FRTP (Carbon Fibre-Reinforced Thermoplastics) could take a leading role in reducing fuel consumption, improving the efficiency and the direct operating costs of an aircraft. Apart from the unique Tenax® high-performance materials for fast production processes, the group is also developing innovative "green" composite recycling solutions to meet environmental and economic requirements. The ability to recycle these highly valuable materials will become a more dominating factor in general material selection for the aerospace industry, as is already the case in the automotive field with its stringent standards. The Tenax® recycling innovations are based on reclaimed materials from CFRTP production.

Closed-loop concept
Toho Tenax has been active in the CFRTP market for many years as it strongly develops the range of Tenax® thermoplastics to enable customers to combine fast processing times with high mechanical performance. Tenax®-E ThermoPlastic Consolidated Laminates (TPCL), consolidated laminates made of several layers of ThermoPlastic Woven Fabric (TPWF), are qualified for use in clips and brackets for the A350XWB aircraft, Airbus’ new-generation extra-wide-body midsize jetliner.

In consideration of the A350XWB production ramp-up and the increasing consumption of these highly valuable materials, efforts have been made to develop recycling solutions that can be immediately implemented. Toho Tenax’s intention was to develop a closed-loop concept for thermoplastic materials and to recapture the exceptional properties of this high-performance material combination. Using different reprocessing techniques, the company can offer a variety of recycled materials which can be converted and returned back by customers into non-structural aircraft parts.

“Green” CFRTP
Toho Tenax is developing different "green" CFRTP routes for individual products in order to serve a wider field of potential production processes and applications. In this context, the group intends to offer Tenax®-E TWPF PEEK-HTA40 Chips, which are made of carbon fibre and virgin PEEK (poly-ether-ether-ketone) polymer. The TPWF material is reclaimed during the production process of the A350 XWB-qualified Tenax® TPCL and reprocessed into Tenax® Chips using a cutting process. The concept is to offer the material in a variety of sizes, such as ±5 mm x 5 mm or even up to ±50 mm x 50 mm. The chip sizes are specified by the market needs as well as the processability and requirements of the final components.

3D stamp forming process
A 3D stamp forming process with thermoplastic materials allows the production of
complex 3D clips. In the first production step, individual preforms are nested and cut out of the original laminate (800 mm x 1,200 mm) and heated to the processing temperature of the polymer matrix. Then, they are quickly stamp-formed in a metal mould in the second production step. Despite the endeavour to arrange precise nesting and therefore an optimum buy-to-fly ratio, a thin TPCL grid will still appear.

In parallel to the Tenax® Chips, the material concept also includes the implementation of a recycling flow for Tenax® TPCL production by-products resulting from the 3D stamp forming process at the part makers. The company plans to transform these by-products into Tenax®-E TPCL PEEK-HTA40 Crushed. This crushed CFRTP material will be available in random sizes due to the applied crushing/shredding process, but downstream sieving stages could generate a more homogenous raw material for further processing steps. Once again, the material grade can be optimized according to the component requirements.

**Recycled compound**

The Tenax®-E Compound rPEEK CF30 is a reinforced material combination made of 30% recycled carbon fibre by weight and recycled semi-crystalline PEEK polymer to offer high strength and stiffness performance in injection moulding applications. This compound has almost identical performance to virgin standard materials in terms of tensile modulus, strength, elongation, viscosity, chemical resistance and abrasion, and a very low moisture absorption completes the picture of this recycled material. The added value of this compound results from the combination of high-performance materials with a 40-60% lower price than virgin carbon fibre-reinforced PEEK compounds.

The closed-loop concept from production remnants via Tenax®-E Compound rPEEK CF30 to the final part won a JEC Award in the Recycling category at the JEC Asia 2016 show on November 16th 2017 in Singapore.

**Conclusions**

The Toho Tenax group’s aim is to recapture the full value of the exclusive carbon fibre-PEEK polymer material combination and to establish a closed-loop concept for its thermoplastic product portfolio. The introduced recycled materials will offer high performance at much lower costs than today’s virgin alternatives. Although they were intended for use in the aerospace sector, they might also be directed to non-aerospace industries due to their significantly reduced cost. Together with an aircraft OEM and partners in various part making and application fields, Toho Tenax will further investigate the reuse of residual materials.