THERMAL SHRINKAGE OF PLASTIC FILM AND SHEETING

This paper reviews the definition and meaning of thermal shrinkage of plastic film and sheeting. For purposes of this paper, film is defined as a thin (less than 40 mils) plastic used in roll form. A sheet is a thick plastic usually over 40 mils that is used in a sheet form. Since many plastics are printed, laminated, embossed, sealed, or fabricated, and since these secondary processes involve heat, shrinkages are an important parameter of plastics. When a plastic film or sheet is reheated, it can change in linear dimension. This is typically referred to as shrinkage. Shrinkage is also important because it can tell the user how the plastic was made. It can be used for quality control or process control as an indication of roll-to-roll or sheet-to-sheet variation.

Before discussing how to measure shrinkages, the following is a review of what causes these dimensional changes. All plastic must be heated to a molten state in order to form the polymer into a film or a sheet. This can be done in several ways, but for our industry, it is most often extruded or calendered. After the film is formed into a given thickness and width, it must be cooled. It is during this cooling process that undesirable stresses are introduced. In order to transport the molten film through the cooling process, the driven transport rolls must "pull" the film or sheet under tension. It is this pulling process that causes a stretching in the machine direction. This results in the film or sheet becoming longer and narrower. When the sheet is cooled, these stresses are locked in.

When the film or sheet is reheated in a subsequent operation, the film or sheet tends to revert back to its original shape. Because there are different shrinkages at different temperatures during processing and because different plastics shrink at different temperatures, it is always recommended to measure shrinkages at several temperatures and plot the results on a chart. The machine direction and cross direction should be plotted separately. It is useful to observe and measure the changes in the surface at the same time. Often, measuring gloss and surface roughness can be useful. This is beyond the scope of this article, but these additional readings can be very meaningful. Traditionally, 212°F is used to evaluate a normal calendering or extrusion process. Many companies will use a higher temperature, such as 240°F, 300°F, or higher because they know to what temperatures the end user will be subjecting the film or sheet.

Normal testing of shrinkages starts with ASTM D618 for conditioning prior to testing. This, however, is impractical for manufacturing since production cannot wait many hours at 23°C and 50% relative humidity for the film or sheet to stabilize. There are two ASTM methods used for testing: ASTM D1204 and ASTM D2732. D1204 uses a heavy paper to hold the test specimen and hot air, and takes several minutes. D2732 uses a wire holder in a liquid and takes several seconds. The test method used is a matter of preference.

Shrinkage specimens can be taken from a variety of positions. Often, samples are taken from the two edges and the center. Sometimes, five samples across the width can be taken. Different processes do produce some variation across the width of the film or sheet. If the end user's width is some multiple of the calendered or extruded width, more readings can be taken. If the end user is using the same width as what is calendered or extruded, then a set of three readings is typical.

Interpreting the results is a matter of experience and history. Shrinkage numbers can be used to determine process conditions and variations from roll-to-roll, sheet-to-sheet, lot-to-lot, etc. If process conditions are carefully monitored and are consistent each time a product is made, a reading every hour or more is all that is needed.

For new customers or new products, it is recommended that a series of shrinkage readings at different temperatures be recorded along with the process conditions used to make the product. It is always a good idea to measure the film or sheet temperatures as well as the machine temperatures and speeds.

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