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PROCESS MONITORING OF THE LASER-BASED TAPE-WINDING PROCESS FOR FIBER-REINFORCED THERMOPLASTIC COMPOSITES

Task

Currently, the demand for components made of fiber-reinforced plastics (FRP) is growing rapidly. However, manufacturing process for components has not yet been automated and, at the same time, is flexible, energy efficient and environmentally friendly. The »ambliFibre« project addresses this challenge: It has developed the first laser-based tape winding process with an easy-to-use software and online quality control. The system enables users to laser weld FRP tapes with integrated process control. The consolidation quality of the welded tapes is monitored online to detect defects in the component at an early stage. Moreover, the user does not need special expertise to use the operating software of the entire system.

Method

The task of the Fraunhofer ILT was to develop the online process control to detect insufficient consolidation of the tapes during winding. For this purpose, FRP tapes were embossed with rectangular structures. Thermal images taken during the winding process identify these embossments and then evaluate both their residual geometry after welding and the quality of the consolidation. The process control algorithm is based on a machine learning approach. In the first step, the existence of the embossments on the tape is detected and then

the connection of the tape evaluated by means of a quality analysis on the basis of learned data sets. The measurement process functions in real-time and is easy to integrate into existing systems due to its interfaces.

Results

The implemented »Machine Learning Model« reliably detects embossments on the surface of FRP tapes. In the evaluation, with more than ten samples per set of parameters, the process achieved almost 100 percent certainty in identifying embossments and in the consolidation quality of the tapes during welding. The delay from image capture to completing the evaluation is less than ten seconds.

Applications

The »ambliFibre« monitoring system is suitable for all applications whose goal is to detect structures on surfaces with different tempered areas. The process can be easily adapted and flexibly expanded through machine learning. Thanks to dynamic object finding, not only can it recognize known imperfections, but also new ones that were created in the process.

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- 3 Infrared image of a FRP tape with imprinting applied.
- 4 Experimental setup for the simulated heating of FRP tapes.