Plastic Materials for Thermoforming
Rheology Challenge with Thermoforming

- Operating temperature range
- Outdoor exposure
- Chemical exposure
- Loads / impact
- Fatigue / vibration / cyclic stress
- Electrical properties (radomes)
- Optical requirements (transparent, light diffusing)
- Appearance (color, texture, gloss)
- Flammability requirements
- Certifications (FDA, UL, etc.)
Rheology Challenge with Thermoforming

- Shallow draw vs. deep draw
- Requirement for pre-drying
- Forming temperature
- Tolerance for regrind
- Processing temperature window
- Shrinkage
- Ease of painting / bonding with adhesives
- Tooling requirements
The material must have sufficient “rubbery” strength to support its own weight during forming.

The material must flow to achieve the desired shape.
Structure of Thermoplastic Molecules

Amorphous thermoplastics
- Molecules lacking a crystalline structure

Semi-crystalline thermoplastics
- More orderly, geometric molecular structures
Amorphous Plastics vs. Semicrystalline Plastics

Amorphous thermoplastics

• Easier to thermoform
• Examples: ABS, HIPS, Polycarbonate

Semi-crystalline thermoplastics

• Difficult to thermoform
• Examples: HDPE, PP
Thermoplastic Triangle

**AMORPHOUS HIGH PERFORMANCE MATERIALS**
- High service temperatures
- High strength
- Hot water and steam resistance
- Thermoformability

**SEMI-CRYSTALLINE ENGINEERING PLASTICS**
- General purpose bearing and wear or structural parts
- Moderate strength and stiffness
- Good chemical resistance
- Moderate temperature

**AMORPHOUS COMMODITY PLASTICS**
- Low temperature
- Low strength
- Good bondability
- Good machinability
- Good formability
- Low cost

**SEMI-CRYSTALLINE COMMODITY PLASTICS**
- Low temperature
- Low strength
- Good chemical resistance
- Low moisture absorption
- Low cost

**AMORPHOUS PLASTICS**
- Softens over a wide temperature range
- Easy to thermoform
- Transparent
- Poor chemical resistance
- Bonds well using adhesives or solvents
- Prone to stress cracking
- Poor fatigue resistance
- Structural applications only (not suitable for bearing and wear)

**SEMI-CRYSTALLINE PLASTICS**
- Sharp melting point
- Difficult to thermoform
- Opaque
- Good chemical resistance
- Difficult to bond using adhesives or solvents
- Resistant to stress cracking
- Good fatigue resistance
- Good for bearing and wear (as well as structural applications)

**IMIDIZED MATERIALS**
- Best physical properties above 400°F
- Best temperature resistance
- High temperature, high load bearing and wear capabilities (bearing grades)
- Good chemical resistance

**HIGH PERFORMANCE**
- High service temperature
- Excellent chemical resistance
- High purity

**HIGH PERFORMANCE TEMPERATURE**
- High temperature
- High load bearing and wear capabilities
- Good chemical resistance

**HIGH COST**
- High material cost

*Materials should be considered for applications up to approximate maximum temperature. Selecting a plastic material for use in a high temperature environment requires careful review of material properties data. This chart is for comparison purposes only.*
HDPE

- Semicrystalline, difficult to thermoform
- Inexpensive
- Good chemical resistance
- Difficult to glue or paint
- HMW (high molecular weight) blow molding grades can be thermoformed
- HMW grades have good cold temperature toughness
Polypropylene

- Semicrystalline, difficult to thermoform
- Inexpensive
- Good chemical resistance
- Difficult to glue or paint
- Available in homopolymer (moderately stiff) and copolymer (flexible and tough) grades
- Can be decorated with transfer paper
HIPS (High Impact Polystyrene)

- Inexpensive
- Easy to thermoform
- Easy to screen print, glue, and paint
- Low strength, stiffness
- Limited operating temperature range
- Moderate impact strength
ABS

• Inexpensive
• Easy to thermoform
• Easy to screen print, glue and paint
• Moderate strength and stiffness
• Limited operating temperature range
• Higher impact strength than HIPS but lower than KYDEX® Thermoplastics
Acrylic – Transparent, brittle

- Optically transparent
- Good UV stability
- LED Light diffusing grades available
- Available in many different colors
- Somewhat brittle
PETG

• Optically clear
• Poor UV stability
• Great for deep draw parts
• Tougher than acrylic but not as tough as polycarbonate
• Not good for elevated temperature applications
• Generally does not require drying prior to thermoforming
Polycarbonate – Transparent, tough, prone to ESC

- Optically clear grades available
- LED light diffusing grades available
- Many different colors available
- Higher impact strength and higher operating temperature than acrylic or PETG
- Outdoor grades available
- Prone to environmental stress cracking
- Must be dried prior to thermoforming
- Degrades when exposed to steam
KYDEX® Thermoplastics

- Typically PVC / acrylic alloys
- Very good thermoforming characteristics
- Tougher than HIPS or ABS
- Available in virtually any color and in many different textures. Low minimums for custom colors.
- Extremely good flammability characteristics (UL grades, aircraft grades, etc.)
- New polycarbonate based grades have higher service temperatures
Polysulfone

- Higher service temperature than polycarbonate
- Transparent yellow appearance
- Stands up well to steam
- Less expansive than Ultem® or Radel® R
Ultem® PEI

- Higher service temperature than polysulfone
- Very strong and stiff
- Transparent amber appearance
- Stands up well to steam including medical autoclave
- Outstanding electrical properties
- Somewhat brittle
Radel® R PPSU

• Extremely high service temperature

• Tougher and more durable than polysulfone or Ultem®

• Transparent amber color

• Stands up well to steam including medical autoclave
Tooling and Fixturing Materials

- Rigid polyurethane boards
- Some are foam, some are solid
- Grades available that are good for low volume thermoforming tooling and trim fixtures
Plexus® Methacrylate Adhesives

- Bonds dissimilar materials
- Gap filling properties
- Can be sanded and painted
- Not greasy
- Available with a wide range of working times
Plexus® MA 420 FS Adhesive

- Working time of 1 to 2 minutes
- 75% of ultimate strength in 5 to 6 minutes
- Can often be replace mechanical fasteners
- Requires very little surface preparation
Plexus® MA 685 Optically Clear Adhesive