Standardized manufacturing cells for flexible and versatile composite production in the smart factory


Dipl.-Ing. Ralf Müller-Polyzou,
Head of Product Management, Marketing and Business Development
LAP GmbH Laser Applikationen
Prof. Dr. rer. nat. Prof. h.c. Anthimos Georgiadis,
Professor for "Measurement and intelligent Systems"
Leuphana University of Lüneburg

Standardized manufacturing cells for manual composite manufacturing can play an important role in the smart factory. In the spirit of Industry 4.0, these cells support efficiency and process reliability in the laser-assisted manual production of composite parts under ergonomically positive working conditions. Furthermore, manufacturing cells provide flexibility and versatility together with high efficiency.

Significant proportion of production will be manual

Industrial projection lasers are used worldwide in manual composite manufacturing. 21% of global composite consumption in 2015, corresponding to 2.18 Mt, was processed using hand lay-up and prepreg lay-up – both manual procedures. The overall market will grow by 5% on average up to 2021, and a significant proportion of production will be manual – even with increased automation.[1]

Projection lasers are among the most important manufacturing systems in the manual production of composite parts in the aviation industry in particular (fig.1). Enhanced manufacturing efficiency, quality through reliability, a high degree of flexibility, robustness and low investment costs are key criteria for the use of laser projection systems.[2] These systems are therefore making a significant contribution to the reduction of composite production costs.

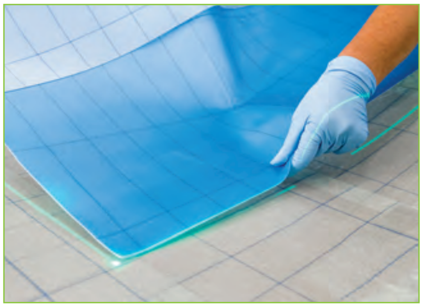

Fig. 1: Production with projection lasers

Fig. 2: Manufacturing cell with projection lasers and camera system

Demand for cost efficiency

The demand for low production costs runs counter to the rising number of product variants in many target industries and the expected momentum for their production.[3]

Market developments which are difficult to plan for, e.g. in e-mobility, require both flexible production plants and versatile systems.[4]

The smart factory based on Industry 4.0 solutions, such as the manufacturing cell described below, provides the required level of flexibility and adaptability together with higher efficiency for the composite manufacturing of the future.

The basis for this is formed by standardized manufacturing cells with projection lasers and an integrated camera system (fig.2).

The manufacturing cells support manual activities, whereby each cell can be used for several work steps and pieces of manufacturing equipment.

Existing laser projection systems can be transformed into manufacturing cells of this type within just a few days, at reasonable expense.

In terms of adaptability, the manufacturing cell can support lay-up processes as well as the assembly of composite parts.

In addition to manufacturing cells, full value creation requires a dynam-

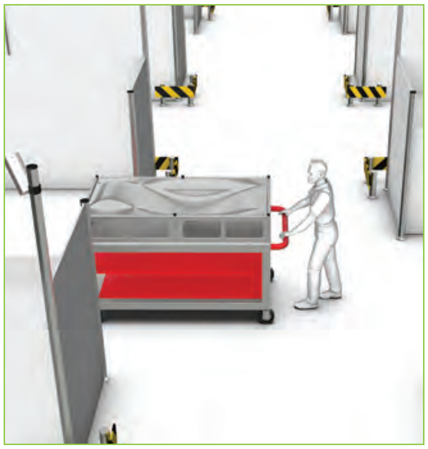

Fig. 3: Transportation of manufacturing equipment between cells

ic system for the supply of materials, and a production control system which continuously ensures a high level of capacity utilization within cell-based production.[5]

Manufacturing cells as an Industry 4.0 solution

The standardized manufacturing cell is a laser projection solution offered by LAP GmbH Laser Applikationen for use in cell-based production.

The system is intended in particular for manufacturing centers that produce small to mid-size composite parts and that require mobile manufacturing equipment to be moved or transported to lamination stations (fig.3).

Manufacturing cells are scalable and offer flexible use. Depending on capacity utilization, customer orders can be distributed flexibly across the cells.

The cell structure enables work processes to be organized flexibly and is suitable for a wide range of manufacturing equipment and operational sequences.

In addition to the lay-up procedure, manufacturing cells can also be used for training new employees, for quality assurance, and for reworking. As soon as a cell is free, one or several new pieces of manufacturing equipment can be introduced.

Thanks to multi-task support of the software, employees are able to simultaneously process multiple jobs in a single cell (fig.4).

Waiting times and bottlenecks in production can be avoided, even if the volume of orders fluctuates.

Laser projection is adjusted automatically, meaning that the position and height setting of manufacturing equipment in the cell can be freely selected. This creates ergonomic benefits, as it results in more space for employees, enhancing their performance.[6]

Technical structure of the manufacturing cell

The standardized manufacturing cell consists of four CAD-PRO laser projectors which are mounted vibration-free on beams in the four corners of the cell. With projection angles of up to 80°, the laser projectors can project from all sides onto the manufacturing equipment located in the cell's working area (fig.4).

A DTEC-PRO camera system is mounted centered at a height of approximately 3.5 m above the working area. This system consists of a camera, infrared ring flash and a lens that is coordinated with the overall structure. The camera system's visual field covers the manufacturing cell's entire working area. The camera system detects the targets' exact position as soon as a piece of manufacturing equipment with the installed laser reflector targets enters the camera's field of view. The infrared flash is not visible to the human eye, which means that it also does not distract users (fig. 5).[7]

Fig. 5: DTEC-PRO infrared camera with reflector targets

The PRO-SOFT laser projection software is the system's central control element. It is intuitive to use and it can be configured by an administrator to meet the specific requirements of a manufacturing process.

A typical work process

Each time a piece of manufacturing equipment is introduced anew into the cell, laser projection starts without requiring any manual calibration, saving valuable process time.

The position of the manufacturing equipment is monitored constantly during the work process.

The PRO-SOFT control software determines possible deviations in position. In the event of deviations, it initiates automatic calibration of the laser projector, even if individual laser reflector targets are obscured. The projection is adjusted in size and proportion to the new situation.

In case of several manufacturing cells, manufacturing equipment can be deployed in each cell – the cell just needs a power supply and an ethernet data connection for

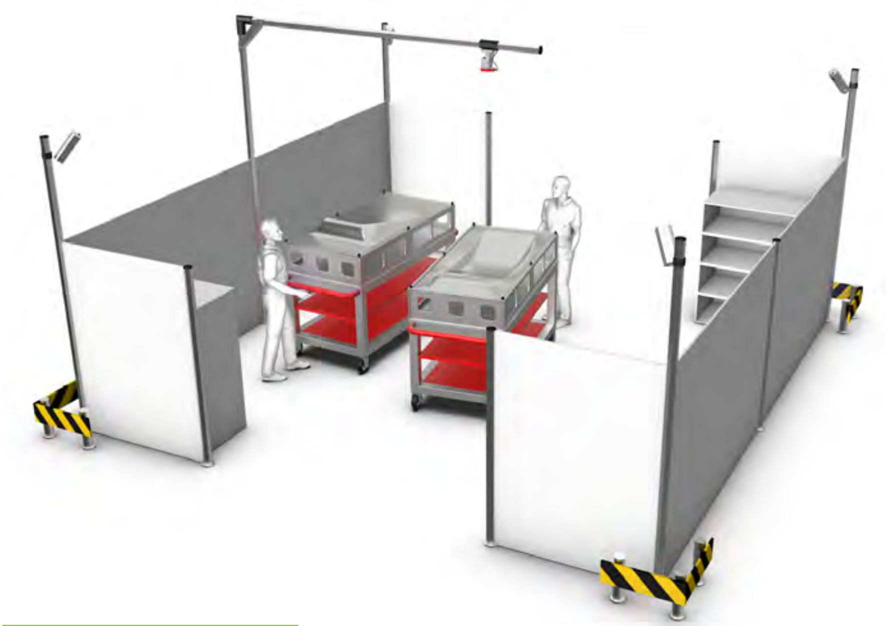

Fig. 4: Cell with multiple tools and workers

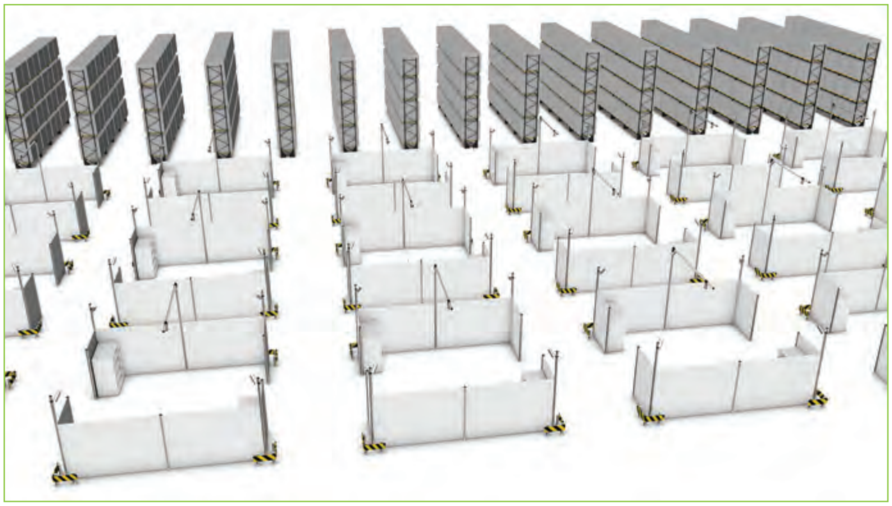

Fig. 6: A smart factory in a matrix layout

order management. In addition, the manufacturing cell makes important information from the system and manufacturing process available for documentation and analysis by a higher-level quality management system. Data evaluation may identify previously unrecognized interactions as causes for production errors or quality deficiencies, and provide decision-relevant information.[8]

Economic efficiency of the manufacturing cell

The business case results from the conversion of an existing CAD-PRO laser projection system into an advanced manufacturing cell.
The camera system, assembly components, a software upgrade and the necessary installation and commissioning tasks must be viewed as investment expense. However, on the other side of the equation we can point to the flexibility as a direct benefit. This is calculated from the reduction in process time resulting from automatic calibration, and is dependent on the rate of change of manufacturing equipment in a cell. Time saved in the setup process must also be recognized as positive. Increased process reliability is calculated based on a reduction in waste from production, while the adaptability achieved should be monetarily assessed in the specific context of production.
A further additional benefit is gained from the images stored in the system for quality documentation purposes. Based on these assumptions, many companies would achieve amortization in less than a year.

Outlook: the composite smart factory

"A smart factory masters the complexity of the production process. It is less susceptible to disruption and has sufficient potential to increase the factory's efficiency on a sustainable basis."[9] In a smart factory (fig. 6), AGVs can transport manufacturing equipment and materials into the manufacturing cells on a fully automated basis. Quality tests during the onward transportation of manufacturing equipment can create further efficiency gains. Operation-relevant data can be continuously saved on the manufacturing equipment's RFIDs. Human-robot collaboration (HRC) is used for temporary automation or to enable activities such as quality control to be performed in parallel (fig.7).[10]
The quality data are transferred directly into the quality management system. Manufacturing cells for manual lay-up processes are combined with fully or partly automated robot cells. All production processes can be simulated at any time through the use of digital planning tools, even for altered scenarios. The basis for this is a digital twin of the manual manufacturing cell.

(1) JEC Group 2017
(2) LAP GmbH Laser Applikationen
(3) Günther Schuh et al. 2017
(4) JEC Group 2017
(5) Greschke 2016, p.231
(6) Landau und Luczak 2001, p.21
(7) LAP GmbH Laser Applikationen
(8) Bundesministerium für Bildung und Forschung BMBF 2017, p.116–117
(9) Uwe Dombrowski et al. 2013, p.344
(10) R. Müller et al. 2015, p.1

Fig. 7: Collaborative robots for quality assurance

More information:
www.lap-laser.com