CoRe HeaT – A new heating method for faster fibre placement

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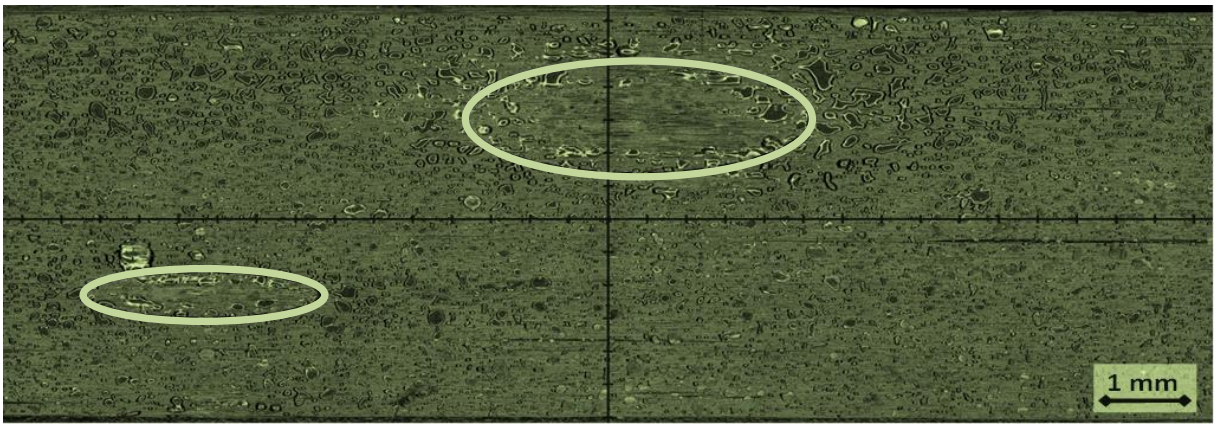
ABSTRACT

CoRe HeaT, the Continuous Resistance Heating method, is an alternative to infrared, laser or hot gas heating systems. It can be used for continuous production processes like Automated Fibre Placement (AFP), Automated Tape Laying (ATL) or similar processes like filament winding or braiding. The technology is suitable for carbon fibre materials, heating them up with the Joule effect via their own resistance. Main advantages of the technology are the extremely high heating rates combined with very fast response times. This gives the opportunity to significantly increase the average lay up speed of fibre placement processes, leading to an increased productivity.

CoRe HeaT is in development at the Center for Lightweight-Production-Technology (ZLP) in Stade, Germany, a department of the Institute of Composite Structures and Adaptive Systems of the German Aerospace Center (DLR). At the ZLP, different fibre placement technologies like AFP, ATL or Direct Roving Placement (DRP) are investigated. With a prospect of increasing the productivity when laying up new dry fibre materials and be able to process thermoplastic slit tapes, an experimental AFP end effector using CoRe HeaT has been built. The prototype is a single tow unit packed with sensors to precisely measure tow tension, consolidation force, temperatures, laminate thickness as well as all other technology related process parameters.

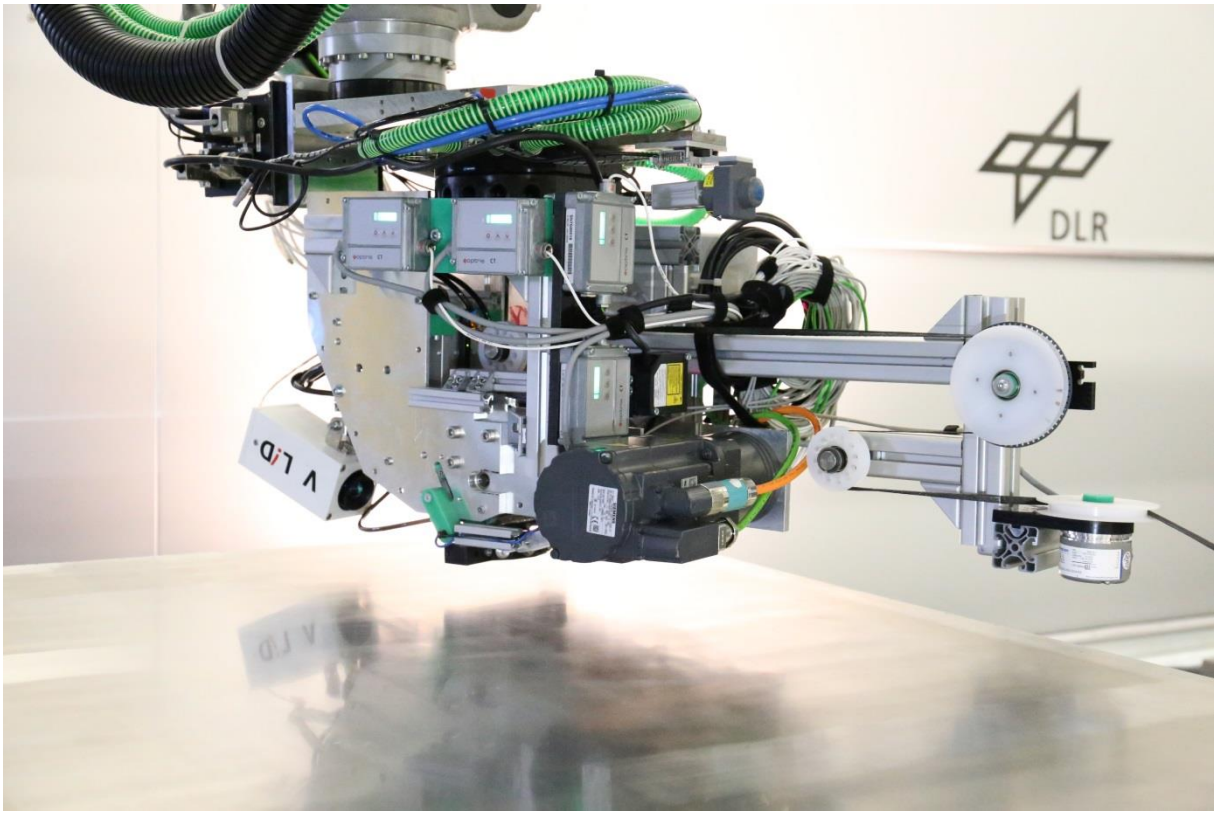
Theoretically, CoRe HeaT has no limits to the heating rate for carbon fibre materials. However, fast heating leads to an uneven heat distribution within the fibre material. First preliminary tests have shown that high heating rates and bad process parameters cause local hot spots that may lead to heat damages. Depending on the material being processed, this could affect the material properties of the final part being manufactured. With one of the tested dry fibre materials, these hot spots lead to local evaporations of the applied binder, which are visible in microscopic images (see picture 1). In those areas, high temperatures could also affect the sizing of the fibres.



Picture 1: Microscopic image of a 6,35 mm (¼ inch) dry fiber slit tape with heat affected hot spots

In order to investigate the effects of CoRe HeaT on mechanical properties, test laminates have been manufactured with the experimental AFP end effector. Inter Laminar Shear Strength (ILSS) test specimen according to DIN EN 2563 were chosen to determine if there are any heat damages to the sizing or the binder that negatively affect the fibre matrix bonding. A first set of 14 different test laminates, comparing CoRe HeaT with an infrared heating device, revealed no differences regarding the inter laminar shear strength. However, a bigger difference between those two technologies and their impact on the preforms was the resulting bulking factor. These results will be discussed in detail in the final presentation.

At the moment, dry fibre materials are in focus of the ongoing research. They are well suited for the CoRe heating technology and since the matrix system is infused or injected after the layup process, influences on the mechanical properties are expected to be insignificant. Nevertheless, the layup of thermoplastic prepreg tapes has already been tested. First test layups with 2 m/s with a PEKK tape and process temperatures above 400 °C were promising. The layup quality appears to be good. However, further testing is necessary to determine the influences of high speed CoRe HeaT layups when using prepregs.



Picture 2: The experimental CoRe HeaT AFP end effector