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Rotational Molding

Process Design, Multilayer Structures

Barcode zu Ansprech-partner und Infomaterialien

Motivation

A multitude of applications, for example fuel tanks, require hollow structures. Rotational molding is a processing technology capable of producing seamless hollow structures with very low residual stresses. Complex geometries can be manufactured in a broad range of sizes up to more than 100,000 liters in volume. This technique therefore competes with other processes for the production of large-volume components, such as blow molding or twin sheet thermoforming. Besides tanks, sporting goods (e.g. kayaks) as well as components for vehicle construction and furniture are typical applications for this technology.
The materials used for rotational molding are mainly thermoplastic powders. Polyethylene accounts for over 80 % of the materials used in this processing technology (Fig. 1). Other thermoplastics used in rotational molding include polyamide, polycarbonat and polyvinyl chloride. In addition to thermoplastics, reactive systems and plastisoles are other common base materials for rotational molding.

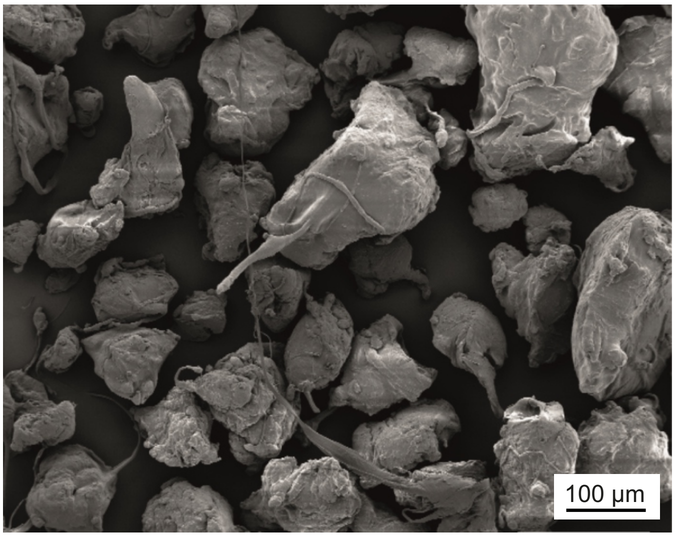

Fig. 1: Polyethylene powder for rotational molding application

Rotational Molding Process

The rotational molding process can be divided into four main process steps (Fig. 2). In the first step, the powdery material is filled into a hollow mold. This mold starts to rotate along two axes which are perpendicular to each other. In the second process step, the mold is heated up to a temperature above the melting temperature of the thermoplastic material. This is often accomplished by convection within an oven. The powdery material adheres to the mold wall as soon as the mold reaches the melting temperature and forms a homogenous melt layer. During this step, air inclusions are removed from the melt by surface tension effects. In the third process step, the still rotating mold is cooled down, e. g. by compressed air or water, before the part is demolded in the last process step.
Multi-layer parts can be generated by adding a second component after the adhesion of the first material. The second material forms the inner layer. Using so called dropbox systems, the material can be added during the ongoing process .
State of the art rotational molding processes are conducted at ambient pressure, enabling a fast and very economic mold design and leading to a very economical production of small series. Further advantages of rotational molding, compared to competitive processes, include the processing without any material waste as well as the possibility to integrate inserts into the molding process.

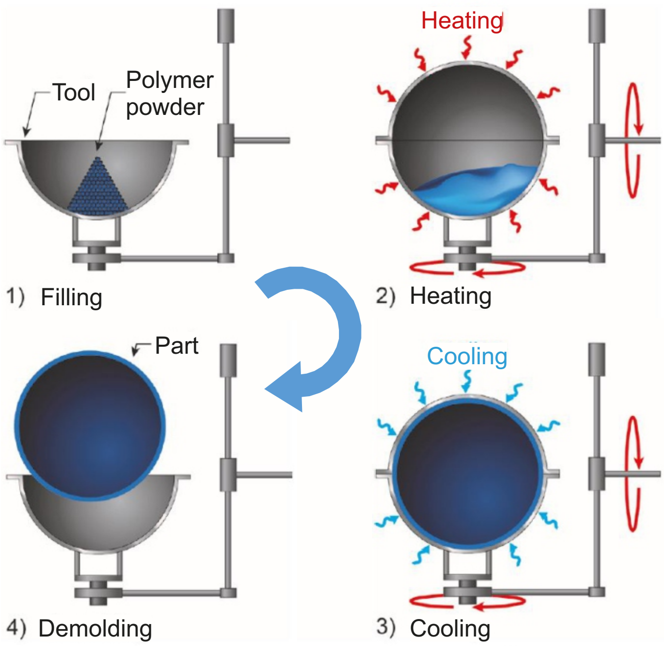

Fig. 2: Process steps of rotational molding

Multi-Material Approaches

Multi-layer composite materials are recently gaining increased attention due to the possible advantages of the resulting parts. Multi-layer parts allow for the integration of functions and the tailored usage of materials. They offer various advantages compared to single layer rotational molded parts such as weight reduction, cost reduction, enlargement of the fields of application and advanced product quality and characteristics.

For materials in composite parts, sufficient bonding between the used materials is a significant selection criterion. Due to limited specific adhesion between certain polymers, the possible combinations are very limited. Especially polyethylene, the polymer mainly used in rotational molding, shows insufficient adhesion to most other thermoplastics. Interlocking of different materials is an approach that can be used to overcome insufficient adhesion of polymers to each other.

The Institute of Polymer Technology (LKT) extensively characterized a processing technology to overcome the issue of insufficient adhesion of materials in multi-layer rotational molding. By integrating a multi-phase interlayer into a multi-layer part in rotational molding interlocking can be generated between the used materials (Fig. 3). This multi-phase interlayer can for example be generated by adding a dry blended material mixture into the process. Utilizing this approach, a significant expansion of the field of potential material combinations is possible. Special emphasis was given to the combination of polyethylene and polyamide 12, whereas the general feasibility was proven for a multitude of different material combinations such as for combinations between thermoplastic polyurethane (TPU) and polyethylene (Fig. 4).

Fig. 3: Interlocking of polyethylene and polyamide within a multi-layer part

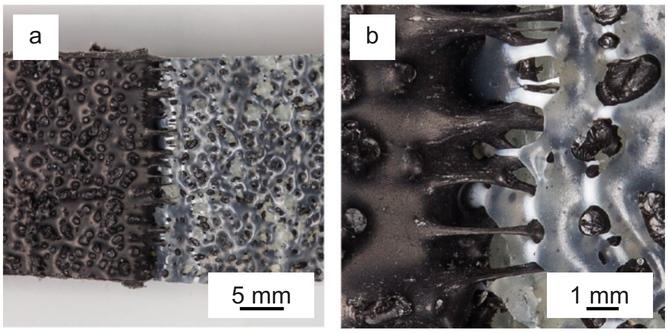

Fig. 4: a) Overview of a multi-layer part bonded by interlocking of polyethylene and thermoplastic polyurethane under peel-load,
b) Detail view

Process Characterization and Optimization

Comparably long cycle times are currently a major drawback for the use of rotational molding in different applications. A significant share of the cycle time in rotational molding is the time to remove air inclusions from the melt layer. The Institute of Polymer Technology works on different strategies to shorten the process time. For example by applying a vacuum during melting of the polymeric powder, the amount of trapped air can be reduced significantly what leads to a drastically shortening of the time to eliminate air inclusions.

Besides the cycle time, the available material range is a limitation of the rotational molding technology. The Institute of Polymer Technology is active in broadening the available material range for rotational molding applications. Therefore, relevant material properties such as powder flowability, rheological behavior and thermal stability are characterized and evaluated with regards to the processability in rotational molding. Processing trials are utilized to validate the results of the material characterization. Microgranules exhibit more uniform particle shapes and thus a better flowability compared to powder. So, microgranules, as illustrated in Fig. 5, show a high potential with regard to possible cycle time reduction and more homogeneous component surfaces.

The further development and optimization of methods for foam generation in rotational molding is another research aspect which is applied particularly with regard to lightweight construction potential and functional integration. The specific focus in process developement is on adjustable foam densities and integral skin-foam-composites.

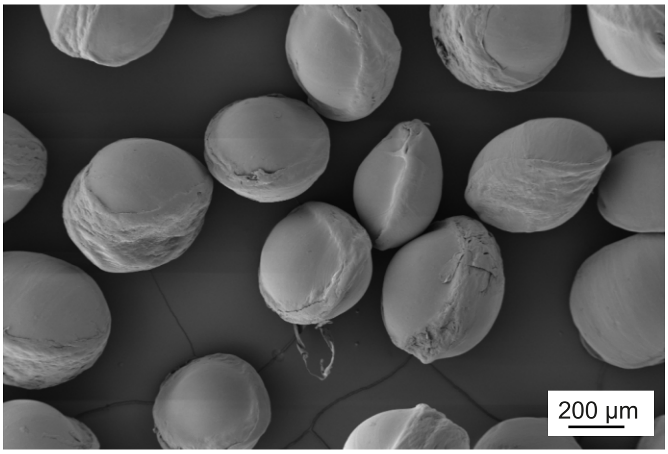

Fig. 5: Polyethylene microgranules for rotational molding

Research Objects and Service for Industry

- Multilayer setups
- Integral skin-foam composites
- Functionalization of rotationally molded parts
- Processing and parameter studies
- Thermal and material characterization of raw materials for rotational molding

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