Heat Sealing

Duncan Darby
Clemson University
Common Method to Close / Shape Flexible Packages

• Supply thermal energy on outside of package
• Soften / “melt” sealant

• Also used in closure of semi-rigid and rigid packages
  – Especially combinations with flexible, e.g. cups & lids, etc.
What Is Needed to Make a Seal

• Two surfaces- thermoplastic “seal partners”
• Time, Temperature and Pressure??

• Actually time, energy and pressure
  – Different seal methods supply energy in different ways
Heat Conduction

• Most common type of sealing is heated tooling
  – Often called hot bar, bar, constant temperature, heat sealing, etc.

• Depending on conduction through the materials

• Generally need higher melt point on outside than on inside
Model of Conductive Heat Sealing

2 mil LLDPE sealed one side at 250 F

2 mil LLDPE sealed two sides at 250 F
Model of Cooling of Heat Seal

Cooling Curve for a Seal

2 mil LLDPE initially at 250 F
To Understand Seal Mechanisms

• Separate:
  – The mechanism of creating the seal
  – The mechanism of opening the seal
3 Mechanisms of Making a Seal

• Chain entanglement across seal interface
  – Aka molecular intermingling, autohesion
  – Molecular chains cross interface & entangle together

• Intermolecular bonding
  – Functional groups on one seal partner attracted to those on other seal partner

• Mechanical Seal
  – No real chemical compatibility involved
  – Plastic flows into pores or around fibers of seal partner
4 Opening Mechanisms

• Destruct / Fusion - Seal is stronger than something else, so something else breaks
• Adhesive (peelable)- When opening, sealant comes away from seal partner
• Cohesive (peelable)- Sealant on one of the seal partners breaks within itself
• Interfacial / delamination (peelable)- Seal strong, but delamination built into structure allows for easier opening
Relating Seal Mechanisms to Opening Mechanisms

• Chain entanglement
  – Typically destruct, cohesive, interfacial peel
  – Blended sealants can result in cohesive or adhesive bonds

• Intermolecular bonding
  – Typically adhesive

• Mechanical
  – Typically destruct, cohesive
Opening Mechanisms

Adhesive
- Sealant
- Sealant separation from other layers

Destruct
- Sealant
- Structure fails rather than seal
- Seal stronger than structure tensile

Cohesive
- Sealant
- Sealant breaks

Interfacial split
- Coex Sealant
- Sealant splits away from coex
Seal Curves

• Help to characterize / predict seal behavior of material
• Derived from seal test
• Y-axis: Seal strength
• X-axis: Energy (usually temperature)
  – Pressure, time could also be used
Seal Test- What To Expect

Typically, one of these will end up in the seal curve
Example Seal Curve

- Small temperature changes -> big strength changes
- Seal strength may drop if too much sealant flows away
- Generally where you want to operate

Seal initiation temperature
(if 200 g/in is MST)
Risks of Using MST / SIT

• Can be arbitrary- different film companies use different “minimums”
  – ASTM specifies a number
• Different polymers / processing may give different shapes
• Best practice is to have entire curve
Seal Curves with MST’s
Hot Tack

- Seal curves measured when seal has cooled
- For some applications, seal when hot is important
- Seal may encounter impact or pressure when hot trying to push seal open
  - Vertical form fill seal machines
  - Hot fill applications
Measuring Hot Tack

• Make seal on device
• Immediately after seal jaw opens, measure seal strength
• The stronger the opening force when hot, the better the hot tack properties
Heat Seal Defects: Poor Seals

- Insufficient / Excess time, energy, pressure
- Incompatible layers
- Wrinkles in seal area
- Misalignment on packaging line
- Completely missed seal
- Tear / delaminate on opening
General Seal Defects
Causes of Leaking Seals

• Product in seal
• Insufficient (or excess) time, energy, pressure
• Gussets, fins, laps that go from one thickness to another
  – Sealant has to flow to prevent open channels
  – “Caulking”
Leaking Seals
Product in Seal: Powders & Particulate

• May not melt at all
• If they do melt, probably not compatible with sealant
• Options
  – Prevent it from happening during fill
  – Flush it out with lots of sealant
  – Get sealant that seals through contamination
Solid in Seals
Product in Seal: Liquids & Grease

• Low vaporization temperatures
  – Vaporize & expand during seal, may break seal back open

• High vaporization temperatures
  – May not blow seal open, probably prevent seal

• Options
  – Prevent it from happening during fill
  – Get sealant that seals through contamination
Liquid in Seals
Packaging Material Components in Seal: Slip Additive

- Added to promote machinability
- Some versions migrate to film surface: “bloom”
- Slick, powdery on surface & prevent good seals

Options
- Adjust slip additive to balance machinability and COF
- Use non-migratory slip additives
Packaging Material Components in Seal: Solvent-free Adhesive

- Solvent-free adhesives start as monomers / oligomers
- Small enough to migrate into and through film
- Interact with slip additive in high slip films to contaminate seal surface
- Options
  - Change slip package / concentration
  - Change adhesive
Thank You