

Handbook on Pet Film and Sheets, Urethane Foams, Flexible Foams, Rigid Foams, Speciality Plastics, Stretch Blow Moulding, Injection Blow Moulding, Injection and Co-Injection Preform Technologies

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Handbook on Pet Film and Sheets, Urethane Foams, Flexible Foams, Rigid Foams, Speciality Plastics, Stretch Blow Moulding, Injection Blow Moulding, Injection and Co-Injection Preform Technologies (Also Known as Speciality Plastics, Foams (Urethane, Flexible, Rigid) Pet & Preform Processing Technology Handbook)

Polyester or polyethylene terephthalate (PET) is an unreinforced, semi-crystalline thermo-plastic polyester derived from polyethylene terephthalate. Its excellent wear resistance, low coefficient of friction, high flexural modulus, and superior dimensional stability make it a versatile material for designing mechanical and electro-mechanical parts. PET is fully recyclable and can be easily reprocessed into many other products for many different applications. However, unlike paper and other cellulose products, PET does not readily decompose. However, biodegradable additives are available that enhance the biodegradation of this plastic without affecting the physical properties.

Formation of a flexible polyurethane foam is an intricate process employing unique hardware, multiple ingredients and at least two simultaneous reactions. The urethane forming reaction occurs between the isocyanate and the polyol. Polyurethanes, also known as polycarbamates, belong to a larger class of compounds called polymers. Polyurethanes can be produced in four different forms including elastomers, coatings, flexible foams, and cross-linked foams.

Elastomers are materials that can be stretched but will eventually return to their original shape. They are useful in applications that require strength, flexibility, abrasion resistance, and shock absorbing qualities.

Thermoplastic polyurethane elastomers can be molded and shaped into different parts. This makes them useful as base materials for automobile parts, ski boots, roller skate wheels, cable jackets, and other mechanical goods. When these elastomers are spun into fibers they produce a flexible material called spandex. Spandex is used to make sock tops, bras, support hose, swimsuits, and other athletic apparel. Co-injection is the process of injecting two resins simultaneously through a single gate to form a multi-layer structure. Recently, there has been a re-emergence of interest in co-injection technology spurred on by the development of new resins, barrier systems, controls, and hardware technologies.

Increasing demand of polyethylene terephthalate (PET) from food and beverage sector like in carbonated soft drinks packaging, increase demand for packaged food due to rise in consumption of frozen and processed food, rise in demand for electronics and automotive applications/industries and ecofriendly substitution are the most important driving factors in the polyethylene terephthalate market. Also, rapid urbanization, innovative packaging and high economic growth is contribution in increasing the demand for polyethylene terephthalate regardless of the geographical location.

This book will be a mile stone for its readers who are new to this sector, will also find useful for professionals, entrepreneurs, those studying and researching in this important area.

1. PROPERTIES AND APPLICATIONS OF SPECIALITY PLASTICS

Polytetra Fluoroethylene (PTFE)
Thermoplastic Polyurethanes (TPU)
Polysulphones (PSO)
Polyether Sulphone (PES)
Polyphenylene Sulphide (PPS)
Polyphenylene Ether (PPE)
Polyether Etherketone (PEEK)
Polyarylates
Polyamide Imide (PAI)
Polyether Imide (PEI)
Liquid Crystal Polymers (LCP)

2. FORMATION OF URETHANE FOAMS

Introduction

The Chemistry of Foam Formation and cure

1. Reaction of Isocyanates
2. Function of the isocyanate in Foaming
3. Role of Catalysts in Foam systems
 - A. The Tertiary Amine Catalysts
 - B. The Tin Catalysts
 - C. Mixed Catalysts Systems

The Final Cure of Urethane Foams

Colloid Chemistry of Foam Formation

1. Bubble Nucleation
 2. Bubble Stability
 3. Urethane Foam Systems
- Viscoelastic Changes in Foaming
1. Effect on Cell Structure, Voids, and Foam Collapse
 2. Relations between Cell Structure and Properties
 3. Structure Factors Affecting Stress Relaxation and Creep in Flexible Foams

3. FLEXIBLE FOAMS

Introduction

Raw Materials Used in Flexible Foams

1. Isocyanates
2. Polyols Blowing
3. Agents Catalysts

4. Surfactants
5. Miscellaneous Additives

Foam Systems

1. General Methods of Preparation
 2. Prepolymers
 - A. Variables in the preparation of prepolymers
 1. Raw Materials Control
 2. Effect of Isocyanate-Hydroxyl Ratio
 3. Effect of Polyol Variation
 4. Effect of Reaction Time and Temperature
 5. Effect of water
 6. Effect of catalysts
 7. Effect of Agitation
 8. Effect of Reactor size
 - B. Procedures for the preparation of prepolymers
 1. Batch Procedures
 2. Preparation of Prewolymer with Biuret Branching
 3. Preparation of Prepolymer with Allophanate Branching
 4. Preparation of Prepolymer with Urethane Branching
 5. Preparation of Polyester Prepolymer
 6. Preparation of Castor Oil-Based Prepolymers
 7. Batch Plant Process for Polyether Prepolymers
 8. Catalyzed Prepolymer Preparation
 9. Stabilization of Prepolymers
 - C. Foaming of prepolymers
 1. Free Isocyanate Content
 2. Water
 3. Surface Active Agents
 4. Catalysts
 5. Other Additives
- #### Plasticizers
- #### Pigments and Fillers
- #### Flame Retardants
3. Semi-Prepolymers
 4. One-shot Foams
 1. Chemical variations
- #### Effect of water
- #### Effect of Catalysts
- #### Effect of Emulsifiers and Additives
2. Mechanical Variations
 3. Physical Variations
 4. Formulation Variations
- B. Variables in the preparation of one-shot Polyether Foams
 1. Effect of Polyols
 2. Effect of Diisocyanate
 3. Effect of Blowing Agents
 4. Effect of Catalysts
 5. Effect of Silicones
 6. Effect of Filters and Additives
 7. Formulation Variations
- #### Methods of Foam Application
1. Foaming Equipment
 2. Manufacture of Slab Stock

- A. Foam Production
- B. Sectioning of Slab Stock
- C. Counter Shaping
- D. Post-Forming
- 3. Molding of Flexible Foam
- 4. Frothing of Flexible Foams
- 5. Foaming of Urethane Elastomers
- 6. Spraying of Flexible Foams
- Properties of Flexible Foams
- 1. General Properties
- 2. Specific Properties
- A. Aging of Flexible Foam
- B. Sound Absorption
- C. Low and High Temperature Properties
- D. Solvent and Chemical Resistance
- E. Oxidation and Ultraviolet Resistance
- F. Flammability of flexible Urethane Foams
- G. Fatigue Properties
- Application of Flexible Foams
- 1. Furniture
- 2. Bedding
- 3. Transportation
- A. Automotive
- B. Aircraft
- C. Public Seating
- 4. Packaging
- 5. Clothing, Textile and Miscellaneous Foam Laminates
- 6. Carpet Underlay
- 7. Sporting goods
- 8. Toys and Novelties
- 9. Sponges and Miscellaneous Household Items
- 10. Filtering Materials
- 11. Construction, Insulation and Miscellaneous Uses
- 12. Military and Missile Uses
- 13. Horticultural
- 14. Footwear
- 15. Medical
- Miscellaneous Flexible Foam Systems

4. RIGID FOAMS

Introduction

- 1. Raw Material used in Rigid Foams
- 1. Isocyanates
- 2. Polyols
- 3. Blowing Agents
- 4. Catalysts
- 5. Surfactants
- 6. Flame Retardants
- 7. Miscellaneous Additives

Foam System

- 1. Polymer Preparation
- A Semi-Prepolymer

B. Complete Prepolymer

C. One-shot Systems

2. Foam Preparation

A. Effect of Isocyanate Variations

B. Effect of Polyol Variations

C. Effect of Blowing Agents

D. Effect of Catalysts

E. Effect of Surfactants

F. Effect of Fillers

G. Flame Retardants

Methods of Foam Production

1. Batch Preparation

2. Continuous or Intermittent Pouring

A. Nonfroth Systems

Metering Equipment

Mixing of Components

B. Frothing System

3. Spraying

4. Production of Finished Foam

A. Continuous Slab Production

B. Molding Operations

C. Foaming-in-Place

Foam Properties

1. General Properties

2. Specific Properties

A. Coefficient of Expansion

B. Service Temperature

C. Closed Cell Content

D. Thermal Insulation

E. Adhesion to Various Substrates

F. Water Absorption

G. Water Vapor Permeability

H. Humid Aging

I. Solvent Resistance

J. Electrical Properties

K. Sound Insulation

L. Fungus Resistance

Applications of Rigid Foams

1. Refrigeration Insulation

2. Refrigerated Trucks and Trailers

3. Insulation of Pipes and Tanks

4. Structural Uses

5. Uses in the Aircraft Industry

6. Military Uses

7. Void Filling and Insulation of Ships

8. Uses in Packaging

9. Uses in the Electric Industry

10. Aerospace Applications

11. Miscellaneous Uses

Miscellaneous Foaming Systems

5. ONE-STAGE INJECTION STRETCH BLOW MOULDING

Introduction

One-Stage Machines

1. One-Stage Machine Construction

Process Stations on one-Stage Machine

1. Injection mould and hot runner
- A. Process conditions affecting perform quality
2. Conditioning Station
3. Blowing Station

Integrated Two-Stage machines

Drying System

1. Requirements for a reliable drying system
2. Drying process monitoring

Preform Design

1. Neck finish
2. Preform weight
3. Cycle time and preform wall thickness
4. Stretch rations
5. Injection mould design and manufacture
6. Preform design for varying container sizes
7. Preform weight adjustment
8. Difference between one- and two-stage preform designs

Container Design

Hot-Fill Pet Bottles

Quality Control Procedures

Preform Examination

1. Appearance and shape
2. Preform weight
3. Neck dimensions
4. Preform eccentricity
5. Polarised light inspection
6. Intrinsic Viscosity (IV)
7. Actetaldehyde (AA)

Container Examination

1. Shape and appearance
2. Dimensions
3. Capacity
4. Container wall thickness and material distribution
5. Top load strength
6. Impact resistance (drop) test
7. Leakage of liquid (seal integrity)
8. Vacuum strength
9. Acetaldehyde (AA)
10. Oxygen permeation
11. Moisture Vapour transmission rate
12. Product filling temperature
13. Container weight

Bottles for Carbonated Beverages

1. Burst pressure
2. Thermal stability
3. Carbon retention

Additional Tests for Hot-Fill containers

Additional Tests for Returnable/refillable Pet Bottles

6. INJECTION BLOW MOULDING

Introduction
Basic Principles
History
Commercial Processes
1. Rotary table machines : Jomar, Uniloy and similar
Tooling
Procrea
Material
Applications
Machine and Process Capabilities

7. PET MATERIAL AND APPLICATIONS

Introduction
Polymerisation and Manufacturing Processes
1. Manufacturing plants
Structures, Morphology and Orientation
1. Structure
2. Morphology
3. Orientation
4. Creep
Properties
1. Molecular weight and intrinsic viscosity
2. End group
3. Thermal properties
2. End group
3. Thermal properties
Rheology and Melt Viscosity
1. Melt viscosity
2. Melt Flow
3. Moulding Shrinkage
Moisture Uptake and Polymer Drying
1. Moisture level
2. Polymer drying
Degradation Reactions
1. Thermal and thermal oxidative degradation
2. Environmental Degradation
Reheat Characteristics
Gas Barrier properties
Amorphous Polyesters
1. Homopolymers
2. Low copolymers
3. Medium copolymers
4. High copolymers
Crystalline polymers
Polymer Blends
Applications
Trends
Globals

8. INJECTION AND CO-INJECTION PREFORM TECHNOLOGIES

Multilayer Characteristics
Applications

1. Performance-Driven Applications
 2. Economics - or Legislative-Drive Applications
 3. Combination Applications
- Closure vs Bottle Permeation
- Container Performance
1. Barrier properties
 2. Oxygen barrier
 3. Carbon dioxide barrier
 4. Scavenger property
- Wall structure
- Preform and Bottle Design
1. Permeation through finish, sidewall and base
 2. Controlled fill
- Headspace Oxygen Absorption
- Oxygen Desorption From Pet
- Beer Containers
- Small Juice Containers
- Small CSD containers
- Core layer volumes
- Comparison of Co-Injection technologies
- Co-Injection Moulding Equipment

9. PET FILM AND SHEET

Introduction

The Film Process

1. Polymer preparation and handling
2. Extrusion and Casting
 - a. Extrusion
 - b. Casting
3. Drawing
 - a. The forward draw preheat (FWDPH)
 - b. The forward draw (FWD)
 - c. The sideways draw preheat (SWDPH)
 - d. The sideway draw (SWD)
4. Heat Setting
5. Slitting and Winding
 - a. In line slitting and knurling
 - b. Winding conditions
6. Reclaim and recovery

Polymer, Process and Properties (3ps)

1. Polymer
2. Process
3. Properties

Surface and Bulk Properties

1. Film properties
2. Coating
3. Co-extrusion
4. Fillers
5. Shrinkage
6. Combination of effects

PET Sheet

1. Extrusion of PET sheet
2. Thermoforming of CPET sheet

- 4. Material
- 5. New developments
- Conclusion-Film

10 PLASTICS AS SAFE & HYGIENIC MEDIUM FOR PACKAGING FOOD & FOOD PRODUCTS

- Glimses of Modern India
- Views & changing practices
- Scarcity among plenty
- Consumer market
- Food packaging a need
- Food Safety The Ultimata
- Risk assessment & food packaging regulations
- Compatibility studies
- Migration modelling
- Package Design
- Packaging Development Process
- Plastics as a Choice
- Plastic Use for Packaging in India
- Lowest cost packaging
- Plastic-Packaging Solution for Food Products
- Growing user of plastic in Packaging
- Plastics and their present usages
- Indian Polymer Demand in KTPA
- Plastics reduce post harvest wastage
- Wastage of food product in India
- Plastic crates for post harvest packing
- Polypropylene boxes for horticulture packaging
- Plastics in bulk packaging
- Bulk Packaging Jute V/s PWS
- Suitability of PP/PE Bags for Food Grains & Sugar Storage
- Specialized Food Packaging
- Case study
- Plastics & Food shelf Life
- Plastics packaging for sterilized/irradiated food products
- National Standards on Packaging code for fresh & Processed Food
- Indian Food Laws and Packaging specification
- Edible Oil packaging Act
- Packaging, Plastics & Environment
- IS packaging or plastics the Real Culprit
- ECO- Protection programmes
- Future: What plastics have to offer

11. TWO STAGE INJECTION STRETCH BLOW MOULDING

- Introduction
- 1. The principles of the Two-stage process
 - a. Preform moulding
 - b. Container stretch blow moulding
 - c. Preform and container design
- 2. Technological Basics of Pet as a Stretch Blow moulding material
- 3. Production concepts and target market
- Preform Injection Moulding
 - 1. Injection machine concepts

- a. Plasticizing
- Clamping
- 2. Mould Design
 - a. Hot runner system
 - b. Gates and cavities
- Productivity Parameters
 - a. Cycle time
 - b. Preform design and key related parameters
 - c. Preform quality and key related parameters
- Stretch Blow Moulding
 - 1. Principles of the two stage stretch blow moulding process
 - a. Preform reheating
 - b. Stretch blow moulding
- Technologies for thermally stable containers
- Thermal relaxation and pre-shrinkage
- Hot-fill
- Heat-set
- Super heat-set
- 2. Machinery concepts
- Mould technology
- Preform and Container Design
- Container design
- Preform design

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business, entrepreneurs are often faced with the dilemma of zeroing in on a suitable product/line.

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