

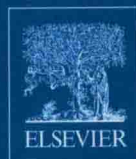
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Thermoforming of Single and Multilayer Laminates

Plastics Films Technologies,
Testing, and Applications

Syed Ali Ashter

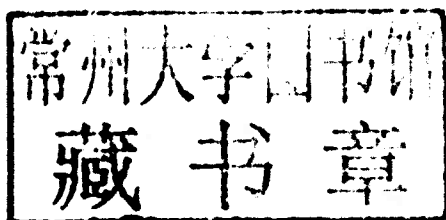


Thermoforming of Single and Multilayer Laminates

Plastic Films Technologies, Testing, and Applications

Syed Ali Ashter

EMD Millipore Corporation



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Library of Congress Cataloging-in-Publication Data

A catalogue record for this book is available from the Library of Congress.

British Library Cataloguing-in-Publication Data

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

ISBN: 978-1-4557-3172-5

For information on all William Andrew publications
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Typeset by MPS Limited, Chennai, India
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Thermoforming of Single and Multilayer Laminates



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This book is dedicated to my father, the **late Syed Zahier Haider**, for his support, guidance, perseverance and encouragement throughout my undergraduate and graduate studies.

Syed Ali Ashter

Preface

This book provides an overview of the fundamentals of thermoforming and covers plastic materials, processing and testing, new developments in the field of thermoforming, application of laminate characteristics to commercial thermoforming, a literature review on modeling of thermoforming and troubleshooting the thermoforming process. This book will provide mechanical and plastic engineers entering the manufacturing industry with essential knowledge of various aspects of plastics beyond thermoforming. This text is also well intended for academic institutions as a textbook for students taking undergraduate and graduate courses in plastics processing.

This book is comprised of 12 chapters covering a wide array of topics. The first two chapters cover the history, markets, applications and fundamentals of thermoforming. The third chapter reviews different characteristics of common plastics for thermoforming.

Chapters 4 and 5 discuss laminates specifically, including typical commercial laminates, different lamination techniques and new developments in the field of thermoforming. It is the author's intention to cover additional topics such as biaxial bulge and biaxial strain not typically available in thermoforming books. Chapter 6 covers the mechanics of materials and includes relevant equations and figures to illustrate stress, strain, stress relaxation, peel and delamination. Extensive characterization techniques are discussed in Chapter 7. Chapter 8 discusses laminate characteristics of thermoforming for packaging, household products, appliances, transportation and sports applications. The safety, recycling and environmental issues of thermoforming are broadly discussed in Chapter 9. Chapters 10 and 11 cover other plastic-processing approaches

and a literature review on modeling of thermoforming. Finally, Chapter 12 provides a detailed thermoforming troubleshooting guide.

Syed Ali Ashter
Summer 2013

Acknowledgments

I would like to thank my doctoral thesis advisor, Professor Stephen Burke Driscoll, for his valuable suggestions and improvements to the text. I would also like to thank the Plastics Engineering Department and specifically Professor Stephen Orroth for all his help and expertise. This book would not have been possible without the support of my colleagues and managers at EMD Millipore Corp. In particular, I would like to thank Dr. Sina Ebnesajjad, technical editor at Elsevier BV, for his constant mentoring, support and encouragement throughout the manuscript-writing process. I also want to extend my gratitude to David Jackson, Associate Acquisition Editor at Elsevier BV, for his patience and assistance during this endeavor.

Finally, I would like to thank most of all, my wife, Tahira Ashter, and my two kids, Zayn and Noor Ashter. Without their unconditional love, encouragement and constant support this work would never have been completed.

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1 Introduction to Thermoforming

Chapter Outline

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Success to any manufacturing process is directly linked to cost-effective production of parts, or at similarly high production costs, but at an improved part quality. There are areas of applications, where injection molding competes with thermoforming, but where packaging technology is concerned, thermoforming is the process of choice with little competition.

The shaping of plastic films and sheets has been known by many names over the years. Originally, shaping was considered one of a variety of fabrication techniques available to transform plastic sheets into finished products. The sheets-plastics industry has grown rapidly in recent years, and is still growing. The modification of older materials and the introduction of new ones led to new applications and new techniques being introduced, but the industry eventually settled on the term thermoforming.

Thermoforming is a primary polymer conversion process in which a plastic sheet is heated to its rubbery state and by either mechanical or pneumatic means formed into a three-dimensional object. Today, it is one of the fastest growing segments of the plastics industry. This has been brought on by the development of new materials and techniques, coupled with innovative production and specialized equipment capable of providing the manufacturing efficiency for the industry. The major advantages of thermoforming are its cost-effective thermoforming tools, reasonably priced thermoforming machines and the possibility for processing even multi-layered materials, foams and preprinted forming materials.