Application Information

Hard/soft composite with a sealing function for engine assemblies subjected to high temperatures

A new hard/soft composite made from polyamide and rubber is now available for engine assemblies in media contact that need to be resistant to very high temperatures. The technology enables the single-step production of a thermoplastic component with a directly integrated elastomer sealing function. Manufacturing can be carried out cost-effectively and with short cycle times, which is a revolutionary development for this combination of materials. The composite is based on glass fiber reinforced Durethan® (polyamide) serving as a hard industrial thermoplastic, and a grade of Therban® hydrogenated nitrile butadiene rubber (HNBR) as the elastomer component. Potential applications include components with sealing functions such as valve covers and oil pans.

Background

Integrating function and design is vital when developing modern plastic components. Multifunctional components with locally defined properties can be created by using different materials with different characteristics. Growing cost pressures are also bringing about a reduction in the number of assembly and manufacturing operations.

Special technologies such as the multi-component process can meet these challenges head-on. Until now, the one-step process has only rarely been used for manufacturing multi-component parts from thermoplastics and crosslinking elastomers. There are a number of reasons for this – including the difficulty of thermal separation in the mold, the thermoplastic's lack of stability when exposed to heat, and long vulcanization times for the crosslinking molding compound. But a huge advance has now been made, especially as regards vulcanization. Whereas previously vulcanization times of several minutes were the norm, the Therban grade developed for the hard/soft combination now greatly reduces vulcanization times, thus dramatically increasing cost-effectiveness. By combining the materials developed specifically by Lanxess for this application with the company's application engineering know-how, and the possibilities that exist for rheological and mechanical design and simulation, Lanxess offers its customers a complete package and one-stop service.

Material selection

Hard/soft composites such as thermoplastics / thermoplastic elastomers (TPE) produced using multi-component technology have secured a very high market share and are already an important standard product in the automotive industry. Hard/soft combinations can be deployed in all areas where materials need to feel comfortable to the touch or where sealing/damping functions are important. Crosslinked elastomers are a perfect material for seals.

They have a lower tendency to creep and thus exhibit better tightness characteristics, particularly when used for assemblies subject to long-term loading. In many areas of application, the requirements regarding resistance to media and temperature (in the engine compartment, for example) are high and cannot be satisfied by thermoplastic elastomers. Crosslinked elastomers and liquid silicones satisfy exactly these requirements.

The primary prerequisite when using multi-component technology is that the materials used must adhere adequately, provided that no undercuts are required for cost or design reasons. Lanxess has developed materials with excellent processing characteristics for injection molding that satisfy the requirements profile and meet the needs of the production process. These materials can withstand continuous use at 150 °C and the action of media such as oil, while also meeting fundamental requirements as regards adhesion and cost-effectiveness. Special grades of Durethan (polyamide) are used for the thermoplastic component while a modified grade of Therban (HNBR) is employed for the elastomer component. Both high-performance components are perfectly coordinated and set new standards in terms of cost-effectiveness and ease of processing.

The trend in the automotive industry towards increasingly compact engines, weight saving, and low noise is continuing unabated. The result of this trend is less and less room for installation and, above all, an increase in geometric complexity. Manufacturing such complex components in metal demands considerable outlay. The excellent molding characteristics of plastic and the high integration potential offered by Durethan represent an interesting alternative. Added to this are the weight and noise reductions made possible by substituting metal with Durethan.

Production process

Jointly processing thermoplastics with crosslinking elastomers in one integrated multi-component process removes potential sources of error and improves quality. It also raises the degree of automation and therefore cost-effectiveness. However, joint processing must also take into account the considerable differences in processing and places high demands on machinery and mold technology. Achieving thermal separation in the mold between the heated cavity for the elastomer and the cooled cavity for the thermoplastic is a huge challenge and requires the hard component to exhibit high levels of heat resistance.

A media container lid featuring a directly molded rubber seal has been produced in a rotary test mold as part of a simulated production scenario. One example of a possible application would be a motor vehicle oil pan or a valve cover.

In the past, producing a multi-component part such as this has almost always involved numerous operations. The thermoplastic body and the seal have to be produced separately and the two components then combined using insertion, gluing or similar. Additionally, enormous outlay is required in quality assurance to ensure that the seal is in the correct position. Manual insertion is very costly and involves a high risk of damage and waste. The possibility of implementing this process in cost-effective cycle times using Lanxess materials and multi-component injection molding thus offers immense potential for making savings and increases design freedom.

Figure 1   Schematic representation of rotary technology

With multi-component injection molding, e.g. rotary technology (Figure 1), the first operation involves injecting the thermoplastic. Once cooling has been completed, the mold opens and the moving mold half in which the thermoplastic pre-form is located is rotated through 180°. The mold then closes again. While the machine at the first station is already injecting thermoplastic again, the part at the second station is being completed with rubber. To this end the elastomer component is first injected under high pressure. As the temperature is high at this stationary mold section, from 160 to 200 °C, the composite crosslinks, forming the finished elastomer. During this phase, the thermoplastic must exhibit sufficiently high stiffness and heat resistance. Once the heating time for the rubber is over, the mold opens and the finished molding is stripped from the mold by means of the ejector pins. A new cycle is then initiated by rotating the moving mold half through 180°.

Cycle time – the decisive factor

Cycle times are the decisive factor in industry. High hourly rates for machines and costly injection molds mean that fast cycle times are essential. When producing multi-component parts, the duration of the cycle depends on the vulcanization times of the elastomer component. Peroxide crosslinked systems are preferred to other systems in terms of their crosslinking behavior and also their subsequent properties, in particular their resistance to aging. However, vulcanization tends to be performed under pressure in order to minimize the effect of foaming. This has a negative effect on resilience, tear resistance, and elongation at break.

The component must exhibit a certain demolding stability, or crosslinking level, in order to avoid damaging the article when removing it from the mold. Crosslinking levels of over 80 % are recommended. The rubber components specially developed by Lanxess can be demolded at lower crosslinking levels and then vulcanized in a cost-effective annealing process. The following figure shows the crosslinking kinetics of a conventional HNBR mix, indicating the times at which conventional mixes can be safely demolded and, by way of comparison, the point at which the HNBR mix from Lanxess can be safely demolded.

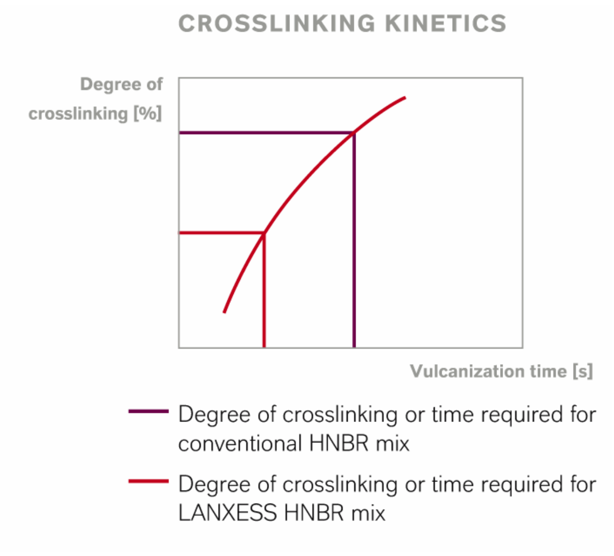

Figure 2 Crosslinking kinetics

This innovative mix enables safe demolding even with a low degree of crosslinking. Subsequent annealing is already standard in the rubber processing industry.

Moreover, the production process has been examined to determine the influence of various machine parameters and a correlation with crosslinking levels was also found here.

Testing parts

Various tests have been carried out, such as:

- burst pressure tests at room temperature
- long-term alternating temperature tests (up to 150 °C)

The testing carried out on the parts produced impressive results. The thermoplastic component displayed excellent material behavior in terms of elongation when subjected to internal pressure, as did the compression set of the elastomer component after the alternating temperature test. This also confirmed results from the earlier computer simulation. Figure 3 shows a schematic reproduction of the deformation behavior of the media box at an internal pressure of 20 bar.

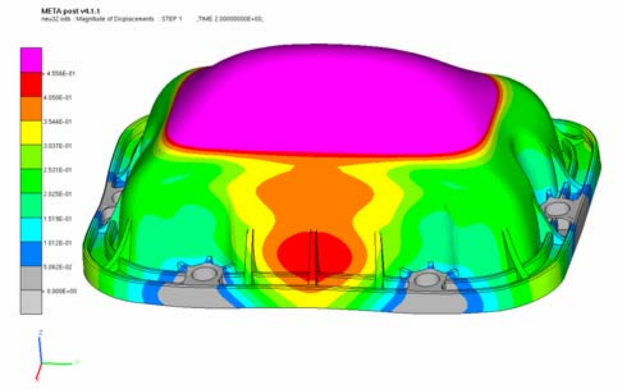

Figure 3 Calculated deformation of a media box by internal pressure

Everything from a single source

Lanxess offers its customers both components (Durethan and Therban), rheological design and simulation, plus application engineering know-how from a single source. This makes Lanxess an attractive partner for this new, innovative, and growing industry segment.
