HELACS

Discover how Centexbel succeeded in developing a method to debond welded thermoplastic textile reinforced composites by means of induction heating

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The aerospace industry is increasingly turning to thermoplastic textile-reinforced composites to enhance production rates, and these composites are also weldable. When the aircraft reaches the end of its life, it is important from a sustainability point of view that these materials can be recycled or recovered. **Centexbel has developed a highly efficient method of debonding these composites using induction heating.** The method works very well with carbon fabrics or when an induction heat absorber (susceptor) is placed at the interface. The applied electromagnetic energy is concentrated at the weld interface, especially when a susceptor is used. Once the temperature is high enough to melt the polymer matrix, only a small amount of force is required to debond the material. The result is a fast, energy-efficient and safe way to disassemble composite parts. The composites are usually not or only slightly damaged, allowing them to be reused; in some cases, a repair step may be necessary.

Induction heating is a rapid method of heating metals or other electrically conductive materials. It is also effective for welding fibre reinforced thermoplastic composites.

The principle of induction heating is that an alternating voltage is applied to a conductive coil, resulting in an alternating current. The current induces a magnetic field. When a conductive and magnetically receptive material is close to the coil, eddy currents are induced at a frequency matched to the frequency of the magnetic field. The material is then heated by the resistive losses of the eddy currents. Eddy currents can only be induced if there is a closed conductive path. A closed circuit exists in the case of carbon fibre fabrics or cross plies. If there is no closed circuit in the composite (e.g. short carbon fibre composites) or the composite is not conductive at all (e.g. glass fibre composites), it is necessary to place a susceptor at the weld interface. A susceptor absorbs electromagnetic energy and converts it to heat. It is a conductive material used to transfer heat to another piece of metal or non-conductive material.

There are several papers and articles showing that induction welding is an effective technology to weld thermoplastic composites. **Centexbel demonstrates that the induction technology is also perfectly useful to dismantle welded composites from end-of-life aircrafts**. This means that the welding equipment should preferably be mobile, as it is difficult to install a static robotic system, which is often used for welding, at the dismantling site.

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To demonstrate the feasibility, two carbon fibre/polyamide (PA) composite panels were first welded together using a DHI-15 PKW Inverter portable induction heater (weight 4.5 kg) with a working frequency of 25-60 kHz and a power of 1.5 kW.

Figure 1: DHI-15 PKW Inverter induction heater

Welding was completed in less than 1 minute. For debonding, a set-up was prepared in which a load was applied to one side of the welded parts and the induction coil was placed on the weld. After 30 seconds, the carbon fibre/PA composites were debonded.

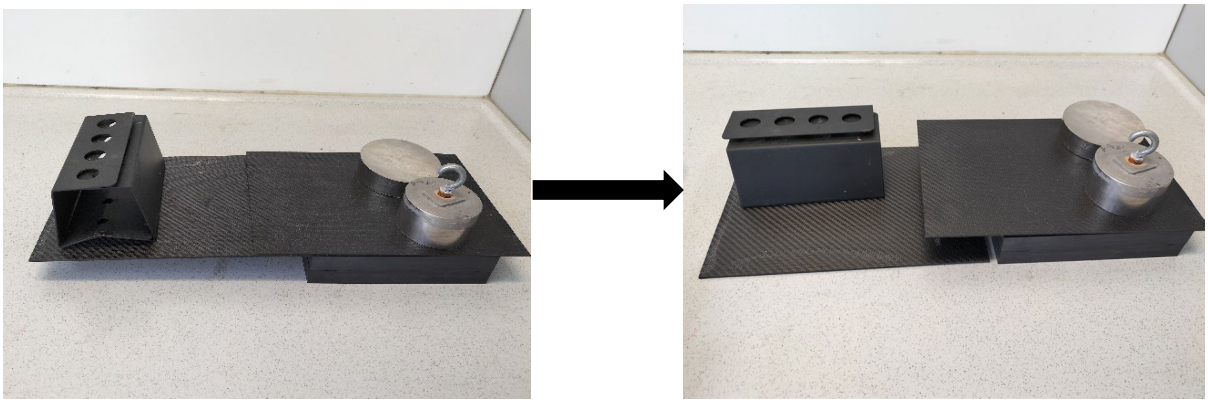

Figure 2: 1) Welded PA carbon composites => 2) after debonding

However in aviation welded structures are typically stringers, clips, brackets attached to a base plate, meaning that debonding is less straightforward because the force should be opposite to the heating direction. To show how this can be practically overcome, we welded a composite component on a base plate. This component is a 3D printed carbon composite glued on a woven carbon/PA composite. This was then welded on a larger composite carbon PA plate.

For debonding we applied induction heating to weaken the interface and used a spatula to create a force in the opposite direction to be able to remove the top part from the base plate. Also the 3D printed part

was not removed from the PA carbon carrier showing that the heat was concentrated at the PA/carbon welding interface and not on the 3D printed part and the composite plate.

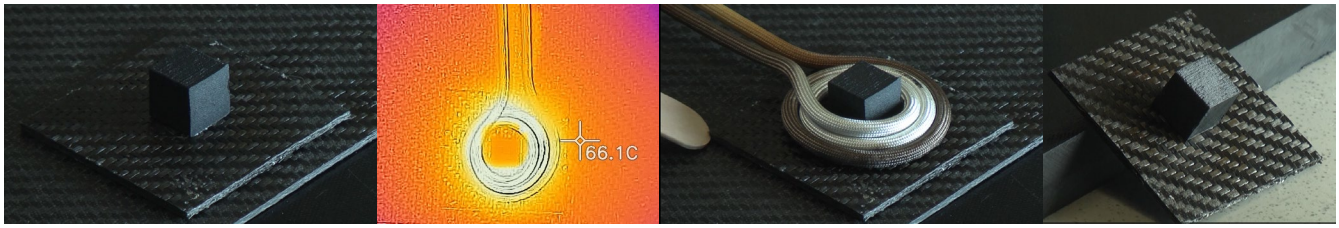

Figure 3: 1) Welded composite part on a base plate, 2) induction heating 3) using spatula to remove the part, 4) debonded part

Further aerospace thermoplastic composites contain high performance thermoplastic resins, such as polyetheretherketone (PEEK). Therefore, the concept was also tested with welded woven carbon fibre PEEK composites. We also made the weld line longer. To efficiently separate these parts. a susceptor (a copper mesh) was used to concentrate the heat at the welding interface. The debonding occurred in several steps to gradually debond the part from the base plate and a putty knife was used to create an upward force. Because the temperature is higher to debond PEEK composites rockwool was placed between the composite and the induction coil to prevent damaging of the coil.

Using induction heating for dismantling offers several **advantages, including speed, energy efficiency and the absence of sawing.** As a result, there **is no release of harmful carbon fibre dust** during the dismantling process. Once dismantled, the composites can be **easily** reused, with the possibility of a **repair step** if necessary, or recycled if the composite is extensively damaged.

This demonstrates how this disassembly technology can contribute to the sustainability and circularity of the aerospace industry.
