Overview of the research of laser assisted automate tape laying process for production of advanced composite materials for self-healing

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OBJECTIVES

In the frame of my PhD thesis, the automated processes for the production of parts of composite materials will be investigated. Those composite parts can be used for different application as well as for self-healing of concrete structures. Focus in the PhD thesis is put on the automated fiber placement (AFP) technology and automate tape laying technology (ATL) and the equipment used to perform those technologies as well as production parameters.

The main purposes of the research are:

- Define the technological parameters of robotic AFP and ATL manufacturing processes (automatic tape laying) that will enable the production of a composite structure on the spot, without further processing into a traditional autoclave furnace or in a press (usually used).
- Comparison of manufactured composite structures using automated procedures with composite structures produced under the same conditions with traditional compression pressing procedure using a press.
- Demonstrate the advantages of applying robotic procedures for the production of composite structures.

INSTRUCTIONS

The essence of automated fiber placement (AFP) technology and automate tape laying technology (ATL) is to lay composite layer with 0,25” width unidirectional prepreg tape. Each single tape is laid down by a robotic system. Each layer can be laid with different orientation, which benefits a structure capable to carry load in ther equired direction. Each tape is pressed to the mould by a roller for proper compaction. The essence of this technology is shown in Figure 1 [1].

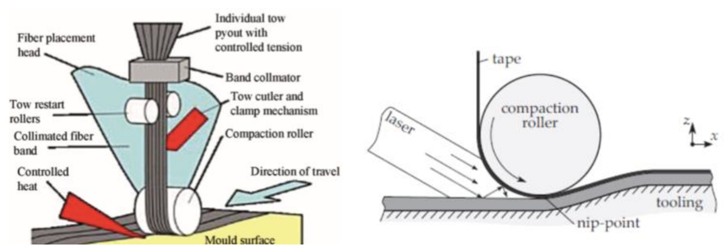

Figure 1. AFP/ATL technology

The AFP/ATL systems are typically individually suited for a particular application, however, each of those systems has a typical component, such as: head with compaction roller; fiber feeding system; robotic arm; control panel (fig. 2).

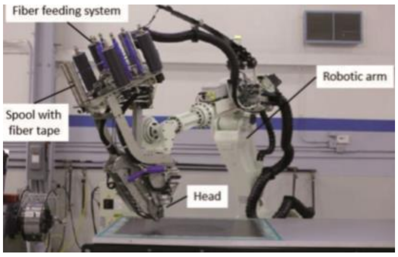

Figure 2. AFP/ATL technology - components

An important part of the whole system is control software. Typically, AFP/ATL producers provide a dedicated software together with the system. The software controls the robot motion and technology parameters like tape laying speed, compaction force, heat source temperature. The software can also analyse fiber direction and perform simulation. The system presented in Figure 2 is designed for small part manufacturing [2].

Commercially available AFP/ATL systems can work with 3 types of composite materials: thermoset prepreg ; thermoplastic prepreg; dry fiber (unsaturated). Each material is supplied on a standard spool as a unidirectional tape. The most common material system used for structure build are thermoset materials. New generation AFP/ATL systems are equipped with a laser heat source to allow thermoplastic materials processing [3].

A combination of system with thermoplastic materials with an aim to achieve in-situ parts fabrication can be very beneficial from the cost stand point. That technology has been used in industry for several years. Nowadays, it can be observed application of in-situ thermoplastic composite technology. The research is still being conducted to obtain a high material quality by means of using in-situ AFP/ATL technology with thermoplastic materials [3,4]. Thermoplastic composites have several advantages [7]: good damage tolerance properties; superior chemical resistance; non-limited storage time; recyclability. These advantages make thermoplastic composites a very interesting material for structures parts manufacturing, not only from the cost perspective but also from structural strength capability stand point. The main advantages of AFP/ATL system are: producibility; fiber direction accuracy, part to part repetability; low amount of material waste. AFP/ATL systems have also several disadvantages and limitations. Typical limitations are related to the mould shape, compaction roller diameter, head geometry etc [2-4].

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