CAD-Based Tape -Stacking

Precise but Highly Efficient

Tapes must be stacked both with high accuracy and efficiency. In the ongoing development of its tape-stacking cell, Engel places a third focus on simplifying operation. CAD-based tape stacking, which Engel has implemented in a customer's system for the first time, will play a role here. Further new features are the pyrolysis function for cleaning the welding elements, as well as the modular end-of-arm tooling for handling the semi-finished products.

The new modular end-of-arm tooling of the tape stacking cell increases both the cost effectiveness and the flexibility. The functional elements can be individually positioned thanks to a perforated grid. © Engel

The accuracy of tape stacking is crucial for the load-bearing capacity of the composite part. The camera-based tape stacking, as presented by Engel two years ago, represents the state of the art. With the camera technology, the position and orientation of trimmed composite semi-finished products, such as UD tapes can be identified in order to orient them precisely before stacking. This requires individually importing the geometries of all the tapes used, which is a laborious programming task. This is precisely where Engel's latest development comes in. In CAD-based tape stacking, the geometries are transferred via CAD files. This reduces the programming outlay and simplifies the operation of the tape-stacking cell (**Fig. 1**). Another advantage is that the system operator can switch more quickly to a new geometry.

Determining the Stacking Position Accurately

After the semi-finished product has been picked up by the end-of-arm tooling, the robot moves it to the test station. With the imaging and evaluation software, the tape is located on the end-of-arm tool. Since the sequence in which the tapes are to be stacked, is defined in the stacking instructions, known as the "Plybook," the system knows what geometry it has to search for. The geometries that are used in each layer are communicated to the evaluation software in a CAD file. The file shows the tapes as they are to be stacked (**Fig. 2**).

The image processing software uses a pattern search to place a specific point – usually the center of gravity of the semi-finished product – with respect to the semi-finished product's outer shape. The position and orientation of this point form the basis for calculating the stacking position. While the tapes were previously stacked edge to edge, the stack-

Fig. 1. The CAD-based tape stacking simplifies the fabrication of stacks of UD tapes. The new technology is already used for developing and manufacturing innovative composite products. © Engel

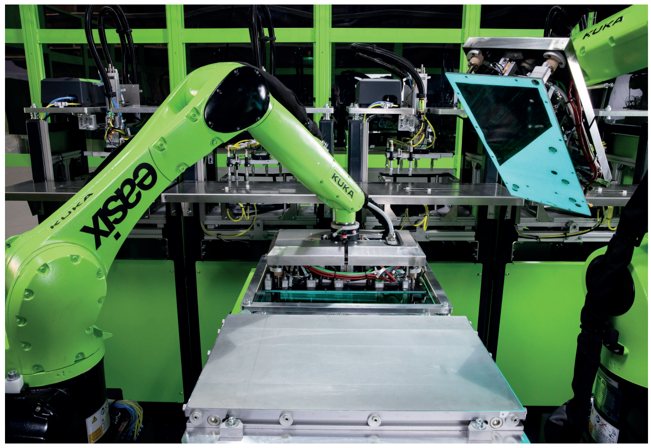

Fig. 2. The control system of the articulated robot automatically determines the optimum stacking position based on CAD data. © Engel

ing position now only has to be oriented using the respective center of gravity.

An additional advantage of the new technology is the possibility of testing the quality of the semi-finished product even before they have been processed. For example, with pattern searching, it can be ascertained how much the contour agrees with the CAD data. Furthermore, it is conceivable to investigate the semi-finished products for homogeneity and to sort out those with, e.g., matrix agglomerations or similar defects. Semi-finished products that do not satisfy the quality specifications can in this way be ejected from the process at an early stage, which avoids unnecessary reject costs.

For the tape stacking, it is important that the robot and optical measuring system are calibrated with one another. Thanks to hand-to-eye calibration, Engel makes this step very simple, too. The calibration is performed with the start-up of the system with the end-of-arm tooling moving to multiple positions and taking an image at each of them. Since the position of the handling unit is known at the time of imaging, the software can calculate a common coordinate system based on the image data.

Engel developed the new CAD-based tape stacking system in cooperation with a material specialist. The new technology for developing and manufacturing innovative composite materials is already in use there.

Pyrolysis: Automatic Cleaning Welding Elements

After the stacking of the tapes, the individual layers are spot welded to one another in order to obtain a stack that can be consolidated into a solid blank. The latest generation of tape-stacking cells makes use of welding elements with a pyrolysis function. The aim of this development is to obtain a high weld quality over a long operation period. With each welding operation, slight dirt deposits might occur on the surface of the welding element (**Fig. 3**). This dirt deposit can continue to build up and subsequently acts as a thermal insulator. The heat transfer to the semi-finished »

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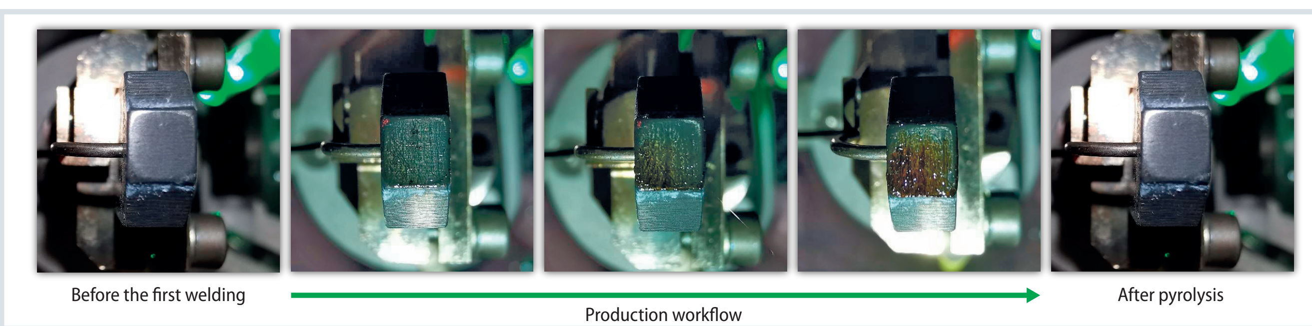


Fig. 3. Dirt deposits increase with the number of welds until the weld quality is impaired. The cyclic pyrolysis ensures weld quality is maintained at a constantly high level. © Engel

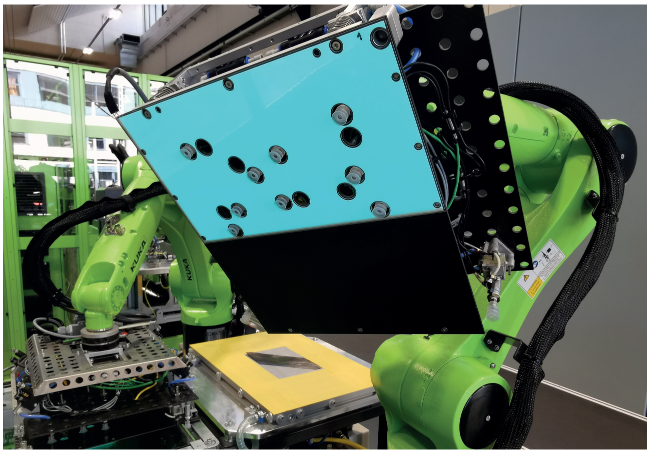


Fig. 4. The illumination plate of the modular end-of-arm tooling can be very easily exchanged by releasing a few screws. © Engel

product thereby becomes less efficient. The result is lower weld quality, so that the strength of the weld spots may be reduced.

The degree to which the welding pin is contaminated depends greatly on the matrix of the semi-finished product and the welding parameters used. Each application correspondingly requires an individual cleaning cycle. Until now, cleaning was a manual process. With the new pyrolysis function, cleaning is automated, which simplifies the operation of the system and also saves time.

To start the cleaning process, the system increases the temperature at the welding pin's surface for a short period. Within only a few seconds, the temperature increases to over 600 °C, which pyrolyzes all deposits. The welding pin cools down to working temperature almost just as quickly. Overall, the automatic cleaning takes less than one minute.

More Flexibility for Varying Tape Geometries

Besides easier operation, the increase of cost efficiency is an important development goal. The newly developed modular end-of-arm tooling from Engel contributes to this. To allow the robots to pick up tapes, product-specific end-of-arm toolings were necessary until now. Comparable with a mold in injection molding, each product requires its own end-of-arm tool.

The modular end-of-arm tooling carries the key functional elements, such as vacuum cup and welding pins, arranged in a perforated grid and flexibly positionable (**Title figure**). Only the illumination film is product specific. It is mounted on a plate that can be fixed with a few screws, and thus very easily interchanged (**Fig. 4**). The modular end-of-arm tooling thereby increases both the cost efficiency and the flexibility, since the user can rapidly change from one tape geometry to another. ■

Hasco Streamrunner with Needle Valve

Next Step in Additively Manufactured Hot Runner Manifolds

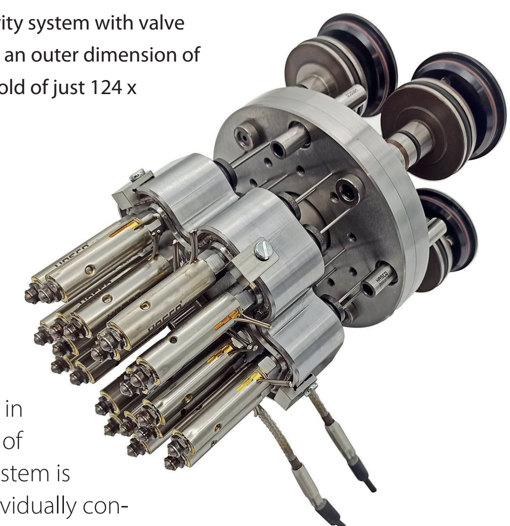
Multiple hot runner applications with very narrow nozzle pitch dimensions are, especially when using valve gate technology, a major challenge for designers. A needle drive needs space, which means that the distribution of the melt in the manifold is usually associated with restrictions when using a valve gating system. This basically leads to a greater space requirement and consequently also to larger mold sizes and injection molding machines.

With the Streamrunner from Hasco hot runner, the first additively manufactured hot runner on the market, now completely new and space-saving options are also available for valve gate systems, according to the company.

Since the market launch in 2019, several customer projects have been carried out, demonstrating the advantages of the system. With the addition of a subsequent version with needle valve technology, Hasco has gone one step further. At Fakuma 2021 the company's hot runner division presented a fully balanced 20-cavity system with needle valve technology in which the outside dimensions of the hot runner are just 124 x 124 mm.

Thanks to the additive manufacturing technology, the flow channels can be optimally designed rheologically by completely avoiding sharp edges and areas with poor flow characteristics. This gentle passage of the melt results in considerably lower shear stress in the melt and consequently better quality of the injection-molded parts.

Fully balanced 20-cavity system with valve gate technology with an outer dimension of the 3D-printed manifold of just 124 x 124 mm. © Hasco



As absolutely no plugs are needed, this compact design of the hot runner enables in some cases a pitch of only 18 mm. The system is equipped with individually controlled, screw-in nozzles, which can also be used for engineering plastics. The stroke motion of the needle takes place via a circular plate package that is driven by four pneumatic cylinders.

As with all other hot runner systems from Hasco, the Streamrunner with needle valve technology is individually designed and adjusted exactly to the respective application.

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