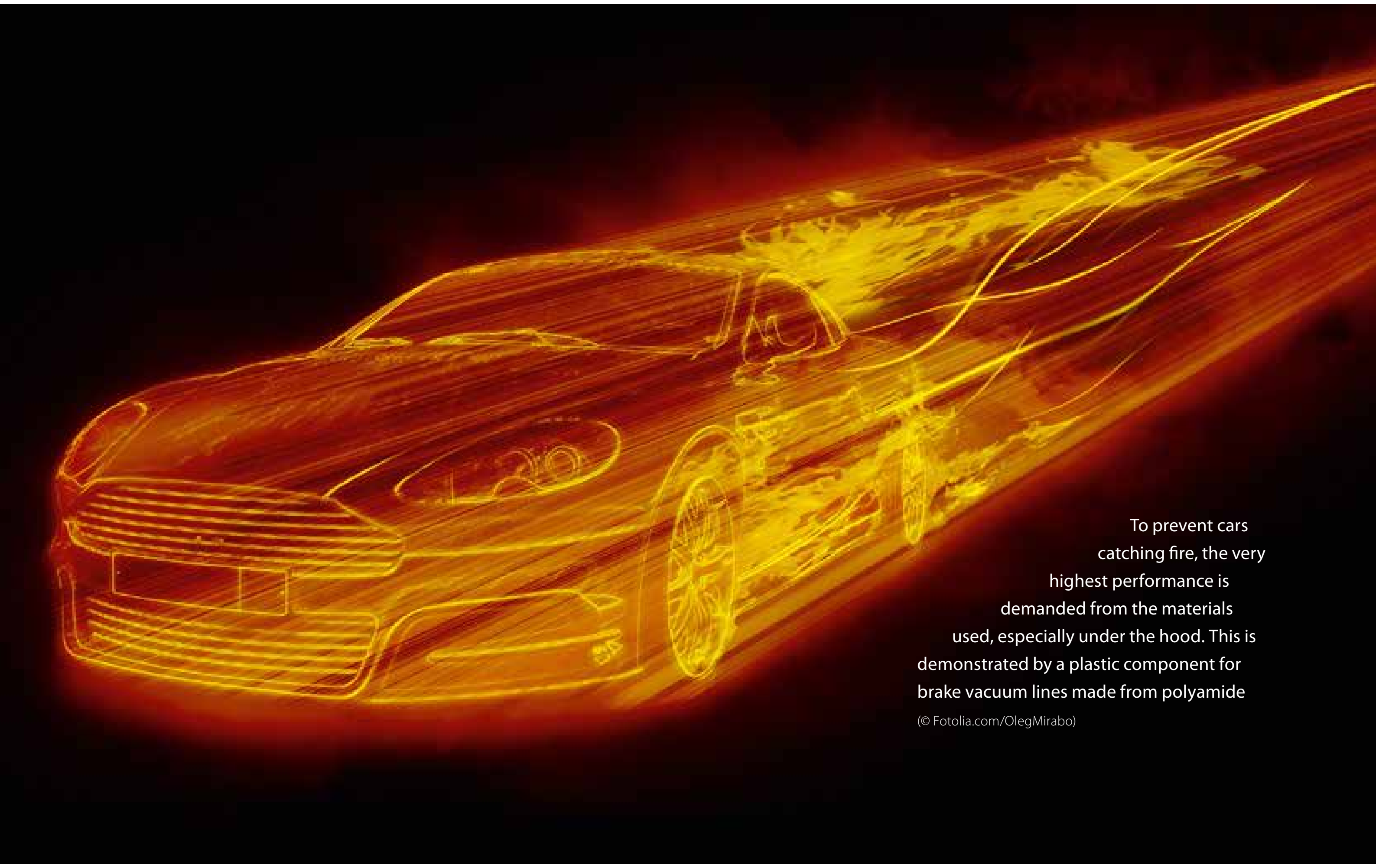
Polyamides also Like it Hot

Quick Connectors for Brake Vacuum Lines Made from Heat-Stabilized Polyamide Withstand Increased Temperatures under the Hood

With the advent of lighter-weight, quieter, higher-performance automotive drives, the temperature that components have to withstand under the hood is also increasing. In such applications, plastics have to sustain high performance over many thousands of hours. Polyamides are able to meet these challenges thanks to new heat stabilization technology, as demonstrated by the example of quick connectors for brake vacuum lines.



To prevent cars catching fire, the very highest performance is demanded from the materials used, especially under the hood. This is demonstrated by a plastic component for brake vacuum lines made from polyamide (© Fotolia.com/OlegMirabo)

The reduction of CO_2 emissions from motor vehicles continues to be the focus of many new developments. One of the ways this is being achieved is to reduce weight by massive downsizing of engines, while at the same time increasing performance. Drives must also be provided with better acoustic insulation to minimize noise and offer drivers an enjoyable motoring experience. However, all these measures lead to higher temperatures under the hood, which presents a challenge for new, higher-performance materials in these applications (**Title figure**).

This rise in temperature is accompanied or even intensified by a change in the mounting position of the turbocharger to achieve better exhaust gas values. In the past, most components of auxiliary units under the hood were exposed to continuous service temperatures of 120 °C for 1,500 h and temperature peaks of up to 150 °C. But the latest engine developments require components to withstand continuous service temperatures of 160 °C for 3,000 h and temperature peaks of 190 or even 210 °C.

Quick Connectors for Brake Vacuum Lines

AFT Automotive GmbH, Greven, Germany, was commissioned to develop quick connectors for brake vacuum lines that could withstand this temperature level. For components that have to be repeatedly actuated for servicing, in particular, this demands high specifications because such components also have to resist high outer fiber strain without cracking after heat aging.

In the quest for materials that could withstand these high temperature stresses, polyphthalamide (PPA) and polyphenylene sulfide (PPS) were tested initially. Both these polymers are characterized by very good heat aging behavior. They also fulfill the requirement for a surface roughness value of <RZ 6.3 µm in the sealing area. However, the elongation at brake and weld line strength, even before aging, of the components were inadequate for detachable coupling of these quick connectors.

Fig. 1. Quick connector for brake vacuum line (© AFT Automotive)

Polyamides with New Heat Stabilization Technology Tested

Following the trials described above, various polyamide (PA) 66+6 formulations based on a new heat stabilization sys- »

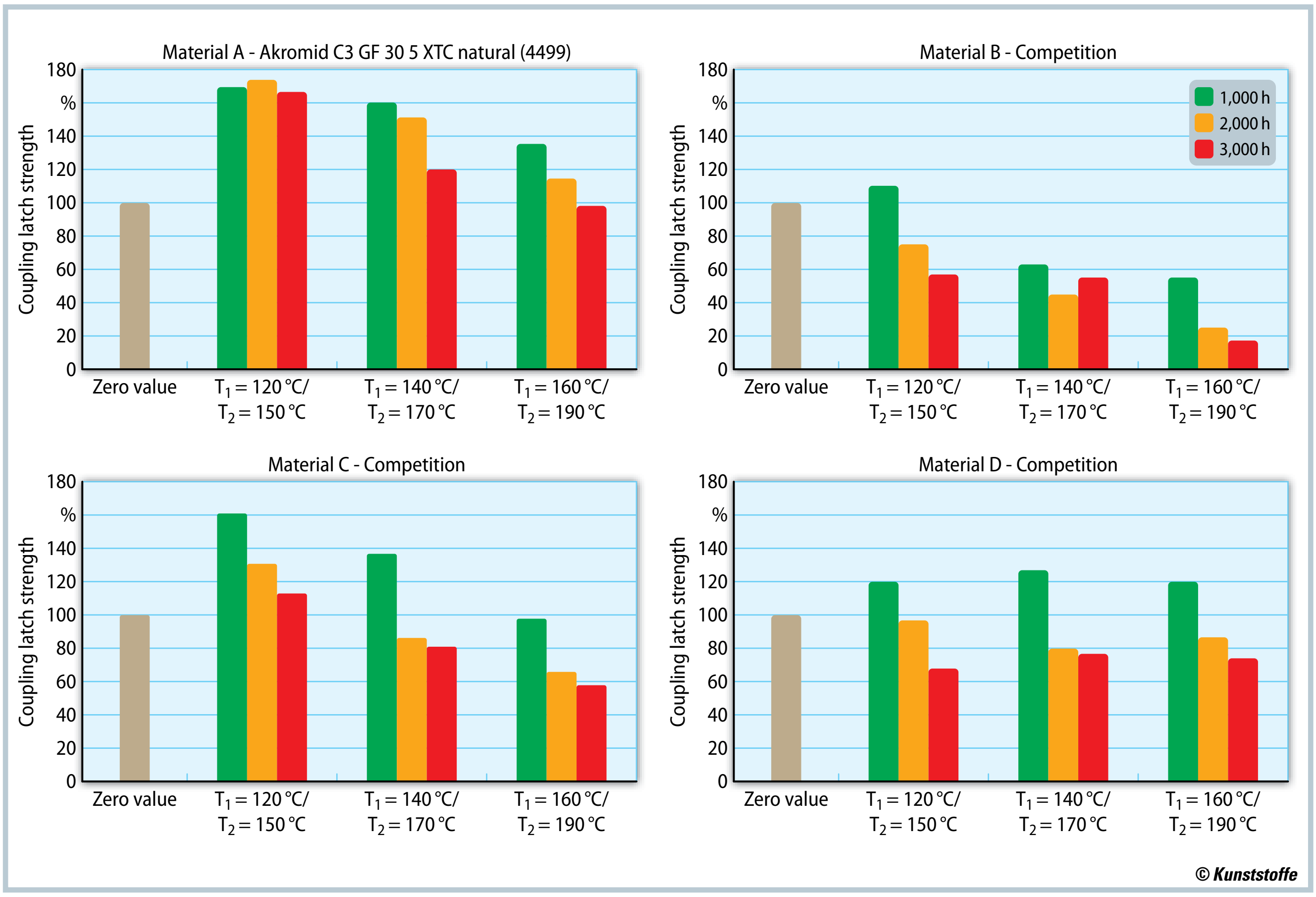


Fig. 2. Extract from the latch strength values measured by processor AFT Automotive on the coupling after exposure to different temperature cycles (source: Akro-Plastic)

Fig. 3. Tensile test bar made from Akromid C3 GF 30 5 XTC natural (4499) after 1,000 h at 210 °C (© Akro-Plastic)

Fig. 4. Tensile test bar made from Akromid C3 GF 30 1 natural after 700 h at 210 °C (© Akro-Plastic)

tem using shield technology were tested. These have both good weld line strength and high elongation at break. Four different commercially available polyamide compounds were studied. All four materials are capable of filling the component geometry and, in particular, the thin-walled area of the locking mechanism (**Fig. 1**). Here, the PA66+6 blends offer an advantage because they require somewhat lower cavity filling pressures and so can be processed at lower melt and mold temperatures. The heat aging behavior of the materials was then tested. To determine the limits, testing was conducted as follows:

Each material was exposed to three cycles of 900 h (T_1) and 100 h (T_2) at the following temperatures:

- T_1 = 120 °C T_2 = 150 °C
- T_1 = 140 °C T_2 =170 °C
- T_1 = 160 °C T_2 = 190 °C

As **Figure 2** makes clear, after the first thermal cycle at the lower temperature, all the materials showed increased coupling latch strength. This can be attributed to both fewer stresses in the injection molding process and re-crystallization of the materials. At the higher temperature, significant differences emerge between the materials, even in the first testing cycle. Materials A, C, and D (PA66+6 GF30) show the lowest degradation, while the properties of material B (PA66 GF30) deteriorate significantly with the step up from 160 °C to 190 °C after only a third of the test cycle duration.

After three cycles at the above-mentioned temperatures, material A (Akromid C3 GF 30 5 XTC (4499) from manufacturer Akro-Plastic GmbH, Niederzissen, Germany) proved the most suitable. This plastic is an electrically neutral, stabilized polyamide 66+6 with 30 % glass fiber reinforcement. The connectors produced from this material still retain their strength after 3,000 h. Their greatest advantage lies in their high elongation at break after aging. They were the only components tested that could still be repeatedly actuated without cracking after storage at the highest temperature. With the components made from all the other tested materials, the locking rings broke after the aging test. The success of the components made from material A is due not only to good material properties but also to the CAD-optimized geometry of the opening mechanism.

Heat-Stabilizing Shield Effect on the Surface of the Component

New stabilizers now make it possible to produce polyamides with extremely high heat aging resistance. One of these relies on the shield effect (**Figs. 3 and 4**). In this technology, the organic stabilizer forms a kind of patina on the surface of the plastic, which is virtually impermeable to oxygen. This prevents further oxidation of the material. The effect starts at an activation temperature that varies according to the additives used. In the case of the XTC stabilizer from Akro-Plastic, activation takes place between 170 and 180 °C. Up to this temperature, another stabilizer protects the formulation so that the material

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- Read the German version of the article in our magazine *Kunststoffe* or at *www.kunststoffe.de* covers a service temperature range up to 230 °C. To verify its effect in different temperature ranges, the formulation was aged for 3,000 h at 150 °C, 180 °C, 210 °C and 230 °C. The material was also aged at different intervals between 150 °C and 210 °C to prove that the stabilizer system could function under the various conceivable stresses in day-to-day automotive production. The elongation at break values after aging in **Figure 5** show, in particular, the potential of this new range of materials. With all temperature variants, the resulting elongation at break remains above 1.5 % (dry); after continual storage at 210 °C for 3,000 h it is an impressive 2.7 %.

AFT carries out the assembly process for the quick connectors entirely on fully automated machines, since these components are installed in safety-critical systems. The components then undergo a 100 % leaktightness test and are optically monitored by a camera system. The component-specific test results are documented. Despite the very high temperature requirements, the processor was able to use products of the PA66 material group. So the assembly and testing processes could remain unchanged and did not have to be adapted, for example by changing material requirements or making design alterations. This guarantees high process stability. Both AFT Automotive and Akro-Plastic are working all the time to ensure optimum product quality. So in both companies, comprehensive quality control tests are carried out at every stage of production. ■

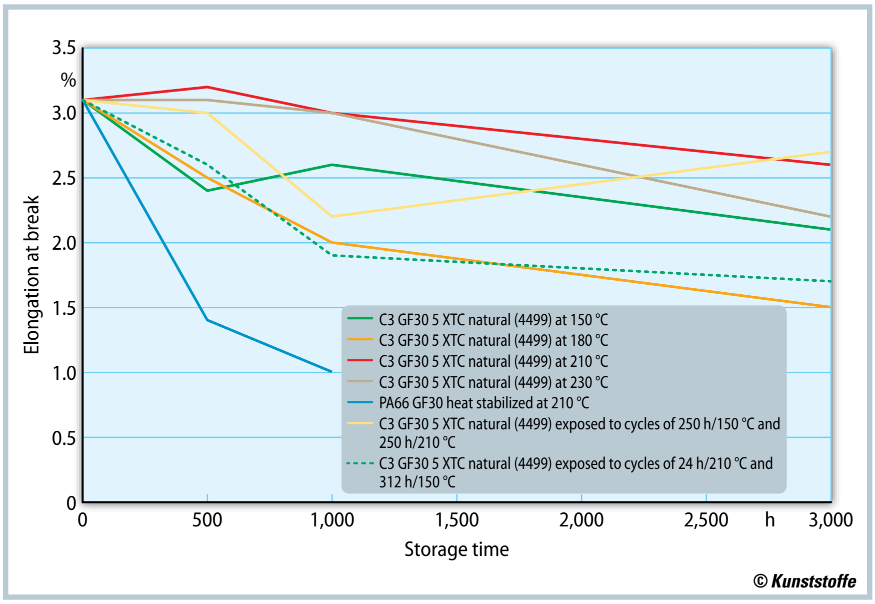

Fig. 5. Elongation at break as a function of storage time for different materials at different temperatures (source: Akro-Plastic)