112
4.3	Printing	126

4.4	Coating and lamination	137
4.5	References	155
4.6	Further reading	156
5	Quality assurance and testing	158
5.1	Quality assurance	158
5.2	Test method details	166
5.3	References	190
5.4	Further reading	192
6	Product engineering – interior trim	194
6.1	Introduction	194
6.2	Seats	195
6.3	Headliners	212
6.4	Door casings	215
6.5	Parcel shelves	218
6.6	Other interior trim	219
6.7	Complete modular interiors	221
6.8	References	222
6.9	Further reading	226
7	Other textile applications	227
7.1	Introduction	227
7.2	Seat belts	228
7.3	Airbags	231
7.4	Carpets	234
7.5	Cabin air filters	238
7.6	Battery separators	241
7.7	Bonnet (hood) liners	242
7.8	Wheel arch liners	243
7.9	Hood material for convertibles	243
7.10	Tyres	244
7.11	Hoses and belts – general considerations	247
7.12	References	249
7.13	Further reading	252
8	Automotive textiles and the environment	254
8.1	Introduction	254
8.2	The greenhouse effect and global warming	255
8.3	Environmental legislation	257
8.4	The effects of pollutants	263

8.5	Manufacturing concerns	265
8.6	Sustainable development	269
8.7	References	275
8.8	Further reading	279
9	Textiles in other forms of transportation	281
9.1	Introduction	281
9.2	Composite materials	282
9.3	Flame retardancy	289
9.4	Fabric coating	292
9.5	Textiles in other road vehicles	302
9.6	Railway applications	306
9.7	Marine applications	308
9.8	Textiles in aircraft	311
9.9	References	319
9.10	Further reading	322
10	Future development and outlook	324
10.1	General survey	324
10.2	Manufacturing	326
10.3	Fabric performance	327
10.4	New developments and opportunities	328
10.5	Environmental issues	329
10.6	Visions of the future – fabric design aspects	331
10.7	Further visions of the future	332
10.8	References	334
10.9	Further reading	334
11	Sources of further information	336
11.1	Conferences	337
11.2	Journals	339
11.3	Technical and professional organizations and institutions	343
11.4	Market information on automotive industry	347
11.5	General textile reference	348
11.6	Glossary of terms and abbreviations	348
11.7	Abbreviations used in references at end of chapters	354
	<i>Index</i>	355

Preface

In preparing this textbook, it has been the authors' objective to provide a work of reference and instruction to all those involved with textiles in the automotive industry. Textiles are present in many forms in the automobile ranging from the seats to battery separators, from headliners to bonnet liners. The automotive textile industry requires knowledge of several disciplines, textile chemistry, fabric technology, plastics' science, production engineering and interior fabric design. The latter, which has become more important in recent years, combines artistic talent with textile technology. Some information is available in specialist trade journals but there is shortage of literature and especially textbooks dealing with the subject as a whole. This book is intended to plug that gap and cuts across all the disciplines involved.

The book is written in a concise, simple style which it is hoped can be understood by anyone with only a basic scientific background knowledge. The scientific principles are explained to help readers understand why processes are done in such a way, and it is also hoped this will assist with problem solving. Because of the practical nature of the industry, all technical, design and manufacturing personnel are frequently referred to as 'engineers'. It is hoped that this book, while containing some scientific theory and some history to make it more readable, will be of practical help to all automobile engineers who deal with components containing a textile and also to interior trim designers.

Today the technical requirements of performance and durability of interior trim fabrics, often seem to override all other considerations such as colour design and texture. However it must not be forgotten that the original driving force for the widespread use of textile fabrics and structures in car interiors during the early 1970s was to expand the design and colour potential of the car interior, which aesthetically had become fairly dull and uninspiring. An attractive interior trim is now regarded as a major aid to sales and model differentiation. The different textile production methods of weaving, knitting and printing all come with their own particular advan-

tages and features, but also with limitations regarding the design and colouration achievable. The importance of all of these aspects, which concern both the fabric supplier and the car manufacturer, is fully explored in this book.

In the face of very severe competition, the automotive industry worldwide is undergoing intensive and wide-ranging restructuring. At present cost is the major driving force in development as a whole. New processes are being introduced to make components more quickly and more economically. Frequently they involve processes and conditions, usually applied to more heat-resistant plastics, which are adapted to process textiles which are less heat resistant and have delicate surfaces and texture. Examples are the newer moulding processes now being used for door casings, seats, and other interior trim. Sometimes the operatives and even supervisors involved have no comprehension of what conditions the textile will withstand in terms of temperature and pressure. The result is many rejects which can be detrimental to the factory involved and to the industry as a whole. This book should help by explaining the physical limitations and other properties of the textile.

Car makers, known as Original Equipment Manufacturers (OEMs) are becoming assemblers of outsourced components or modules made by their direct suppliers, the so called Tier-1 companies. When Henry Ford invented the production line his warehouse always carried 4 months of spares so that the production line never stopped. Today, the efficient OEM has virtually no warehouse but relies on just-in-time (JIT) deliveries of components. This necessitates the Tier-1 suppliers' production to be always right up to schedule. In turn the production schedules of the suppliers to the Tier-1s must also be on time. Severe financial penalties may be imposed by the OEMs, if production lines are held up. This situation demands that any production problem must be quickly identified and put right.

Frequently the past history of the textile has contributed to a particular fault and it is very important that the quality engineer is familiar with the previous process, which the textile has already undergone, to solve that problem – and better still to prevent it happening again. In addition, the quality engineer should be fully aware of the process conditions his own customer will subject the material to, so that he can be sure that his own process is not likely to cause problems further down the production chain or for the ultimate customer, the car purchaser. This book should be invaluable to the quality engineer in these activities to improve quality and efficiency and hence profitability.

The book should also be of use in universities and colleges for both students and research workers, who now have all the relevant information in one textbook, together with numerous literature references, refer-

ences to test methods and a glossary of unfamiliar terms and abbreviations. A detailed list of technical and professional organizations, journals and recommended conferences are also presented for keeping up to date.

Acknowledgements

The authors thank the Directors of Collins and Aikman Automotive Fabrics Ltd for permission to write this book. Thanks are also due to the following who have helped by checking parts of the manuscript for accuracy, by supplying information or have helped in some other way; Peter Adshead, Martin Barrick, Peter Booth, John Briggs and Melanie Wray, (Collins and Aikman Automotive Fabrics Ltd), Cliff Kemp (Collins and Aikman Carpet Division), Nick McMichael (Collins and Aikman Acoustic Division), Barrie Crabtree (Cosmopolitan Textiles), Keith Barlow (Selectus), Bill Whitehouse (Acordis), Ian Charnock (Toray Textiles Europe), Geoff Formoy (Cornelius Chemical Co), Chris Hinchcliff (Courtaulds Textiles), Dr Kevin Niderost (Kumho Europe), Dr John Barnes (DuPont Europe), Dr Harry Fung (EA Technology), Jeff Caunt (Karl Meyer Textile Machinery Ltd), Michael Clay (Allertex Ltd Bradford), Michael Dicks (Shima Seiki Europe Ltd), Jim Freeman (Jefftex Ltd), Irene Haasis (Mayer & Cie GmbH & Co), Malcolm Howard and Simon Maynard (Robert S Maynard Ltd), Ralph Moakes (Vernon Cooper Ltd), Gilbert Moulin (Michel Van de Wiele), Stewart Partridge (Web Consulting Ltd), Matthew Robinson (Rieter-Scragg Ltd), Duncan Sephton (Standfast Dyers and Printers Ltd), Dave Walton, (Freudenberg), Richard Bates (Crompton & Knowles), Dr Darren McMurray (Phoenix Fire Inhibitors), John Retford (Lantor), Walter Duncan (Synthomer), David Dykes (British Vita), Gerald Day (formerly Delphi), Simon Beeley (John Holdsworth and Company), Ian Leigh (BF Goodrich), Simon Fung (ADtranz, DaimlerChrysler Rail Systems), Guy Badham (Rolls Royce plc), John de Main (Velcro Europe), Brian McDonagh (Hope Industrie), Helmut Schierbaum (Bayer), David Wallwork and Keith Parton (Clariant), Alastair Hendry (Virgin Airlines), Geoff Holmes and Peter Tyers (Bostik), Alan Cross (BASF), Marcel Mallens (Griltex-EMS), Andrew Christie (3M Germany), Francis Woodruff (Web Processing), Tom Govier (Shirley Developments Ltd), Jim McCullough (Barbour Campbell Threads Ltd), Dr Ranber Mann (BFF Nonwovens), Mike Appleton (Sybron/Tanatex), Alan Wootten (formerly Alplas),

Sheila Morris and John McGarrie (Ciba), Jason Payne (3M Automotive Systems) and Juli Case and staff at IFAI Technical Services.

Thanks also to the following for supplying illustrations and permission to reproduce material; Reeves Brothers, Inc. USA; Beaufort Air-Sea Equipment Ltd. (Wardle Storeys); EDANA, Brussels; DH Leather, Textile Machinery Ilkley; Paul KIEFEL GmbH, Frielassing; DuPont International SA Geneva; Herbert Meyer GmbH; Thies (UK) Ltd; Ozark Systems; Roaches International; SAE International, Warrendale PA USA; British Rubber Manufacturers Association Ltd; Freudenberg Vliesstoffe KG; Chris Chiles, (Nordson); Ulli Sellen (Alplas/Atlas); Phil Hextall (Border Textiles/Obem); Siubhan Reid-Litherland (LMC Automotive Services), Nick Butler (Technical Textiles International); Robert Jackson Wardle/Werner Mathis AG and 3M Deutschland GmbH.