Breaking the mold: Researchers engineer faster way to create complex composite structures

New manufacturing method produces specialized components for aircrafts without the need for dedicated molds, tooling or temporary support materials

By Aisha Kaddi, ASU News
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An aircraft component can be built on a computer screen within hours, but turning that digital design into a high-performance composite structure takes months.

The challenge often begins with the tooling. Strong, lightweight composite structures made from materials such as polymers and reinforced fibers typically require molds or temporary supports. Designing and producing that tooling adds time before fabrication can begin.

Mostafa Yourdkhani is working to remove that barrier.

Yourdkhani, an associate professor of manufacturing engineering in the School of Manufacturing Systems and Networks, part of the Ira A. Fulton Schools of Engineering at Arizona State University, is developing manufacturing methods that could produce complex composite structures without dedicated molds, tooling or temporary support materials.

“The goal is to combine material and process design with robotic fabrication so that lightweight structures can be manufactured rapidly, at scale and with minimal resources,” he says.

Reducing the need for dedicated molds and tooling could make it more practical to produce specialized parts in smaller quantities, adapt designs quickly and create complex geometries that were previously deemed impractical. The approach could enable lighter, multifunctional and architected structures while reducing material use.

Yourdkhani's team has begun creating internal components of aerostructures, including panels that support aircraft wings and wind turbine blades. Advanced manufacturing methods could make these traditionally difficult and costly designs faster and more economical to produce.

The work takes place in two complementary research spaces in the Interdisciplinary Science and Technology Building 12, or ISTB 12, at ASU's Polytechnic campus.

In the Composites and Polymer Science and Engineering Lab, or ComPoSE Lab, researchers develop materials and determine how processing conditions affect their performance. The newly operational nexus robotic cell allows researchers to work with a wider range of materials and full-scale parts that often cannot be produced in the ComPoSE Lab.

Large robotic arms provide the range of motion needed to manufacture large structures and study how materials and processes perform at an industrial scale. Cooperative robotic systems will also enable researchers to work with multiple materials and manufacturing scales simultaneously, while in-situ monitoring can help make those processes efficient.

"Manufacturing high-performance polymer and composite parts without tooling or support materials creates new opportunities to design and produce lightweight structures for aerospace and energy applications," Yourdkhani says. "We envision extending this approach to other industrial sectors."

Rethinking how composites are made

Yourdkhani's interest in manufacturing grew from an important question: Why do composite materials fail?

His graduate research showed that manufacturing processes can shape a composite's internal structure and ultimately influence how it performs.

Composite manufacturing traditionally involves several hands-on steps that can introduce variations in the finished part. Automation can improve consistency, but the challenge involves more than assigning a robot a task previously performed by a person.

"Our goal is to help move composite manufacturing toward processes that are more automated, reproducible and digitally controlled," Yourdkhani says.

Collaboration between robots

Three industrial robotic arms share a work area in the nexus robotic cell. Two of the arms were donated by Dexcom, a medical device company that makes wearable glucose monitors.

"When I first designed the lab, I envisioned it as more than a collection of individual machines," Yourdkhani says. "I wanted to create an environment in which multiple robots could work together across different stages of production, from manufacturing and finishing to inspection."

Researchers are also studying how simulations, sensors, artificial intelligence and machine learning could help robots work together by detecting problems and adjusting manufacturing processes.

“The robotic cell offers students experience with industrial-scale technology while solving automation challenges faced by aerospace and automotive manufacturers,” says Rajdeep Adak, a doctoral student studying robotics and autonomous systems in the mechatronics and automation concentration in the School of Manufacturing Systems and Networks.

“Students gain practical experience with robot kinematics and industrial control systems, which are essential skills in the automation industry,” Adak said.

Those skills also support the team’s broader vision for advanced manufacturing systems in which robots can place and process materials, machine surfaces and inspect components as part of one coordinated process.

“We have shown that we can expedite the manufacturing process of high-performance polymers and composites, from weeks or months down to minutes or hours,” Yourdkhani says.

For manufacturers, the work points to a larger opportunity in ISTB 12. Bringing materials research, characterization and industrial-scale robotics together can move promising ideas closer to the production floor.

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Main image



Rajdeep Adak (left), a doctoral student studying robotics and autonomous systems in the mechatronics and automation concentration, and Mostafa Yourdkhani (right), an associate professor of manufacturing engineering, discuss potential manufacturing applications for the new NEXUS robotic cell. Photo by Aisha Kaddi/ASU

Text image(s)



Mostafa Yourdkhani, an associate professor of manufacturing engineering in the School of Manufacturing Systems and Networks, part of the Fulton Schools, stands in the nexus robotic cell. Photo by Aisha Kaddi/ASU