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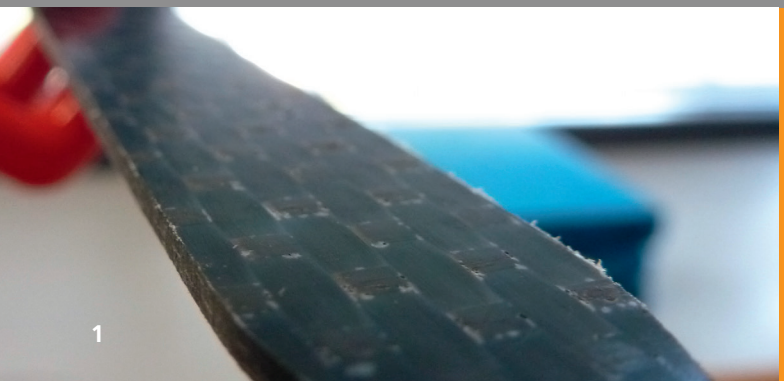

1 *(Carbon fiber) reinforced cast PA6 (2 mm).*
2 *Cast-PA unit with mold carrier (© Fraunhofer ICT).*

FLAME RETARDANT SYSTEM FOR CAST POLYAMIDE-6 PROCESSED VIA T-RTM

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Flame retardants minimize the risk of fire and help to contain it, thus saving resources and human lives. As most polymers are flammable and represent a high fire load it is essential to protect them with appropriate flame retardants. In the selection of these flame retardants various factors must be taken into account, including the chemical structure and the required mechanical properties of the polymer. The most suitable flame retardant must then be selected and adapted to the specific polymer and its application.

Polyamide-6 (Nylon 6) is a thermoplastic polymer with a high toughness as well as excellent sliding properties and resistance to abrasion. Globally about 4.2 Mtes (2010) of polyamide-6 are produced each year, finding application for example as fibers in the textile sector or as engineering plastics and surface coatings in mechanical engineering (roll, bearing, gears, vehicle body, fuel line, packaging film, etc.) and electrical engineering (cable sheathing).

Reinforced cast polyamide-6 for aircraft

The raw material for cast polyamide-6 (PA6), ε-caprolactam, liquefies at approximately 68 °C and shows a viscosity equivalent to water. With this property it is possible to penetrate a glass or carbon fiber fabric which can then be reinforced by the polymerized PA6. This allows a lightweight construction material with good mechanical properties to be obtained.

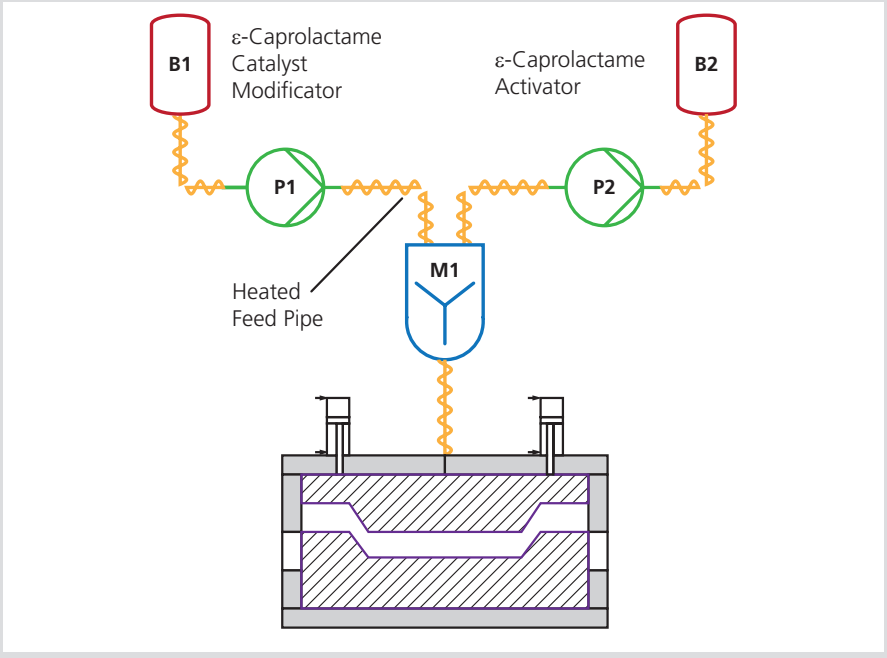
In order to implement this technology, for example in an aircraft, the material needs to meet the high fire resistance standards applied in the aviation industry.

The innovation

Until now no flame retardant (FR) system was available which would allow the manufacturing of a fiber-reinforced polyamide-6 part with the thermoplastic resin transfer molding (T-RTM) process and also meet fire resistance standards. The manufacturing process and the anionic polymerization of PA6 place important restrictions on the FRs which can be used to protect the material.

The FR needs to show two specific properties: (a) it must be non-reactive so that it does not disturb the polymerization process and (b) it must not be solid during the manufacturing process, which means that it has to dissolve in the raw material or be in the liquid phase at manufacturing temperature and mix with the raw material. If this is not in the case it will be filtered out by the fabric and/or will produce a heterogeneous dispersion. With the material hexaphenoxy-cyclotriphosphazene (HPCTP) it was possible to develop a phosphorous-based, non-toxic, environmentally-friendly FR which is capable of meeting the two criteria. With a loading of approximately 25 wt% the material is able to pass the FAR 25 test.

T-RTM process



3 *UE 94 flame test.*

4 *(Carbon fiber) reinforced cast PA-6 plate (1 mm) (© Fraunhofer ICT).*