A robotic system from Electroimpact Inc., equipped with a 21’ (6.4-m) robot arm moving on a track, builds large composite components held by a rotisserie-like structure. The system was recently installed at the Composites Technology Center in NASA’s National Center for Advanced Manufacturing at the NASA Marshall Space Flight Center in Huntsville, Alabama.

Expanding the Horizons of Aerospace Automation

More automation in paint and surface prep, composite airframes and engine components will be needed for aero builders to meet production goals.

Patrick Waurzyniak  
Senior Editor

Once considered also-rans behind automated drilling and filling, alternative aerospace automation processes, like painting, coating, sanding and other surface preparation, are starting to catch on with aerospace builders, especially in commercial aviation where immense order backlogs loom large and demand immediate attention. Boeing, for example, forecasts that the world fleet of new commercial airplanes will double in size by 2032, with more than 35,000 new airplanes, worth an estimated $4.8 trillion, on the horizon to be built.

That has airplane manufacturers and suppliers urgently examining automation possibilities in the many secondary and tertiary applications, beyond drilling and filling, in order to help reduce order backlogs. In addition to paint and prep work, increased opportunities for automation include speeding composite tape layup operations for constructing composite airframe structures to improving machining cycle times with flexible manufacturing systems (FMS) used in producing metal components for aircraft engines.
Taking a Holistic Automation Approach

Historically, the aerospace industry has had relatively low levels of automation compared to the automotive industry, but that has been changing over time, with those in aerospace increasingly looking to the automotive sector for solutions.

“Aerospace OEMs and tiers are employing automation to improve their production rates, product quality and employee safety while targeting reductions of their manufacturing costs,” said Dan Friz, director of business development, KUKA Systems (Shelby Township, MI). “This is a difficult task for any company. However, when it is approached holistically most of these challenges can be addressed head-on. The largest bang for the buck comes when the manufacturing process, tooling and automation methodology, and logistic strategy are investigated, versus being focused only on, for example, a drilling application. This is key since it allows for the opportunity to address all of the requirements the customer is looking for.

“The major automation challenge within the aerospace industry is simply the aircraft was never designed for an automated process,” Friz added. “There are various reasons for this, with passenger safety being the most important, however, it limits the automation possibilities without having to produce customized solutions for specific problems. This gets back to addressing the manufacturing process holistically and understanding that the process or tooling may have to be tweaked to better realize the associated gains.”

Broadening Automation’s Scope

Much of robotic automation’s focus has been drilling and filling holes, necessitated by the sheer volume of holes in every airplane. But automation experts see tremendous potential for gains in many other areas.

“I see them going after specific areas that are challenging from the throughput, quality, ergonomics and safety perspective,” said Chris Blanchette, manager, aerospace automation, FANUC America Corp. (Rochester Hills, MI). “Those are some high runners—keeping people safe. They’re looking at those high-volume processes where they might be challenging to get enough people in there to actually get the work done, because there’s so much work that has to be done, like drilling and filling thousands and thousands of holes.”

Automation of surface preparation for painting and sealing applications is critical, Blanchette said. “Surface prep for both of those areas, painting and sealing, is a huge area, and
it affects the aircraft in a lot of different ways. The beauty of putting paint on an aircraft’s fuselage with robots is there’s a material savings of between 30 to 50% by doing it robotically, and that also means a 30–50% savings in weight as well.”

That weight savings on fuselages translates directly to increased fuel savings for airline customers, leading manufacturers like Boeing to be keenly interested in shaving fuel costs by as little as half a percent to benefit their customers, Blanchette said. A number of FANUC automation integrators, including Encore Automation (Auburn Hills, MI) and Nordson Sealant Equipment (Plymouth, MI), have had successes developing new paint prep processes and sealing applications for aircraft fuselages and other airframe components, he added.

“For prep and paint, and sealing, you can’t have any gaps in the fuselage,” Blanchette said. “We’ve been working with Nordson Sealant Equipment, and they have some unique dispense tools that they’ve developed for the aerospace market that are compatible with the materials that the industry is using, and the materials are very, very special to the aerospace industry, and you can’t just say ‘we want to dispense this material, put it on a robot, and dispense it.’ You have to have the right equipment for the dispensing part.”

The system uses FANUC software, called Dispense Tool, Blanchette said, that gives it the precision that’s required for the sealing process of the assembly.

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At Encore Automation, the integrator focuses on new methods that offer flexibility from the monument-type systems of the past, noted Art Scafe, Encore business and product development manager. “We’re working primarily in the areas of painting, sealing, material handling, and drilling/fastening,”

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Scafe said. Encore Automation has developed a full aircraft painting automation system for commercial aircraft. “The system has been in production and consists of two FANUC P-250iB paint robots mounted on 40-m rails and a 3-m Z-Lift. It utilizes electrostatic bells and closed-loop flow control as well as robotic vision to find the craft and offset the robot paths. Offline programming was used extensively on the project.”

Another FANUC integrator, Aerobotix Inc. (Madison, AL), has developed aerospace processes for sanding applications and for in-process inspection on layup of composite parts, Blanchette said. “They’re doing on-part inspection with composite layup, called in-process mold,” he added. “They’re scanning the surface, putting more composite resins on the surface and curing those, then they’re scanning it again and doing some surface material removal in order to get the exact shape that’s required.”

Material handling of large flexible parts, like the stringers used in the assembly process for composite wing structures, also are a challenging and emerging application for robots, Blanchette said. With larger parts such as stringers, a structural component in aircraft wings, multiple robots have been configured by FANUC integrator PaR Systems.
Inc. (Minneapolis) in a process where mid- to smaller-sized robots act as a workholding on an assembly line, he noted. “The stringer is a structural component that goes on the wings—it’s almost like the little I-beam,” Blanchette said. “For these large composite wings, they have to use composite stringers, which are cut, drilled and trimmed, because the composite molding process is not precise.” The PaR Systems solution uses a few dozen robots to position and hold the wings for the cutting process using an overhead gantry-mounted KMT waterjet.

“Aerospace manufacturers also are using material handling robots to manipulate parts into assembly or kitting, tracking the parts with the robots and tool management, he said. “Kitting is used when you need to get about three million parts into the assembly process per day,” Blanchette said. “They’re looking at making this more efficient—the worst thing is when they put these parts into a kit, and there’s one missing.”

Even more alternatives are on the horizon for automating aerospace, with additions of mobile robots and, more recently, collaborative robots that can work in close contact with humans. KUKA is addressing several new areas of automation to meet the needs of the next generation materials and manufacturing processes of customers, Friz said.

“Although some of these include further advancements in drilling and fastening technologies, such as clip-to-frame end-effectors, collar swage and nut spinning end-effectors, we are focused on the development of human-robot collaboration [HRC] automation,” Friz added. HRC is focused on using safe, intelligent robotics, he said, to perform the repetitive and ergonomic challenging tasks alongside skilled labor.

“In essence, HRC solutions allow the highly skilled labor that is found within the aerospace industry to continue to perform the required craftsmanship while allowing the robot perform the unwanted/unskilled tasks,” Friz said. “Furthermore, KUKA is focused on the introduction of mobile automation. These applications are important when trying to achieve the customer’s vision of a flexible assembly line as it allows for the reduction of typically unforeseen or obvious reoccurring costs. Mobile automation is a key ingredient to the Industry 4.0 philosophy and KUKA is excited to be a front runner of these types of technologies already today.”

In recent months, any aspect of the manufacturing process is being evaluated by the customer base, Friz said. “KUKA is beginning to see many opportunities beyond structural build for automation in areas such as part fabrication, surface preparation, systems installation, interiors manufacturing and installation and logistics,” he said. “In most cases, reutilizing the current automation can address the majority of the new focus areas,” he added. “However, there are several topics that are driving new technology which will greatly increase the efficiency of the manufacturing processes.”

**Perfecting the Paint Process**

Automating the process of painting a full aircraft fuselage remains a difficult task for aerospace builders, due to the sheer size of airframe fuselages and safety concerns. “The big ticket for Boeing and Airbus is to paint the actual entire airplane,” said Didier Rouaud, Global Business Development Manager, Paint Process Automation, ABB.
regarding fully automating the process. “This is huge. This is not done yet.”

Last year, several suppliers submitted a study on how to best tackle this task, Rouaud said. “There are no big jumps,” Rouaud said of robotic painting technology. “Everybody’s trying figure out how to do it. The biggest obstacle is that the airplane cannot move from process to process, and that it has to be done in an explosion-proof area.” With indoor painting processes, explosive paint fumes are the issue.

Painting currently is done inside large air-conditioned hangars, in enclosed areas, he said, using three options, with automation solutions that are floor mounted, with ceiling-mounted systems, or with robots mounted on automated guided vehicles (AGVs).

“People are doing a very good job of doing that right now,” Rouaud said. “The latest option is the AGVs. The difficulty of that is that it needs to be explosion-proof, and these AGVs are battery-powered or dragging long cables, so explosions can be a concern.”

“For prep and paint, and sealing, you can’t have any gaps in the fuselage.”

Painting the aircraft is a complex process that requires many coats of paint, up to six total, Rouaud said, first with primer, base coat, and then the application of the livery, where the airline’s colors and logos are painted. Aircraft builders also are seeking automation options for the masking process, he added, which today is largely a manual process. “They want to automate that process because of the backlogs,” he said. Among the considerations is an ink-jet type of painting, he added.

**Speeding Component Production**

To help boost production, aircraft builders are also turning to technologies that help cut cycle times on producing a variety of aerospace parts, from engine components to compos-
ite airframe pieces. Dropping cycle times dramatically on assembly of metal engine parts and ribs that support composite wings, for example, help builders meet production goals on big aircraft programs.

With its Power Motion i, FANUC offers a line of multiaxis motion controllers that are being used in automation for driving a wide variety of equipment, ranging from composite fiber-layup machines to AGVs, robots and the machining cells that cut all the titanium and other metals used in aircraft. The Power Motion i is a high-performance, scalable general motion control supporting applications requiring from 1 to 32 axes. It supports up to four simultaneous interpolated axes in four parallel, programmable paths. To support flexible machine design requirements, the Power Motion i also includes a high-performance PLC with the capability of running five parallel ladders simultaneously.

“There’s a lot of complex motion involved in these parts, be it tape laying or machining,” said Rick Schultz, program manager, aerospace, for FANUC America. “From the CNC side, we’re constantly pushing the envelope.

“There’s a boatload of metal that goes into an aircraft,” Schultz said, “and as we transition from aluminum to composites, there’s a lot of titanium that goes into those components.”

With the aerospace industry’s production targets, higher accuracy is required. “From a traditional CNC aspect, the drive for automation is feeding the need for better, more accurate parts,” Schultz said. “It’s also driving a need for shorter cycle times.”

In the factory, everything that moves can be driven by CNCs like the Power Motion i, Schultz said. “CNCs are kind of a master of motion.”

With FANUC’s Power Motion i controllers, manufacturers can automate a lot of processes around the aircraft, Schultz said. “We’re driving higher precision, and shorter cycle times,” he said. “FANUC’s Power Motion i controller handles a lot of that...
When we talk about that Fanuc One initiative, the Power Motion is a key thing because it bridges the gap between the robot and the AGV and the part manufacturer.”

**FMS Optimizes Aero Parts Machining**

Maximizing spindle times is another key way to cut production costs, and new flexible manufacturing systems (FMS) like those offered by Fastems LLC (West Chester, OH) can help aerospace manufacturers boost productivity on high-volume machining lines. Aerospace customers are investing in new machining centers, particularly new five-axis machines, noted Robert Humphreys, Fastems international sales manager.

With its RoboFMS, robots carry the FMS to the machine, optimizing spindle uptime and keeping production rates high. The Fastems FMS can result in spindle uptimes of 90% or higher, far exceeding industry averages.

“We’re finding the aerospace business as a whole is looking at cost reduction and the only way to get that is to get more spindle uptime,” Humphreys said. “This is really designed to get the maximum spindle hours. The more you’re cutting chips, the more you’re generating income.”

“We’re driving higher precision, and shorter cycle times.”

An average ROI on Fastems’ FMS is about 18 months, Humphreys said. Kimberly Machine (Garden Grove, CA), a small, family-owned job shop, installed one of Fastems’ smaller FMS systems to help produce highly complex aerospace parts in largely unmanned production on its Okuma machines. “They’re doing high-accuracy jobs, a little defense work, and some are very complex,” he said.

“With modern machining centers, they’re so accurate and you don’t need to turn parts,” Humphreys said. Many manufacturers fail to initially recognize what FMS can do for optimizing their operations, he added. “They think it’s too difficult, that’s not for me, that’s not my production work. If you look at what the aerospace manufacturers have, it’s the setup that kills them.”

The latest Fastems MMS5 FMS automation software features dynamic scheduling capabilities to help optimize machine spindle uptimes. “It’s dynamic, so it’s always putting the most urgent jobs first,” Humphreys said. The Web-based MMS5 software is part-oriented, he added, and it has predictive scheduling and real-time management and reporting on a number of variables. The system is currently used by large aircraft engine manufacturers to track coolant temperature, and measure load on the spindle, he added. “If everything’s within a certain temperature, it’s green and good to go.”

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