CNC Automated Part Handler

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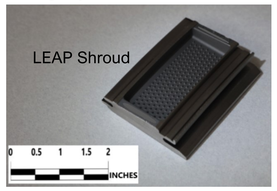
Background

GE Aerospace in Muskegon produces many parts for military and commercial aircraft engines. One of those parts is the shroud for the LEAP engines that power the Boeing 737 Max and the Airbus A320neo commercial airplanes. To complete the manufacturing process for this shroud, operators must manually transfer parts through four stations on a fixture within a CNC mill. Operators have experienced issues with metal burrs from the partially processed shrouds becoming embedded in their hands and causing injuries.



Objective

GE Aerospace requested a solution that automated the existing process to a point where operators would have little to no risk of injury while performing required tasks. To achieve this, a CNC tool was outfitted with a state of the art, pneumatically powered robotic gripper. The tool was designed to be capable of moving parts throughout a HAAS mill environment. The grinding operation is completed with minimal manual intervention from a machine operator. As a result, machine operator safety is increased due to the reduced contact.

Key Specifications

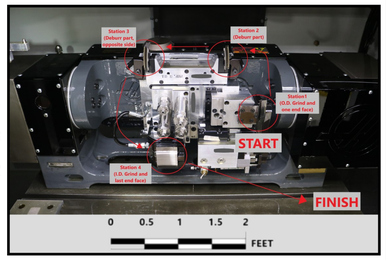
- The automated part handler had to be integrated into an existing system with minimal fixture modification.
- The time to complete the process must not exceed 60 seconds.
- Adherence to GE Aerospace's applicable Engineering Manufacturing Standards was required.
- Total cost of the project could not exceed $20,000.
- Minimum travel along x-axis: 10.3 inches.
- Minimum travel along y-axis: 7.9 inches.
- Minimum travel along z-axis: 11.8 inches.

Environment

The fixture inside of the Haas VF-2YT is broken into four separate stations. The part handling solution will operate inside of the Haas, transporting shrouds between the 4 stations in a specific order.

Order of Operations

- Station 4⟶Dropbox
- Station 3⟶Station 4
- Station 2⟶Station 3
- Station 1⟶Station 2
- Operator Loads Station 1

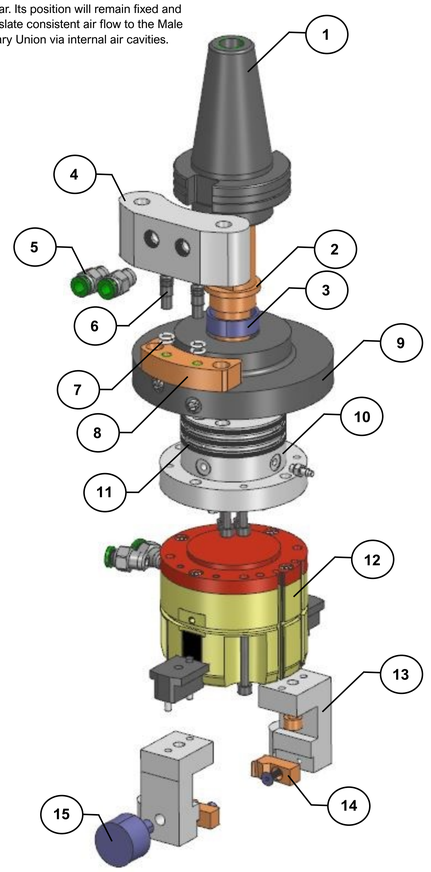


Design Challenges

- **Minimum Fixture Modifications -** The machining processes outside the scope of this project are based upon the layout of the fixture and cannot change. Because of this, no changes that alter the layout of the four stations were allowed. Modifications such as the radial feature and ball plungers on stations 2 and 3 help to replicate an operator opening the gates.
- **Repeatability and Presence of Burrs -** Every part must be loaded consistently. Burrs pose a challenge since they cause variability in the surfaces used to pick and place the part. Features such as the finger pads were required to alleviate the effects of these inconsistencies.
- **Rotational Freedom -** To accommodate the current layout of the fixture, 360 degree spindle rotation in either direction is required. The parallel gripper used requires an air supply typically connected with air lines. However, draped air lines would become entangled around the tool when any major rotation occurred. To allow for free rotation of the tool without the need for an air hose, the Rotary Union Assembly was designed.

Design

1. Tool Holder
2. Rotary Union Top Cap
3. Brass Bushing
4. **Spindle Air Mount** - Remains permanently fixed to the exterior of the Haas spindle and serves as the initial connection between shop air and the Parallel Gripper without the need for continuous airlines (a hazard for entanglement).
5. Preslok Fitting (x4)
6. Male Connector (x2)
7. O-Ring (x6)
8. **Air Collar** - Allows for easy maintenance and part replacement should the Male Connectors snap (designed fail point).
9. **Female Rotary Union** - Accepts air from, and will mate with, the Spindle Air Mount via Male Connectors and the Air Collar. Its position will remain fixed and translate consistent air flow to the Male Rotary Union via internal air cavities.
10. **Male Rotary Union** - Accepts air via external air cavities which mate with and complete those in the Female Rotary Union to form solid air channels. It remains free to rotate (in unison with Parallel Gripper) while translating consistent air flow to exterior ports (for connection with Parallel Gripper) via internal air channels.
11. X-Profile O-Rings (x3)
12. Parallel Gripper
13. Gripper Finger
14. **Finger Pad (x2)** - Custom surface to mate with shroud in vertical and horizontal orientation. Allows for consistent pick and place by limiting allowable rotation or slippage.
15. Compliant Mechanism



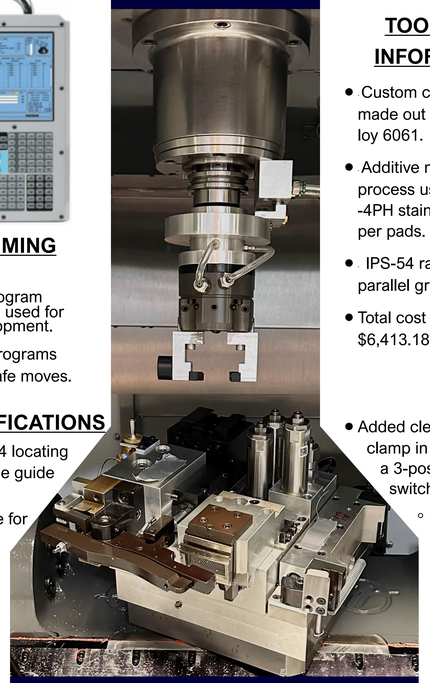
Final Build

PROGRAMMING

- G-Code
- Desktop NC program editor and HMI used for program development.
- Included sub-programs for dwell and safe moves.

FIXTURE MODIFICATIONS

- Chamfered station 4 locating details and tapered the guide rails.
  - Increased clearance for the part loading sequence.
- Created rounded gates at deburr stations.
  - Provided rolling action with gripper finger to open and close deburr stations.



TOOL BUILD INFORMATION

- Custom components made out of aluminum alloy 6061.
- Additive manufacturing process used to create 17 -4PH stainless steel gripper pads.
- IPS-54 rated Destaco parallel gripper.
- Total cost of final build $6,413.18.
- Added clevis to station 1 clamp in conjunction with a 3-position 2-way air switch.
  - Permitted three different states of clamping-

State 1: Air cylinder on, part clamped.

State 2: Air cylinder off, part unclamped.

State 3: Air exhausted, free movement.

Future Improvements

- Add lightbox to each station on the fixture to ensure parts are loaded correctly.
  - This would negate the need for additional probing which reduces overall takt time.
- Upgrading the male connectors to a more robust design.
  - Modify the existing design to replace the two O-rings being sheared, to a one O-ring design that crushes in order to create the seal.
    - The wear on the O-rings and potential for failure would be significantly reduced.
  - Fasten male connectors to the air collar with springs to allow for height adjustment to provide a more secure connection.
- Utilize a PID controller design for increased spindle orientation accuracy. Also, would be beneficial when making adjustments to account for variation across several machines due to age/wear.

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