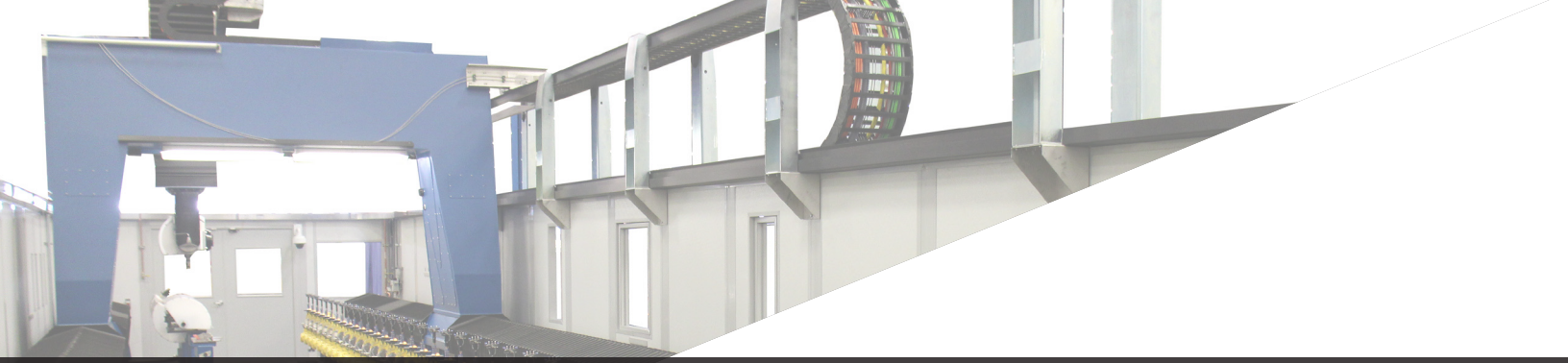

Adaptive Manufacturing System

Challenge

Using composites for aircraft components presents opportunities for new ways to process parts. However, composites come with unique challenges such as impacting the ability to produce accurate parts and high part diversity even within a family of parts. Traditionally, parts have been trimmed only while clamped in rigid tools to secure nominal shape. This results in significant investment in tooling, design, production, maintenance, storage and handling.

Solution

As an alternative, PaR Systems has developed the Adaptive Manufacturing System that incorporates a Robotic Fixture, a Precision Motion Machine and an Integrated Process Head. The Robotic Fixture allows the entire family of parts to be managed with one fixture that remains within the machine footprint.

- Cost Effective: 1 fixture for more than 400 parts
- High Productivity: The fixture can quickly change to accommodate over 400 parts. Time to change between parts is less than 1 minute.
- 100% Inspection: Laser scanner provides fast and accurate inspection while the part is in the cell.

Lastly, a verification process is used to measure the trimmed part.

Robotic Fixture

The fixture design was developed from a targeted family of parts. While all similar in function, the parts are widely diverse in length, height, width and angularity. There are over 400 unique parts per ship set for a single aircraft. The fixture is comprised of 38 individual FANUC LR Mate robots that are programmed to unique positions and poses based on local part geometry. The Robotic Fixture accommodates variations within the part family and does not restrain the part to its nominal contour.

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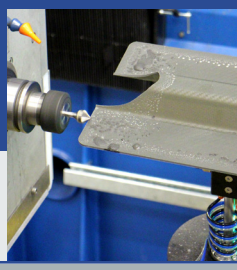
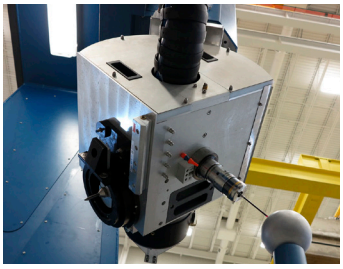


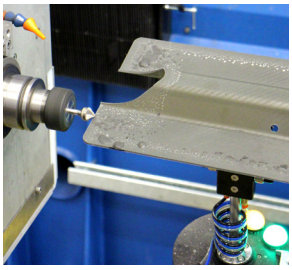
Integrated Process Head



The Integrated Process Head measures the actual location, pose and contour of the part. It is equipped with a trimming mechanism that will not over power the fixture by using abrasive waterjet and laser profilometry to locate and map parts. Further, secondary options include a spindle for chamfering and drilling drain holes.

In order to maximize fidelity between the different process tools, they are all integrated into a single head. Two laser profilometers, the waterjet cutting head with its interchangeable catchers, and spindle with automatic tool change are mounted orthogonal to each other to prevent interference from one process in another process.

Waterjet Cutting Head and Spindle



The waterjet cutting head is comprised of a high pressure plumbing to deliver 60,000 psi. Waterjet cutting provides high precision cutting with two catches for trimming different part areas. While waterjet is the primary process for trimming parts, some secondary operations require a spindle. Hole drilling and edge chamfering are accomplished with automatic tool exchange.

Motion System and Controls

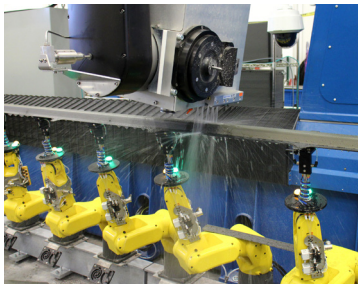
The motion system is a PaR LM Series precision gantry machine with Siemens 840D controls. The LM Series features linear motors on the X and Y axes. These linear motors provide excellent speed and acceleration performance to ensure precise, quick moves to optimize cycle times.

Adaptive Trimming

The system locates the part within the fixture. Multiple parts can be loaded on the fixture at the same time. The system then scans the part with the laser profilometer to create a reference frame. That reference frame depicts the position, orientation, and local contour of the part as actually presented in its unconstrained state, to the machine. The system then creates an adaptive tool path that corresponds with the current contour. The part is cut in the unconstrained state in such a way that it will be the correct size when it is constrained to its nominal shape when installed in the aircraft.

Inspection Process

Following the trimming process, the part is washed and dried. A second laser profilometer is used to verify the trimmed geometry. This scan is used to make discrete measurements of features like chamfer nose height and edge location.



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