Novel measuring method for determining the degree of crosslinking of liquid silicone rubber in injection molding processes

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Method for in-line measurement of the degree of crosslinking of liquid silicone rubber in injection molding processes by measuring and analyzing cavity pressure.

- Evaluation and documentation of the process for quality assurance and management
- Increased output through significant reduction of cycle times
- Energy savings through reduction of cycle time
- Easy adjustment of the injection molding process due to batch fluctuations, material changes, changed manufacturing conditions.
- Legal security of the processing company: archiving of the evaluated internal pressure curves through individual part tracing for legal security in the event of product recalls, defects, etc.

Fields of application

The method is universally applicable in all injection molding processes of liquid silicone molded parts. However, the method is advantageous for components where the crosslinking time of the liquid silicone is a particular focus. This is the case, for example, with two-component parts made of thermoplastics and liquid silicone. Here, care must be taken to ensure that a thermoplastic pre-molded part is exposed to the high mold temperatures for crosslinking the silicone for as short a time as possible to prevent material damage or geometric losses. With

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Development Status
TRL5

Patent Situation
DE102022206727.4 pending
PCT/EP2023/067425 pending

Reference ID
21/073TLB

Service
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the invention, the two-component part can be ejected immediately after it is determined that the liquid silicone has completely crosslinked, and the thermoplastic component is exposed to the high mold temperature for only as short a time as necessary. Furthermore, the invention is particularly relevant for products for which no downstream annealing process is provided. Here, it must be ensured at all times that a silicone component is 100 percent crosslinked. The invention enables this to be verified during the manufacturing process.

Background

Liquid silicone rubber is characterized by excellent properties such as high temperature resistance, very good low-temperature flexibility, outstanding aging resistance, excellent electrical insulating properties, high resistance to chemicals and high elongation capacity. The applications and uses of this plastic are correspondingly diverse, especially in the automotive and electrical industries. Due to its high physiological compatibility, however, liquid silicone rubber is also used in many products and molded parts in the pharmaceutical industry and medical technology. These plastic components, which are diverse in terms of their shape and application, are generally manufactured by injection molding.

Problem

Measurement and analysis of cavity pressure is part of the usual procedure in the production of injection molded parts from thermoplastics. Accordingly, there is extensive experience in interpreting the internal pressure curve for thermoplastics. In comparison, there is hardly any experience and knowledge on the interpretation of the internal pressure curve for injection molding with liquid silicone rubber. The reason for this lies in the different sequences of the injection molding processes. In thermoplastic injection molding, the hot plastic cools down after injection into the mold, causing the cavity pressure to drop due to volume shrinkage. In liquid silicone rubber injection molding, on the other hand, the cold components are injected into the hot mold, where the crosslinking reaction then occurs. Heat absorption causes the plastic mass to expand, as a result of which the cavity pressure increases. A problem in the analysis of the internal pressure curve is the fact that during the transition of the liquid plastic components into the chemically crosslinked solid, the packing density of the molecules and thus also the density changes, so that the pressure does not increase continuously during the phase transition.

Solution

In a project funded by the Baden-Württemberg-Stiftung gGmbH, Esslingen University of Applied Sciences has succeeded in overcoming the problems described above and developing a reliable and meaningful analysis method for evaluating cavity pressure during liquid silicone rubber injection molding processes. Here, the cavity pressure curve is measured during the production process and analyzed using mathematical methods. In this way, it is possible to obtain information on the crosslinking reaction within the mold in real time. In this way, existing production processes can be optimized in terms of cycle time and energy consumption, fluctuations can be compensated for, and quality can be assured and checked. In addition, the method can be used to decouple and standardize the dependence of process control on the knowledge and, above all, the experience of the user and on textbook values. This makes it possible to optimize the cycle time in such a way that the crosslinking reaction can run completely without having to add unnecessary safety times due to unknowledge of the process - as is currently the case.

An exemplary analysis of the crosslinking behavior in the mold was carried out in the SnakeSkin project. Here, a heating time of 60 seconds was always applied to the example component with bar sprue at a mold temperature of 180°C. The mold pressure in the mold was then analyzed using the newly developed method. Analysis of the cavity pressure using the newly developed method showed, however, that the component was fully crosslinked after only about 32 seconds and could be ejected. This corresponds to a saving of 28 seconds or 46.7%.

Liquid silicone rubber molded parts with structured surface of micro- and nanostructures (produced within the SnakeSkin project).

Publikationen und Verweise

Dennis F. Weißer et al., *Novel approach to characterize the cross-linking effect of liquid silicone rubber via cavity pressure analysis during injection molding*Journal of Applied Polymer Science, 2022.https://doi.org/10.1002/app.53381