PRESS RELEASE

Fraunhofer LBF develops new approach for rapid process stabilization of plastics

Plastic materials are prone to degradation by atmospheric oxygen. These auto-oxidation reactions occur at ambient temperature already but become especially relevant during melt processing. Adding antioxidants to the polymers results in a pronounced slowing-down of the oxidation processes. Only by this way, the production of the well-known plastic parts by injection moulding, for example, is possible. Developing new plastic grades is accompanied by lengthy experimental procedures to optimize the antioxidant content. Researchers at Fraunhofer Institute for Structural Durability and System Reliability LBF see online rheological investigations as a promising method for accelerating the development process.

Antioxidants

Organic matter and therefore also plastics, degrade by auto-oxidation when being in contact with air. This degradation is initiated by elevated temperature or light and propagates as a radical chain reaction which causes cleavage of the polymer chains. The latter are primarily attacked by the OH radical resulting in the formation of hydroperoxide moieties. These triggers follow up reactions leading to regeneration of the OH-radical. For an optimum protection of the polymer, two different types of antioxidants must be added: The primary antioxidant, often containing a phenolic structure, quenches the OH-radical. Secondary antioxidants consist of sterically hindered alkyl-derivatives of functional groups, such as phosphites or thioethers. These react with the hydroperoxide without OH formation. Both types of antioxidant act in a synergistic way, therefore. A typical commercially available stabilizer package containing both antioxidants in equal amounts was used in the described experiments.

Studying process stabilization

Commercially available virgin plastic grades are typically equipped with appropriate stabilizer packages to be ready for use. For the sake of resource efficiency and economy, the optimum content of process stabilizer must be determined during the development of new plastic grades. Processing of used plastics to recyclates faces the same problem because the stabilizers have been regularly depleted during the previous life cycle. Compounding the mill charge to recyclates to be used for example in injection molding, requires adding stabilizers adjusted to the respective type of plastics and its stage of aging. The traditional way to optimize the stabilizer content is based on compounding a series containing varying amounts of antioxidants. The compounds are then characterized offline by means of different tests, such as the melt volume rate

Redaktion
Anke Zeidler-Finsel | Fraunhofer-Institut für Betriebsfestigkeit und Systemzuverlässigkeit LBF | Institutsleiter: Prof. Dr.-Ing. Tobias Melz | Bartningstraße 47 | 64289 Darmstadt | www.lbf.fraunhofer.de | anke.zeidler-finsel@lbf.fraunhofer.de | Telefon +49 6151 705-268

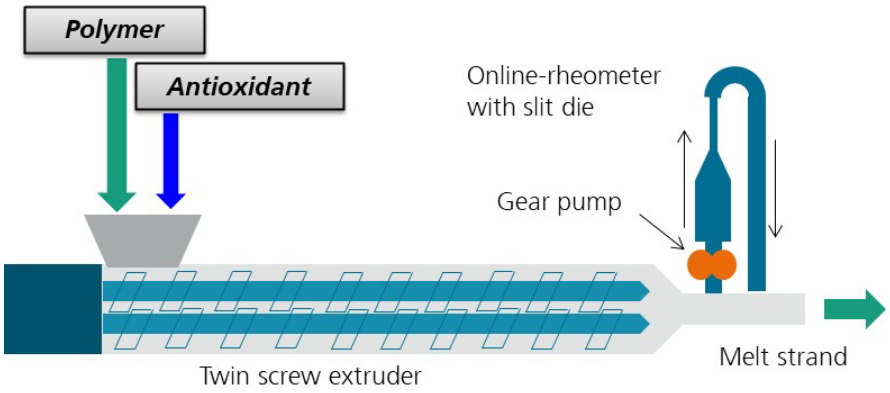
(MVR, DIN 1133-1) or the oxidative induction time (OIT, ASTM D3895-19). First reliable results are obtained only after the compounding step.

Online characterization offers new potential

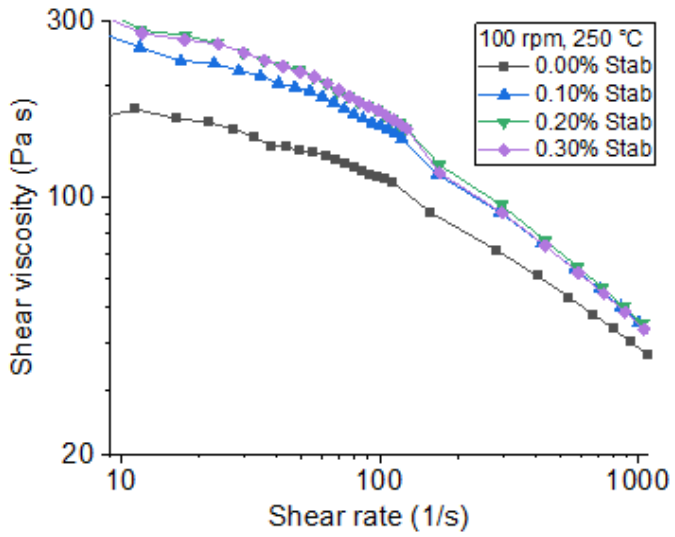
Researchers at Fraunhofer LBF aim at obtaining an indication regarding the efficacy of the actual stabilizer content already during the compounding step. Towards this goal the viscosity of the melt is used as a response recorded while varying the recipe. This is realized by incorporating an online rheometer behind the screw tips of a twin screw extruder to measure the flow curves of the shear as well as the elongational viscosity. First experiments were carried out on a minimally stabilised virgin polypropylene (PP). The amount of stabiliser added was varied at selected screw speeds. The reduced process-related degradation is immediately reflected in an increase in viscosity in the flow curves. Above a certain additive level there is no further increase in viscosity. This means that for the actual processing conditions, the stabiliser concentration has reached the limit above which no further improvement can be achieved.

Thus, online rheology provides the formulation developer with valuable information regarding the efficacy of a processing stabilizer already during compounding. Furthermore, the flow curves of the different polymers are not identical. The information content of a flow curve is therefore much higher than that of a single numerical value from an MVR measurement. In addition, the flow curves of the elongational viscosity can be included in the evaluation. Supported by an appropriate AI based system, online rheology appears to be a very promising tool to implement stabilizing during the production of recyclates with the ability of real-time adjustment to the aging stage of the mill charges.

More information: www.lbf.fraunhofer.de/online-rheologie-en



Scheme of the experimental setup with twin screw extruder and online rheometer.
Graphic: Fraunhofer LBF



Flow curves of shear viscosity for various amounts of antioxidant ("Stab").
Graphic: Fraunhofer LBF

Das Fraunhofer LBF in Darmstadt steht seit über 80 Jahren für **Sicherheit und Zuverlässigkeit von Leichtbaustrukturen**. Mit seinen Kompetenzen auf den Gebieten Betriebsfestigkeit, Systemzuverlässigkeit, Schwingungstechnik und Polymertechnik bietet das Institut heute Lösungen für drei der wichtigsten Querschnittsthemen der Zukunft: Systemleichtbau, Funktionsintegration und cyberphysische maschinenbauliche Systeme. Im Fokus stehen dabei Lösungen für gesellschaftliche Herausforderungen wie Ressourceneffizienz und Emissionsreduktion sowie Future Mobility, wie die Elektromobilität und das autonome, vernetzte Fahren. Umfassende Kompetenzen von der Datenerfassung im realen betrieblichen Feldeinsatz über die Datenanalyse und die Dateninterpretation bis hin zur Ableitung von konkreten Maßnahmen zur Auslegung und Verbesserung von Material-, Bauteil- und Systemeigenschaften, bilden dafür die Grundlage. Die Auftraggeber kommen u.a. aus dem Automobil- und Nutzfahrzeugbau, dem Schiffbau, der Luftfahrt, dem Maschinen- und Anlagenbau, der Energietechnik, der Elektrotechnik, der Medizintechnik sowie der chemischen Industrie. Sie profitieren von ausgewiesener Expertise der gut 300 Mitarbeitenden und modernster Technologie auf mehr als 17 900 Quadratmetern Labor- und Versuchsfläche.

Weiterer Ansprechpartner Presseservice:
Peter Steinchen | PR-Agentur Solar Consulting GmbH, 79110 Freiburg | Telefon +49 761 38 09 68-27 | steinchen@solar-consulting.de
Wissenschaftlicher Kontakt: Dr. Bernd Steinhoff | Telefon +49 6151 705-8747 | bernd.steinhoff@lbf.fraunhofer.de