Closed Door Machining

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Introduction

The Closed Door Machining project revolves around making a series of process changes that would allow a decrease in operator intervention while maintaining the tight tolerances needed for parts of a jet engine assembly. In an ideal scenario, a CNC Machine would operate in a controlled environment and there would be no concern for environmental effects on the product. In realty, the cost of maintaining a controlled environment in large factories or machine shops is an unrealistic and expensive goal.

As shop temperature varies, so does part temperature. A change in part temperature while machining results in a change in part size that needs to be adjusted for when targeting precise dimensions.

Approach

To compensate for thermal expansion we will be using an artifact that is same material as the part and of known size at 68 °F.

The artifact will be mounted to the part fixture. During multi-cut processes this artifact will be probed and the difference in length will be used to compensate during the next cutting sequence.

Testing & Moving Forward

- The use of the artifact was confirmed through a series of tests on the CMM, measuring the artifact alone and measuring the part and artifact together at a range of operational temperatures.
- The heat transfer test was then performed to ensure the rates were comparable between artifact and part. It was discovered that the heat transfer rate was much slower, with the artifact taking 400% longer than the part to reach the steady state temperature.
- Two solutions to this problem were developed. In order to continue testing with the current artifact a coolant flush was introduced to bring both part and artifact to a known temperature.
- And using available 3D-printing, alternate designs for the artifact would be suggested/evaluated in order to find one that more closely matched the heat transfer rate of the part. This artifact can be used as the project is expanded to other parts in hopes that the coolant flush will not be needed.

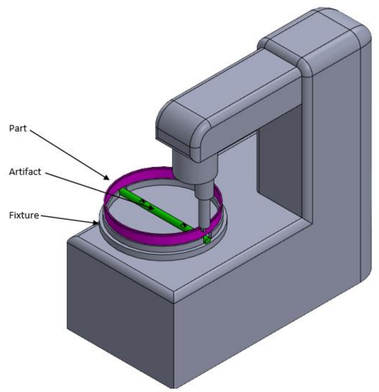
Alternate Fixture Design Considerations

The design of a new artifact was undertaken with the understanding that future artifacts would be 3D printed. This set some limitations on the design:

- Bed Size: 9.8” x 12.8”
- Nominal Feature Tolerances: +/- 0.005”
- Minimum wall thickness: 0.018”
- Vertical rod aspect ratio limit: 3:1
- Maximum Unsupported Overhang Angle: 45°

Computer Numerical Control Machine

DMU 85 monoBLOCK by DMG MORI



CNC Machine

Alternate Design Descriptions

Alternate design A: The original artifact concept was broken down into three pieces to conform with printer restrictions. Several methods of increasing the surface area were explored including radially arranged holes, and vertical hole patterns. Fins were chosen to maximize the surface area. This allows the artifact to match the heat transfer rate of the part more closely. Segments will be connected by a tight-fitting tongue-in-grove secured by two bolts so as not to allow for flexing or loss in thermal expansion. Each slot also has a slightly angled bottom to a drainage trench to prevent the accumulation of coolant in the artifact.

Alternate design B: Fins of 0.025” thickness are arranged radially in a circle with an outer diameter of 9” allowing it to be printed in one piece. The fins are enclosed on three sides to prevent coolant and metal shavings from getting caught in the fins. The outer diameter allows for probing in two dimensions which can be used to as a quality control measure for comparison. In addition, the spacing of the fins can be adjusted to match the surface area of the part much more closely. In this model, there is less than a 2% difference between the surface areas of the artifact and test part.

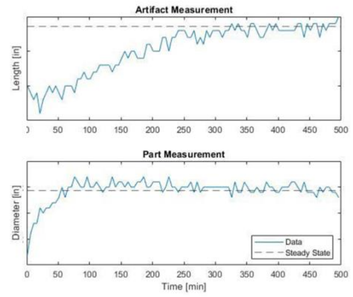
In both designs, the parts would require finishing machining for placement of mounting hard ward and removal of printing supports.

Data

Artifact Viability CMM Results

Temp (°F)	Error
125	49.58%
91	1.42%
81	7.97%
75	5.62%
68	6.12%
27	44.52%

Heat Transfer Test Results



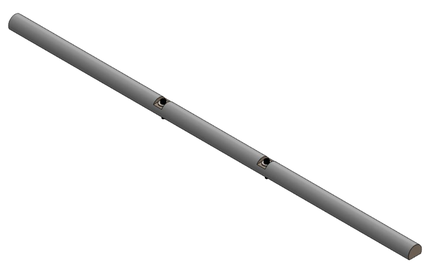
Conclusions

- Two test parts have been run.
- Due to a tooling oversite the first test part was not usable after the full operation had been run.
- The second test part ran successfully. Data collected by the machine and in subsequent CMM testing indicates

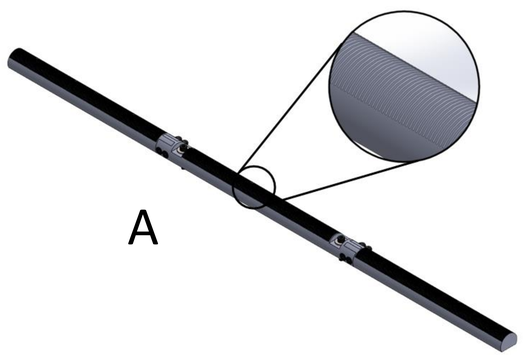
PASS	Adjusted Value (in)	Temp in Shop (°F)
ROUGH	0.000359632	71.82
SEMI	0.000356232	71.78
FINISH	0.000494739	73.26

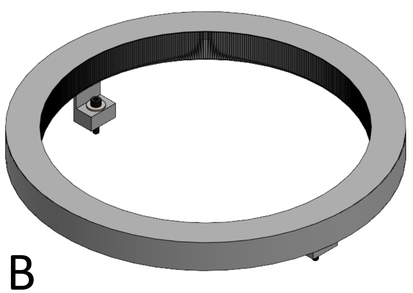
- Next step is long term data collection. After a period of 12 months, data will be examined to determine if process changes have been beneficial to product quality and production time.

Artifact Designs



Original Artifact Design





Artifacts Moving Forward