Robots are coming to aircraft assembly

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This modular, lightweight,carbon fiber reinforced plastic gripper is able to flexibly grasp and handle aircraft components. It was developed by the Fraunhofer Project Group Joining and Assembly FFM. Credit: Fraunhofer IFAM

Up to now, aircraft have been put together in huge assembly cells, but to build the necessary facilities is expensive and time-consuming. That is why Fraunhofer researchers have come up with a flexible assembly-line concept that features robots working in the same way they do in automotive production.

The developers are presenting their new manufacturing approach at the Composites Europe trade fair in Stuttgart (Hall 4, Booth D03). One of this future assembly line's first elements can also be seen there: a versatile component gripper made of lightweight CFRP (carbon fiber

reinforced plastic). Aircraft parts are simply enormous. Individual fuselage segments alone can measure ten meters or more. But they need to be fitted together with the utmost precision. The maximum deviation from plan that aircraft manufacturers can tolerate is 0.2 millimeters – on components that weigh several metric tons. To position the giant parts accurately, manufacturers rely on massive production facilities known as assembly cells. These are huge gantries that move along the fuselage like container cranes on steel rails and massive concrete foundations, for instance bolting aluminum parts together. It takes a lot of money and effort to build this kind of assembly cell – and they need to be built from scratch for each new kind of aircraft, which pushes their production and construction costs even higher.

This state of affairs calls for automation concepts and facilities to make aircraft assembly – and in particular high-precision drilling, milling and adhesive bonding – simpler, more flexible and more economical in the future. And that is exactly what developers in the Fraunhofer Project Group Joining and Assembly FFM at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Bremen, are working on at the research center CFK Nord in Stade. Theirs is a totally new assembly philosophy: Aircraft will in future be machined – and their parts increasingly bonded together – by a host of small industrial robots, much as we see in today's automotive sector. Dr. Dirk Niermann, head of the Fraunhofer FFM, and his team of developers have come up with a design for a suitable facility that would replace the common assembly cell: They envision fuselage segments, tail fin and wings sitting atop a kind of rolling assembly line and being carried past one-armed robots, akin to automotive production methods. These robots then work at various points on the parts in succession to bond, drill and mill them as they pass. Of course, a facility of this kind would still need to be tailored to each new aircraft type, but the installation costs incurred would be significantly lower.

At the Composites Europe 2011 trade fair from September 27 to 29 (Hall 4, Booth D03), the scientists from Stade will be presenting the first key element of their new assembly line: a gripper that can deal flexibly with various geometries of aircraft component. "Aircraft are made up of shells of varying curvatures, and a gripper system has to be able to adjust accordingly," says Niermann. This is done using configurable arrays of suction pads that sit on robust joints. The suction pads are mounted on a framework structure made of carbon fiber reinforced plastic that is both sturdy and considerably lighter than metal. Thanks to its low mass, industrial robots can position the gripper and the component with exceptional precision.

The gripper concept might seem only too simple, but in fact handling the components is a real challenge. Once they are put together, the dimensions of these large aircraft parts can deviate from plan by up to several millimeters as a consequence of their being fitted to the fuselage. Up to now, the fitting of these components into the fuselage has been painstakingly done by experienced technicians working on the assembly cell. The parts are sometimes even compressed or bent slightly in order not to breach the overall 0.2 millimeter tolerance. In future, it will be up to the robots and the gripper to achieve this. "That's why we're developing a high-precision recognition system to measure the components exactly during assembly," says Niermann. This is combined with powerful software that takes fractions of a second to calculate the precise position in which the robot has to hold the workpiece to make everything fit together perfectly. However, there is one more challenge: Aluminum, the classic aircraft material, is increasingly being replaced by CFRP. But, unlike aluminum sheeting, CRFP components are unyielding during assembly, so they sometimes need to be assembled under tension. While technicians have developed a feel for how much tension is permissible, which allows them to assemble these parts manually, robots don't know how to do this yet. Nonetheless, Niermann and his colleagues are certain that they will have an initial demonstration facility up and

running around three years from now. The gripper can already be seen at Composites Europe, and the Fraunhofer Project Group Joining and Assembly FFM is also presenting its entire robotic aircraft assembly concept there.

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