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The Ten Fundamentals of THERMOFORMING

2-Video Program & Companion Volume

Sponsored by
SPE Thermoforming Division

The Ten Fundamentals of Thermoforming
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Society of Plastics Engineers

The Ten Fundamentals of THERMOFORMING

Authored by William K. McConnell

The Society of Plastics Engineers is proud to announce its partnership with William K. McConnell in offering **The Ten Fundamentals of Thermoforming**, a 2-Video Series accompanied by a Companion Volume.

Bill is today's best-known expert in the thermoforming industry. His knowledge and reputation come from over forty years of experience, study, and application. He has traveled the world consulting and lecturing on all aspects of thermoforming.

Traditionally, thermoforming has been more "art" than science, a tradition that is sharply challenged by today's competitive marketplace. Simple in concept, thermoforming is challenging in practice. Ever-increasing demands for product complexity, performance, and cost effectiveness have led to the development of a wide variety of processes that shape articles from sheet or film. Knowledge that was once adequate must now be upgraded and broadened.

Operators, supervisors, managers, process engineers, mold and product designers, cost estimators, sales reps, and quality personnel will all find something of value in the Ten Fundamentals of Thermoforming. Bill McConnell's vast experience and knowledge are distilled into a practical, accessible form that is written in a clear and concise style. The Videos and comprehensive Companion Volume include the same topics that Bill covers more in-depth in his SPE Seminar Series.

Topics include Basic Thermoforming Methods, Costing, Mold and Product Design, Involving the Appropriate Team, Plastic Materials, Production of Film and Sheet by Extrusion, The Heating of Film and Sheet and Heating System Requirements, Tooling, Vacuum and Compressed Air Systems, Good Thermoforming Practices (Safety, The Plant Environment, and Effective Problem Solving and Troubleshooting).

The videos are enhanced with 3-D animation and simulations that provide a look "behind the scenes" at the principles on which the manufacturing process is based. Footage for the videos was filmed at four plant locations: Prent Corporation, Milsco, Portage Casting & Mold and Thermoform Plastics. Additional support was provided by the SPE Thermoforming Division, PMW Products, Inc., Plastic Ingenuity, and Morton Custom Plastics. SPE is grateful to these companies and individuals for their time, cooperation and generous support.

Video and Companion Volume Topics

BASIC THERMOFORMING METHODS

- ◆ Vacuum Forming
- ◆ Pressure Forming (Use of Compressed Air)
- ◆ Mechanical Forming
- ◆ Modifications of Basic Forming Methods
- ◆ Webbing Prevention
- ◆ Prestretching
- ◆ Snap Back
- ◆ Billow Snap Back
- ◆ Plug Assist
- ◆ Billow Plug Assist
- ◆ Twin Sheet Thermoforming

This chapter explores the most well-known processes and their advantages or disadvantages as they relate to tooling, forming, ancillary equipment and machinery. Schematics, line diagrams and photos are used to illustrate parts, processes and molds.

COSTING

- ◆ Economics and Costing in the Design Stage
- ◆ What Must Be Considered When Estimating Cost
- ◆ Elements of Production Costs
- ◆ Sheet Weight Formulas

Costing can make the difference between profit and loss, yet it is easy to overlook vital details. Comprehensive checklists are included in this chapter to assist in establishing material, tooling and processing costs.

MOLD AND PRODUCT DESIGN

- ◆ Design Guide Outline
- ◆ Establishing Guidelines
- ◆ Preliminary Design Considerations
- ◆ Detail Part Design
- ◆ Following Through
- ◆ Design Details

Guidelines and checklists are presented, to help ensure that the appropriate steps are taken during the design cycle.

INVOLVING THE APPROPRIATE TEAM

- ◆ Team Players
- ◆ Suppliers

Producing a successful product involves cooperation from internal and external sources.

PLASTIC MATERIALS

- ◆ Thermosets
- ◆ Thermoplastics

A synopsis of the two major classes of polymeric materials, and how they relate to the thermoforming process. Tables are provided for Key Material Properties and Standard ASTM Terminology for Abbreviated Terms.

PRODUCTION OF FILM AND SHEET BY EXTRUSION

- ◆ The Extrusion Process
- ◆ Feedstocks
- ◆ Orientation
- ◆ Regrind
- ◆ Sheet & Film Spec Checklist

An overview of the extrusion process is the essential first step in the manufacture of thermoformed products. Understanding how film and sheet are made is an indispensable tool for establishing a repeatable process and building a good relationship with your supplier.

THE HEATING OF FILM AND SHEET AND HEATING SYSTEM REQUIREMENTS

- ◆ Thermoforming Processing Temperatures
- ◆ Heat Transfer Modes
- ◆ Principles of Radiant Heating

Sheet temperature and forming rate are crucial elements in thermoforming a quality part. This chapter explores how plastics are heated and how forming temperature affects both the material and the finished part.

TOOLING

- ◆ Molds—Design & Construction
- ◆ Plug Assists
- ◆ Cooling Fixtures
- ◆ Trimming Fixtures
- ◆ Tooling Spec Checklist
- ◆ Mold Design & Ordering Spec Checklist

Well designed and well built tooling is important to achieving consistent, economical thermoformed parts. Diagrams, checklists and tables are provided to help the thermoformer make sound, informed decisions about tooling.

VACUUM AND COMPRESSED AIR SYSTEMS

- ◆ Vacuum Systems
- ◆ Basic Vacuum Pressure Measurements
- ◆ Determining Vacuum System Capacity

Rapid, controlled forming is the key to consistent thermoformed parts, and vacuum and compressed air systems must be properly designed, built, and maintained. This chapter outlines the principles.

GOOD THERMOFORMING PRACTICES

- ◆ Safety in the Plant
- ◆ The Plant Environment
- ◆ Record-keeping
- ◆ Developing a Repeatable Process
- ◆ Process Monitoring
- ◆ Effective Problem Solving & Troubleshooting
- ◆ Sheet Extrusion Troubleshooting Guide

This final chapter discusses general rules of safety, the effects of ambient conditions on employees, good record-keeping, achieving a repeatable process, monitoring the process, and logical problem solving. An extensive Troubleshooting table covers everything from blisters to tearing.



WILLIAM K. "BILL" MCCONNELL, JR. Author

Bill is president of McConnell Co., Inc., Ft. Worth, TX. His company provides comprehensive consulting work to the Thermoforming industry.

Honors and Achievements:

- ◆ The 1st Thermoformer of the Year
- ◆ Lifetime Achievement Award
- ◆ Fellow of SPE
- ◆ Plastics Pioneers Association
- ◆ Founding Member of the SPE Thermoforming Division
- ◆ SPE Thermoforming Division Board Member
- ◆ International Seminar and Workshop Instructor
- ◆ Published Author

After majoring in Aeronautical Engineering at Texas A&M, Bill taught aerial navigation for the Navy and founded a non-scheduled airline. He was Vice President and General Manager of Texstar Plastics before starting his own manufacturers' rep business dealing in plastic sheet, film and equipment. He also founded AAA Plastic Equipment, Inc., manufacturing shuttle and rotary thermoforming equipment.

Bill belongs to the Polymer Science and Engineering Technology Advisory Committee at Pittsburg State University in Pittsburg, Kansas, and is also a member of the Industrial Advisory Board of the Polymer Technology Consortium of Texas A&M University.

Bill's career gives him a unique knowledge of all aspects of plastic thermoforming production, from the design of equipment and manufacturing to the successful marketing of the product.

Video scripts were written by Scott Bogue, Polymers Center of Excellence. Mr. Bogue edited the Companion Volume and contributed to its writing.