CFRP STRUTS USING ALUMINIUM SLEEVES WITH CMT-PINS FOR LOAD TRANSFER: MECHANICAL AND THERMO-STABILITY TESTS

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Abstract:

Structural payloads such as satellites, robots, antennas etc. shall meet high requirements in terms of mass, stability, strength, stiffness, and radiation resistance. The working environment of space differs significantly from terrestrial applications, e.g.: high-energy particles, ionising radiation, vacuum, large thermal fluctuations, or fast micro-meteorites. For assemblies as well as multi-material combinations, joints and hinges are of essential importance as these must guarantee their full operational / mechanical functionality at elevated as well as at very low temperatures.
For very large antennas, radiation shields or solar panels, minimum stowage volume at minimum mass is of highest importance as stowage volume is limited in spacecrafts and payload mass has a direct influence on fuel costs.
ESA-TDE Project ADALFIC CN 4000126211 demonstrated a new method for integrating very light Aluminium sleeves (AW2024) into carbon fibre reinforced struts (CFRP) by using micro-pins. The cold-metal-transfer process (CMT) is a welding process which enables the localized deposition and shaping of filler wire on metal surfaces. Process and parameter settings have been optimized for Aluminium welding wires (ER2319) in phase 1 so that micro-pins with a diameter of 2.30 mm and a maximum height of 1.50 mm could be generated. Using the CMT process in combination with an 8-axis robot system allows for the structuring of the joining surfaces of Aluminium sleeves according to a defined pin position plan. Aluminium sleeves are then integrated into the manufacturing process of the CFRP struts.
According to technical requirements, a set of CFRP-Al-Sleeve struts with a length 500 were manufactured for breadboard mechanical tests. In there, pin-number, pin-positioning were studied. In addition, breadboards were tension and compression tested at elevated and reduced temperatures (+160 / -160 °C) [1]. The objective of the final phase was the assessment of the behaviour of such ultra-light struts with regards to thermo-stability during thermal cycling. Axial expansion was recorded and extrapolated for a 1.500 mm long strut. Subsequently, the load-transfer-performance and final safety / knock-down factor of the struts post thermal-cycling tests were assessed.

This paper presents the major results of the tests performed in phase 2 & 3 of the ADALFIC project:

- The tension and compression test results which are way higher than the application requirements with failures always occurring in the CFRP part of the struts.
- The thermo-stability test results showing that the mechanical performances of the struts are not impacted by thermal cycling.

Furthermore, an outlook for future mandatory activities for reaching full TRL will be given.

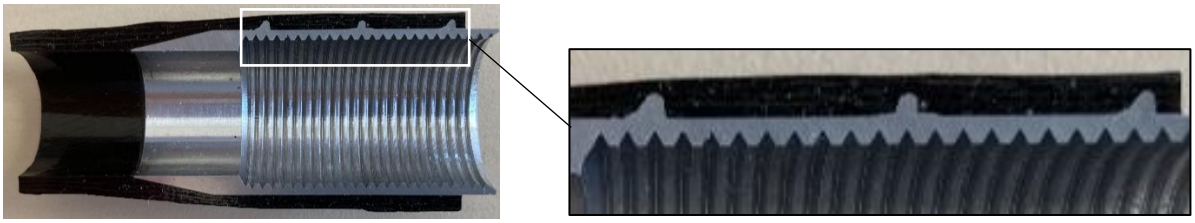

Fig: End of a CFRP strut with Al-sleeve containing pins

1. Ucsnik S., Schnall M., Birgmann A.: "Load transfer behaviour of ultra-light-weight CFRP-metal struts under elevated and cryogenic working temperatures"; EUROMAT 2021, Online; 13.11.2021 - 17.11.2021.