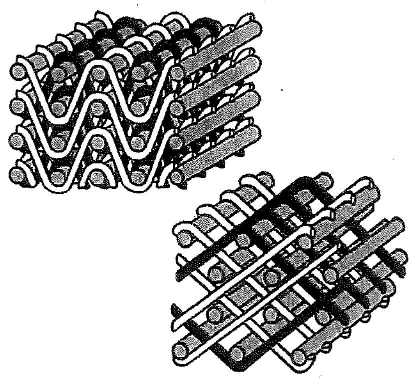
WOODHEAD PUBLISHING IN TEXTILES



3-D fibrous assemblies

Properties, applications and modelling of three-dimensional textile structures

Jinlian HU

CRC

The Textile Institute

WP

Woodhead Publishing in Textiles: Number 74

3-D fibrous assemblies

Properties, applications and modelling of three-dimensional textile structures

Jinlian HU

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, Granta Park,
Great Abington, Cambridge CB21 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 2008, Woodhead Publishing Limited and CRC Press LLC

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 978-1-84569-377-0 (book)
Woodhead Publishing ISBN 978-1-84569-498-2 (e-book)
CRC Press ISBN 978-1-4200-7986-9
CRC Press order number: WP7986

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

1

Introduction to three-dimensional fibrous assemblies

Abstract: Three-dimensional (3-D) textiles are those materials that have a system or systems in all three axes of plane. These materials offer particular properties, such as interlaminar shearing force, mechanical and thermal stability along all three axes of space, that are not achievable with other reinforcements. The development of three-dimensional textiles has taken place rapidly over the past two decades. It can be credited largely to the growth of another technology: composite materials, which combine fibres and a matrix. An understanding of the production methods and structures of these 3-D fibrous assemblies would go a long way in design, process control, process optimization, quality control, clothing manufacture and development of new techniques for specific end uses. This chapter introduces various 3-D woven, knitted, non-woven, braided and stitched fabrics with their brief description and advantages.

Key words: three-dimensional (3-D) textiles, 3-D woven fabrics, 3-D knitted fabrics, 3-D non-woven fabrics, 3-D braided fabrics.

1.1 Introduction: concepts of three-dimensional fibrous assemblies

Textile structures such as in woven, knitted, non-woven and braided fabrics are being widely used in advanced structures in the aerospace, automobile, geotechnical and marine industries. In addition, they are finding wide application as medical implants such as scaffolds, artificial arteries, nerve conduits, heart valves, bones, sutures, etc. This is because they possess outstanding physical, thermal and favourable mechanical properties, particularly light weight, high stiffness and strength, good fatigue resistance, excellent corrosion resistance and dimensional stability. In addition, they act as attractive reinforcing materials in various composite applications with low fabrication cost and easy handling (Tan *et al.*, 1997). With high-end applications such as in aerospace, the orientation of the fibrous reinforcement is becoming more and more important from a load-bearing point of view, as is the need for placing the reinforcement oriented in the third dimension (Alagirusamy *et al.*, 2006).

Textile fabrics, termed preforms in composites and other applications, consist of various reinforcing fabrics such as wovens, knits, braids and non-wovens. Two-dimensional fabrics have allowed us to drape bed, board and body in a profusion of texture, pattern and colour over the centuries. The development of advanced fibres has led engineers to consider textiles for high-performance applications such as in construction and aeronautics. These fabrics have been relatively well developed in terms of production, analysis and application and some of them have long been used in structural composite fields (Chou and Ko, 1989; Mohamed, 1990). However, the strength of these traditional fabrics is anisotropic, manifesting itself primarily in the direction of the fibre orientations. Most of these 2-D textile structures retain the inherent weakness of laminated composites that are susceptible to delamination.

To extend the use and value of textiles into industrial and engineering applications, which typically require strength in more than two directions, textile designers have bound together layers of textiles and exploited the chemical properties of fibres and binders to create novel non-woven textiles whose fibres are not restricted to two-dimensional arrangements. More recently, they have taken the next step: finding ways to manufacture true three-dimensional (3-D) textiles. Hence, 3-D fabrics have been introduced to respond to the needs of a number of industrial requirements such as composites capable of withstanding multidirectional stresses.

The development of 3-D textiles has taken place rapidly over the past two decades. It can be credited largely to the growth of another technology: composite materials, which combine fibres and a matrix. Textile engineers have been challenged to develop strong fibre architectures and new manufacturing processes for building textile structures in three dimensions, as these 3-D fabrics hold great promise for use in industry, construction, transportation and even military and space applications. They are often made into a near net shape so that the overall manufacturing cost can be very low for certain applications (Mohamed, 1990).

An understanding of the production methods and structures of these 3-D fibrous assemblies would go a long way in the design, process control, process optimization, quality control, clothing fabrication and the development of new techniques for specific end uses. The interrelationship between their structure and various properties may be of great help in designing new types of 3-D structures for the construction, medical, sports and aerospace industries.

1.2 Two-dimensional structures (two-dimensional fabrics)

1.2.1 Two-dimensional wovens

Weaving is the most widely used textile manufacturing technique and accounts for the majority of the two-dimensional (2-D) fabric produced

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming inter-face) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.

WHAT WILL YOU BUILD? | **sales@docketalarm.com** | **1-866-77-FASTCASE**