Fraunhofer IWS

CONTIjoin

Advanced Laser In-situ Joining for Large-scale Thermoplastic Composites

Fraunhofer IWS has developed a process suitable for the continuous processing of high-performance fiber-reinforced thermoplastic laminates that avoids autoclave post-processing.

The Thermoplastic Age

Thermoset matrices still play a dominant role in construction and production of modern composite-based aircrafts and their fuselages. The use of fasteners or adhesive systems to join these parts has proved inevitable, resulting in an increase of total aircraft weight and additional requirements for surface pretreatment. In contrast, thermoplastic matrices allow joining and forming processes based on the meltability of such polymers.

A New Approach to Joining

Advanced laser in-situ joining (CONTIjoin) utilizes the thermoplastic material properties to join large-volume fuselage structures by continuous co-consolidation. The general principle (Figure 1) is comparable to state-of-the-art layup techniques like automated tape laying (ATL). The two major differences between CONTIjoin and these processes concern the types of processed materials and the energy source: While commonly known layup processes rely on single-layered unidirectionally reinforced materials (tapes), CONTIjoin enables the layup and instantaneous co-consolidation of multi-layered, multidirectionally reinforced thermoplastic laminates with up to six pre-consolidated plies. Currently, the process facilitates maximum laminate widths of 360 millimeters. To heat up the material, a CO_2-laser in combination with a highly dynamic beam deflection is used, here the radiation of 10.6 µm is absorbed directly by the polymer matrix (surface heating), in contrast to widely used fiber laser radiation (wavelength 1.06 µm), which is absorbed mainly by the carbon fibers (causes a volume heating). Therefore, surface heating occurs and allows the interfaces of the joining partners to be plasticized very sufficiently, resulting in high mechanical performance without the need for further co-consolidation.

Advanced Laser In-situ Joining

Key Characteristics

- CO_2-laser as energy source
- Processability of multi-layered laminates
- Instantaneous in-situ co-consolidation

More Information

BUSTI-Project

s.fhg.de/BUSTI

Multifunctional Fuselage Demonstrator

s.fhg.de/MFFD

A pyrometric measurement system feeds temperature data into a laser power control circuit to maintain a high set temperature accuracy across the whole width of the laminate. To ensure an homogeneous force distribution even on curved substrates, a shape-mimicking segmented consolidation roller system was developed and equipped with spreading elastomer sleeves. The investigations by Fraunhofer IWS have shown that laminates joined with CONTIjoin achieve over 90 percent of a static heat press joint's reference strength. This constitutes an essential benefit when working with large-scale aircraft structures, as an autoclave and the necessary tooling of these dimensions prove extremely expensive.

Applications

The results and developments shown above are part of the BUSTI project to create the longitudinal joint of the Multifunctional Fuselage Demonstrator (MFFD), the world's largest known aircraft structure made of thermoplastic composites. As a full-scale demonstrator its length measures 8.5 meters and its diameter 4.5 meters, with CF/LM-PAEK being the utilized material. The largest laminate strap size ranges from 360 millimeters in width to over 4.5 meters in length. The BUSTI project is part of the European Union's Clean Sky 2 campaign.

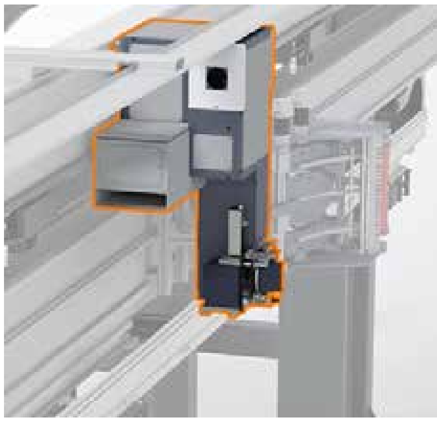
Outside the Aircraft

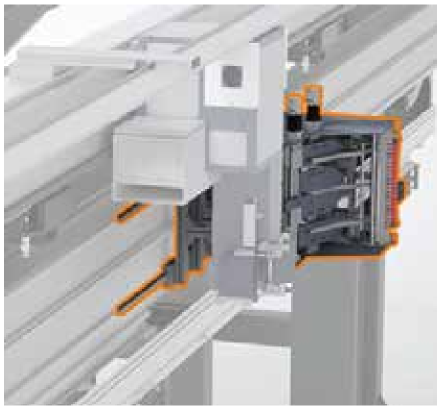
Although being developed in an aircraft scenario, CONTIjoin can be the process of choice wherever high-performance thermoplastic laminates are an option, especially on a large component dimension. A perfect example is the manufacturing of rotor blades in wind power plants; however, pipelining, ship building and lightweight construction work may also feature as sectors of application.

Funding

This project "Butt strap integration technology development with tooling design, validation, implementation in major component assembly and operation – BUSTI" has received funding from the Clean Sky 2 Joint Undertaking (JU) under grant agreement No. 945583. The JU receives support from the European Union's Horizon 2020 research and innovation program and the Clean Sky 2 JU members other than the Union.

Clean Sky 2 — This project is funded by the European Union

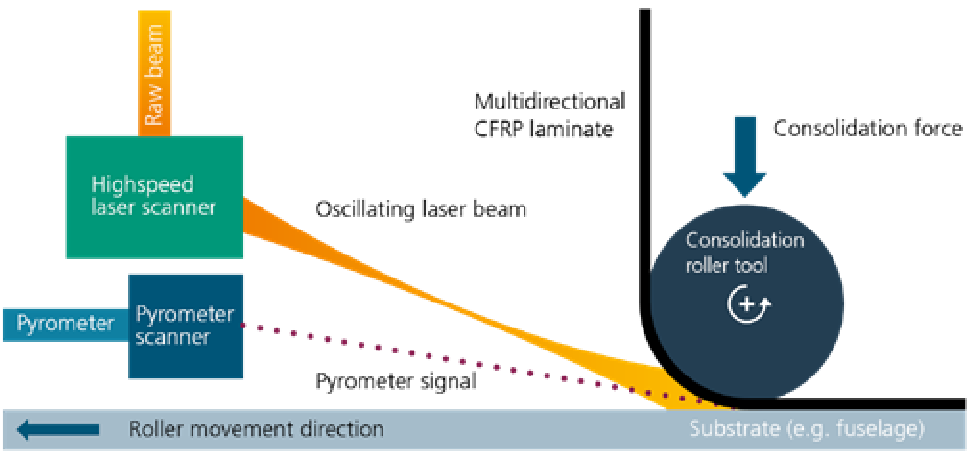




Top
Laser scanner and pyrometer optics: components on the optics linear axis.

Bottom
Device for positioning and consolidation of strap laminates: Components on the mechanics axis.

Figure 1: CONTIjoin Method



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