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Film Extrusion and Thermoforming

Barcode zu Ansprech-partner und Infomaterialien

Film Extrusion

Motivation

Extrusion allows to adjust the film properties in a targeted manner during the processing of the thermoplastic base materials. A holistic view from granule to the finished film is relevant, as the physical properties of cast films, with unaltered material, can be greatly influenced by extrusion parameters and their interaction.

Process Technologie

Film extrusion, as shown in Fig. 1, is a widely employed technique in commercial polymer processing and film products are commonly used in daily life. These films can be manufactured in a wide variety of different processes, ranging from cast-film to stretch and blow films. Boh the production of bar stock for further processing or direct manufacturing of final products are possible. The product usage can reach from packaging to technical applications such as capacitor films. This demands a specific understanding of the processes and their effects.

Material Functionalization as Research Focus

The process of plastics conditioning and functionalization, comprises all operations to which a raw polymer is subjected, such as the addition and incorporation of fillers and reinforcing materials, before the compound obtains its final shape in subsequent processing.

The Institute of Polymer Technology (LKT) is investigating application-specific functionalizations of flat-films by material treatment of the raw polymer matrix, such as the addition of radiation-crosslinkable additives and fillers, for the use in tailored composite systems. The adhesiv strength between inorganic fillers such as fibers and the polymer matrix can be greatly improved by the influence of adhesion promoters or crosslinking, as shown in Fig. 2. To ensure constant compounding, the melt temperature, -pressure and material dosage can be recorded and reviewed for comparability. The compound composition of most inorganic fillers can be traced and validated offline by thermogravimetric analysis.

Furthermore additive-free adjustments are specifically investigated, such as the blend morphology and crystallinity as a function of processing technologies and parameters, as shown in Fig. 3. For investigations into changes in material properties, the influence of a multi- or single-step setup of the process must also be taken into account.

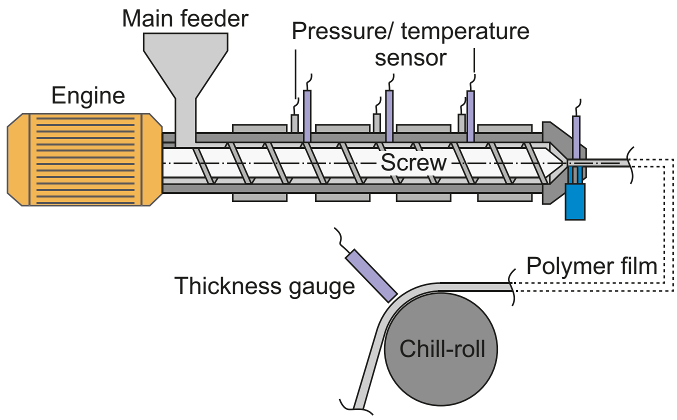

Fig. 1: Schematic illustration the flat-film extrusion process with different sensor and feeding possibilities

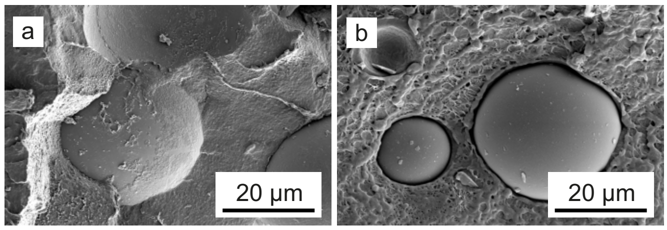

Fig. 2: Facture surface of tensile sample recorded with SEM of polymer filled with glass spheres (10 Vol.-%)
a) With crosslinked polymer matrix
b) Without crosslinked polymer matrix

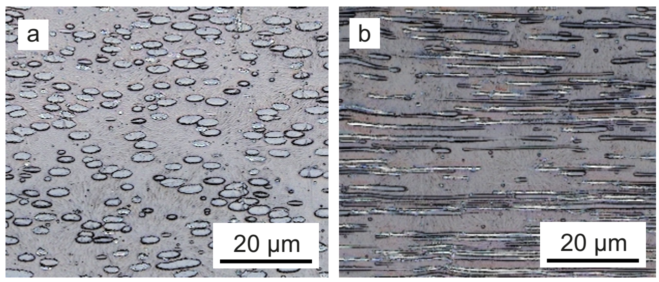

Fig. 3: Blend-morphology of a COC-phase in a PP matrix-polymer at different shear rates
a) Low shear rates
b) High shear rates.

Thermoforming

Motivation
Thermoforming is one of the oldest polymer processing methods. The main area of application for thermoformed products can be found in the packaging industry. In the technical field, items such as dash-boards or door linings are produced by thermoforming .

Processing
Thermoforming refers to the elongation of heated flat thermoplastic films into three-dimensional components under the influence of pressure or vacuum. The thermoforming process can be divided into four phases, Fig. 4. Due to the wide processing window, the thermoplastics usually processed in thermoforming are amorphous.

Influence of Crosslinking on Thermoforming
The thermoformability of polyamide generally represents a major challenge. Polyamide tends to drip off during the heating phase due to its low melt stiffness. In general, crosslinking leads to an increase in melt stiffness, to increased strain hardening and to reduced elongation at break in the melt. One research focus at the LKT is the thermoforming of radiation-crosslinked semi-crystalline plastics. The fact that electron beam irradiation has a positive effect on the thermoformability of polyamide is shown in studies carried out at the LKT, Fig. 5. Using polyamide 12 as an example, the significant widening of the thermoforming window by cross-linking of the films could be demonstrated. It became evident that especially low degrees of crosslinking have a positive effect on thermoformability. Increased degrees of cross-linking have a negative effect on thermoformability, as at higher areal draw ratios, the forming sharpness of high crosslinked samples is reduced or the films are ruptured. Furthermore, it could be shown that radiation crosslinking has a positive effect on the wall thickness changes during processing and that more homo-geneous distributions can be achieved.

Crosslinking with Fillers
In addition to the influence of radiation crosslinking on the thermoforming process, the LKT also researches the forming behavior of radiation crosslinked semi-crystalline filled films.
Added fillers can specifically functionalize films and can be differentiated between inactive and functional fillers. Inactive fillers are often used to reduce the cost of a compound, while functional fillers also contribute to increased mechanical properties such as stiffness, dimensional stability or shrinkage.
In order to determine the influence of fillers on the thermoforming behavior, the properties of the final part such as wall thickness distribution or elongation development, illustrated in Fig. 6, different degrees of filler and different filler shapes (spherical and fibrous) are considered. In addition to the material, the entire process chain is taken into account as well, including the production of the films, the compound composition and its properties, as well as the extrusion processing parameters. Thermal and mechanical analyses complete the investigations in order to be able to generate a basic understanding of the interaction of filler addition and radiation crosslinking on the forming behaviour. Fig. 7 shows the benefit of radiation crosslinking on the forming behavior of glass-fiber filled high-density polyethylene and the broadened processing window.

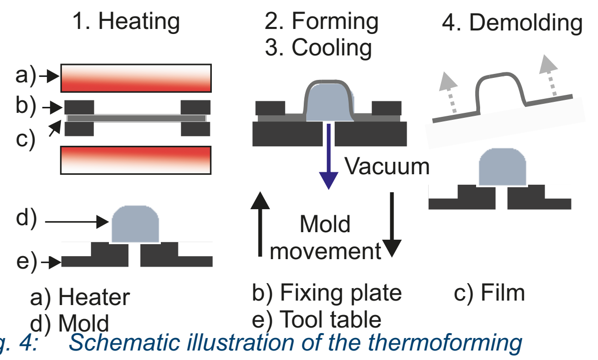

Fig. 4: Schematic illustration of the thermoforming process

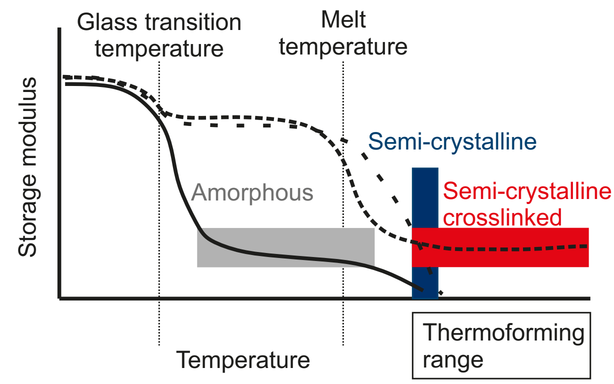

Fig. 5: Influence of radiation crosslinking on the thermoforming processing window

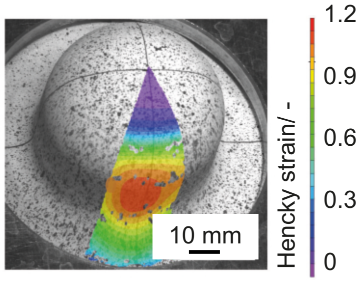

Fig. 6: Elongation development of a thermoformed part

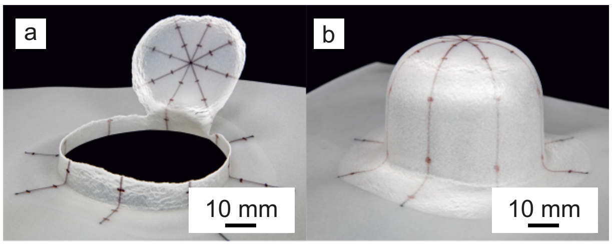

Fig. 7: Component image of thermoformed parts
a) PE-HD filled with 10 vol.-% glass fibers, Irradiation dose: 0 kGy
b) PE-HD filled with 10 vol.-% glass fibers, Irradiation dose: 132 kGy

Research Objects and Service for Industry
- Film extrusion
- Testing of polymer films
- Morphological studies
- Thermoforming studies with different areal draw ratios
- Strain analysis
- Characterization of thermoformed components

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