Chapter 47

# Polyethylene

## Welding

### BASF AG: Lupolen

Since they are thermoplastic, Lupolen and Lucalen moldings and film can be welded together by the application of heat and pressure. Examples of the techniques that can be adopted are vibration, ultrasonic, friction, hot-gas and hot plate welding.

Film can be heat-sealed by slit-seal, thermal contact and thermal impulse techniques. The main factors that govern the quality of the seam are temperature, pressure and time.

**Reference:** *Lupolen, Lucalen Product Line, Properties, Processing,* supplier design guide (B 581 e/(8127) 10.91) - BASF Aktiengesellschaft, 1991.

### BASF AG: Lupolen

In common with all other thermoplastics, Lupolen PE-HD and PE-MD blow moldings can be bonded together by the application of heat and pressure. They can also be bonded by this means to injection moldings and extruded or thermoformed articles. The materials from which the various parts have been produced should have roughly the same melt viscosity, an idea of which can be obtained from the melt index.

**Reference:** *Lupolen Polyethylene And Novolen Polypropylene Product Line, Properties, Processing,* supplier design guide (B 579 e / 4.92) - BASF Aktiengesellschaft, 1992.

### PE

It was shown that ultrasonic, induction and infrared heating are some of the best choices for the sealing of aseptic food packages. $CO_2$ and YAG lasers provide for fast melting of the polyethylene film, but do not shorten the cycle time sufficiently to justify their high price. Ultrasonic sealing provides a short cycle time of less than 0.5 second and very consistent seal quality with peel strengths being limited by failure in the cardboard. Discontinuities in the aluminum foil always occur during ultrasonic sealing of the package material. Additional work is needed to determine the effects of the discontinuities in the aluminum foil on the integrity of the food. Induction sealing also provides a short cycle time of less than 0.5 second with consistent failure in the cardboard. Because of the low holding pressure, the aluminum foil remains intact. The cycle time for infrared sealing is longer because it is a two step process. Under the optimal sealing conditions, the aluminum foil remains intact. Infrared is more suitable for continuous sealing.

**Reference:** Yeh, H.J., Benatar, A., *Methods for Sealing of Aseptic Food Packages,* ANTEC 1991, conference proceedings - Society of Plastics Engineers, 1991.

# Ultrasonic Welding

### BASF AG: Lupolen

Ultrasonic welding of polyethylene is restricted to the near field. High-frequency techniques are inapplicable, since they do not allow polyethylene to be heated to the requisite temperature. This is because the energy requirements in the high-frequency field are given by the product of the dielectric constant and the dissipation factor tan delta, and this product is very low for polyethylene.

**Reference:** *Lupolen Polyethylene And Novolen Polypropylene Product Line, Properties, Processing,* supplier design guide (B 579 e / 4.92) - BASF Aktiengesellschaft, 1992.

### DuPont Canada: Zemid (applications: cold weather; features: homogeneous; filler: mineral)

Parts made of Zemid resins can be sonically welded, resulting in good bond strength. Lab tests have demonstrated that the bond strength has exceeded the shear strength, under the following conditions:

| | |
|---|---|
| Amplitude | 0.008 cm (0.003 in) @ 20 kHz |
| Time | 0.4 sec |
| Energy | 300 J |
| Pressure | 0.14 MPa (20 psi) |

**Reference:** *Zemid Product Information Guide,* supplier marketing literature (H-07490) - DuPont Canada, 1990.

### PE (features: 5.8 mm thick)

Most olefin fibers, woven and non-woven have good ultrasonic welding characteristics.

**Reference:** *Ultrasonic Sealing and Slitting of Synthetic Fabrics,* supplier technical report - Sonic & Materials, Inc.

# Infrared Welding

### PE

Infrared welding of polyethylene pipes with a tubular radiant heater was successfully conducted. With only nine seconds of heating time, a weld strength and elongation close to the parent material was achieved. Although the weld strengths were close to the parent material over the wide range of parameters used, there were some brittle failures at very low and high heating levels due to underheating and overheating of the part surface. Weld strength should be evaluated with elongation; weld strength alone did not indicate the quality of the weld. Elongation varied with different welding parameters. It reached its peak at 9 seconds heating time, 7 mm heating distance and 334 N forging force (2.7 mm bead size). Any longer heating time, shorter heating distance, and higher force (larger than 2.7 mm bead size) beyond this condition did not improve the elongation. Weld bead size can be a good indicator for heating level because it is very dependent on heating time and heating distance.

**Reference:** Yeh, H.J., *Infrared Welding of Polyethylene Pipes Using Radiant Heater,* ANTEC 1996, conference proceedings - Society of Plastics Engineers, 1996.

# Laser Welding

### PE

Low power $CO_2$ lasers have the capability of joining thin (<0.2 mm) plastic sheets in lap and cut/ seal configurations at high speeds (50 m/min). Applications could include high speed packaging where a non-contact, flexible, computer controlled system would have advantages over ultrasonic, dielectric and heat sealing techniques. The Nd:YAG lasers, with lower absorption capabilities of the shorter wavelength, have potential to be applied to joining plastics in the thickness range of 0.2-2.0 mm in lap and butt joint configurations. Benefits include low distortion and low general heat input. Differences in the melting of the plastic materials and the effect of pigmentation with Nd:YAG lasers have been noted and must be examined further.

**Table 47.1:** Summary of laser welding conditions and tensile properties for polyethylene joints.

| Material | | | Laser Conditions | | | Tensile Properties | |
|---|---|---|---|---|---|---|---|
| Type | Thickness, mm | Joint type | Type | Power, W | Speed, m/min | % of parent | Failure mode |
| PE | 0.1 | lap | $CO_2$ | 100 | 16.5 | >100 | parent |
| PE | 0.1 | lap | $CO_2$ | 200 | 36 | | |
| PE | 0.1 | lap | $CO_2$ | 300 | 50 | | |
| PE | 0.1 | cut/seal | $CO_2$ | 100 | 5.7 | 94 | weld |
| PE | 0.5 | lap | Nd:YAG | 80 | 0.1 | 68 | weld |

**Reference:** Jones, I.A., Taylor, N.S., *High Speed Welding of Plastics Using Lasers*, ANTEC 1994, conference proceedings - Society of Plastics Engineers, 1994.

# Mechanical Fastening

### BASF AG: Lupolen

If the necessary holes are drilled, Lupolen parts can be joined together by self-tapping screws. If the connections have to be loosened very often, preference should be given to threaded metal inserts, which can be firmly bonded to the Lupolen part by various means, e.g. encapsulation by molding, countersinking by force or ultrasonic techniques.

By virtue of their flexibility, Lupolen and Lucalen moldings can be firmly joined together by means of projections, beads, or hooks that fit into corresponding recesses. The size of the retaining angle, which may vary between 15 and 90°, determines whether the connections are permanent or can be easily loosened.

**Reference:** *Lupolen, Lucalen Product Line, Properties, Processing*, supplier design guide (B 581 e/(8127) 10.91) - BASF Aktiengesellschaft, 1991.

# Adhesive and Solvent Bonding

### BASF AG: Lupolen

Since Lupolen moldings are nonpolar and offer high resistance to solvents, very little scope exists for bonding them together with adhesives. However, if their surface tension has been increased by treatment with a flame or corona discharge, bonds with adhesives are feasible, provided that no high demands are imposed on their strength. Thus a suitable application is labelling.

**Reference:** *Lupolen, Lucalen Product Line, Properties, Processing,* supplier design guide (B 581 e/(8127) 10.91) - BASF Aktiengesellschaft, 1991.

### BASF AG: Lupolen

Lupolen's high resistance to solvents prevents any adhesive from solubilizing the surface of a blow molding. Consequently, only pressure-sensitive bonds can be formed. The adhesion can be improved by prior treatment of the surfaces to be bonded together, e.g. by exposure to a flame or corona discharge.

The following types of adhesives are used for bonding high density and medium density polyethylene:

- two-component polyurethane or epoxy adhesives
- vinyl acetate copolymer hot melt adhesives
- dispersion or solvent-type pressure-sensitive adhesives
- polyurethane contact adhesives

**Reference:** *Lupolen Polyethylene And Novolen Polypropylene Product Line, Properties, Processing,* supplier design guide (B 579 e / 4.92) - BASF Aktiengesellschaft, 1992.