BepiColombo HGA ARA C/SiC Struts: A thermo - mechanical challenge for support structures in harsh environments

Florian Wigger[1], Dr. Stephan Schmidt-Wimmer[1], Dr. Steffen Beyer[1], Eckhard Sperlich[2]

[1]ASTRIUM SPACE TRANSPORTATION Ottobrunn; [2]ASTRIUM SATELLITES Friedrichshafen

The BepiColombo orbiter, ESA's ambitious mission to Mercury, requires a lot of sophisticated solutions to overcome the technical challenges resulting from the harsh environment in Mercury's orbit, with temperatures ranging from -196°C to 550°C.

During the cruise phase BepiColombo consists of the "mercury transfer module" (MTM) with two attached spacecrafts (the "Mercury Planetary Orbiter" (MPO) and the "Mercury Magnetospheric Orbiter" (MMO)). When Mercury's orbit is reached, the MPO and MMO will be separated.

For communication and measurements a high gain antenna is installed on the MPO. To ensure the antenna's thermo-mechanical integrity during flight, a lot of well suited solutions are required. One of the principles designing the spacecraft is avoiding thermal loads wherever possible, otherwise reducing them to an absolute minimum. If this cannot be realized, materials withstanding the high temperatures have to be used.

The tetrahedron support structure of such antennas is a typical example for a highly thermally loaded structure. Being part of the antenna reflector frame assembly (ARA), along with the sub reflector's support structure, they have to withstand not only the entire temperature range between -196°C and 550°C, the thermal expansion also has to be very low to guarantee a permanent stable position of the sub reflector.

This structure consists of two times three struts, made of ASTRIUM's ceramic matrix composite SICARBON®, a carbon fiber reinforced silicon carbide (C/SiC) ceramic matrix composite (CMC). Although developed for high temperature propulsion applications, such as satellite engines reaching up to 1600°C, the SICARBON® material is also able to provide uniquely low thermal expansion in the defined temperature range. Taking into account the engineering of the fiber lay up, a minimal coefficient of thermal expansion (CTE) is reached.

All struts are manufactured via filament winding and polymer infiltration and pyrolysis (PIP). Using the robot assisted process all possible kinds of fiber lay ups can be manufactured for rotation-symmetrical parts.

For flight acceptance a wide range of inspections and tests is conducted. In addition to accompanying witness samples, non-destructive inspections via X-ray computed tomography (CT), CTE measurement, vibration testing as well as mechanical characterizations have to be executed.

This paper will present the manufacturing process as well as the test results and will give a detailed outline of the chosen flight acceptance approach for such struts.