The Properties' Champions League

Modifying High-Performance Plastics for Specific Applications and Thermoplastic Processing

Due to its high melt viscosity and its melting point of over 327 °C, polytetrafluoroethylene cannot be processed by common thermoplastic processes. However, appropriate modification makes this high-performance plastic workable from the melt, thereby enabling economical large series production. This will be elaborated here on two sealing applications.

Legislative and regulatory demands in medical and analytical technology are high and continue to become more so. The introduction of a quality management according to EN ISO13485:2016 illustrates that patient safety and consequently product security are being emphasized by medical product manufacturers. The necessary approvals, such as USP Class VI in combination with requirements regarding specific functions, severely limit the selection of materials for sensitive applications. They consist mostly of only high-performance plastics such as polytetrafluorethylene (PTFE), perfluoroalkoxyalkane (PFA), polyfluoroethylene-propylene (FEP), polyetheretherketone (PEEK), or polyphenylene sulfide (PPS) with their specific properties. Due to its very low coefficient of friction, PTFE is the basic material suitable for dynamic seals. Thanks to a very stable chemical combination of fluorine and carbon atoms providing almost complete shielding of the carbon chain, this plastic has nearly universal chemical resistance, enabling its use even at extreme operating temperatures ranging from -250 to approx. +250 °C [1].

Spring-Supported Seal

Figure 1 shows a spring-supported seal for a ball segment made from the PTFE material Moldflon from ElringKlinger Kunststofftechnik GmbH of Bietigheim-Bissingen, Germany, and modified for processing by injection molding. The automobile component is used in the engine cooling water circuit. The seal should perform reliably for the entire engine lifetime with very low friction and avoid stick-slip so that the corresponding servomotor can be designed for low power consumption. Additional requirements for the material include chemical and thermal resistance, as well as good dry running properties with low wear for maximum durability. Moreover, the spherical surface incorporated in the application as a dynamic seal support places strong demands on the design and precision of the seal. In addition, the production process should be configured for piece numbers in excess of 100,000 parts per year.

Conventional PTFE does not fulfill these requirements, due predominantly to its high melt viscosity and the processing methods it requires, such as pressing and sintering that allow for suspension polymerizing of the material. That is why modified PTFE Moldflon was selected for the sealing element. This plastic typically exhibits such properties as high temperature resistance, chemical resistance, light and weathering resistance, as well as very good sliding and anti-adhesive behavior. It is non-flammable, electrically insulating, physiologically harmless, and FDA and USP Class VI approved. The most important aspect, however, is its thermoplastic processibility. This material thus enables a design freedom that either cannot be achieved by conventional PTFE processing methods, or would be very complicated. Reliable tightness is ensured by an external steel spring that has the task of readjusting the sealing lip. The sealing surface is thereby defined and reliably and constantly pressed down across a temperature range of 5–90 °C for the entire life of the seal.

Right from the start, the planned piece numbers were the reason for selecting an injection molding process, in order to stay within an economical cost

Fig. 1. A spring-supported seal for a ball segment used in an engine cooling water circuit. It is made from modified PTFE, processed by injection molding, and demonstrates the usefulness of this material – for medicinal areas as well (© ElringKlinger Kunststofftechnik)

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framework. The seal went into serial production with fully automatic mounting of the spring and 100 % optical inspection.

Sealing Lip from PTFE Compound

Figure 2 shows a PA housing cover with an encapsulated PTFE seal which was to be installed in a vehicle engine compartment. This part was designed to exclude dirt and water and had to easily retrofit to an existing engine platform. A seal width of a few millimeters was specified. Additional requirements included a temperature range of -40 to 220 °C, a peripheral speed of >6000 rpm and low-friction operation.

The requirements were met by a modular constructed front cover made from 30 % glass-fiber-reinforced polyamide (PA66-GF30) manufactured by injection molding. Polytetraflon, an unmodified, linear, partially crystalline PTFE compound from ElringKlinger Kunststofftechnik, was used for the machined sealing lip. This material exhibits very good sliding properties with low wear. Four metal bushes and the multi-layer sealing element Metaloseal were integrated for simple installation and reliable static sealing. Despite its complexity, the part designed for the application is an easily installable component. Further examples of products developed for specific customers include media resistant devices for endoscopy and analytics.

Fig. 2. This component is installed in housing covers in a vehicle engine compartment. It consists of a front cover made from 30 % glass-fiber-reinforced polyamide with an encapsulated sealing lip made from a PTFE compound. It also contains a metal insert and is designed for rapid installation (© ElringKlinger Kunststofftechnik)

Combined PTFE and PEEK

For high-performance liquid chromatography (HPLC), the materials PTFE, PFA, PEEK, and polyethylene (PE) are used exclusively due to the requirement for high analysis result quality. Compared to PTFE, PEEK offers advantages in terms of creep tendency, permeation and thermal dimensional stability. For pure PEEK, the latter is approx. three times as high as that of unfilled PTFE. Due, however, to its high hardness and low elongation at break, PEEK has only limited suitability as a sealing material. Nonetheless, combining them would be logical in order to utilize the advantages of both materials. Thermoplastic processing of Moldflon PTFE combined with PEEK results in high surface quality that cannot be achieved using conventional PTFE, but is critical for good sealing efficiency. Depending on the application, the PEEK content can be raised or lowered.

Moreover, the processing method permits parts to be machined so that prototypes or low piece numbers can also be produced economically. Thus for example, dimensionally stable mixing valve bodies can be designed with an integrated sealing function. ElringKlinger Kunststofftechnik has a class 8 cleanroom, is certified according to ISO 13485 and is familiar with all relevant regulatory matters. ■