

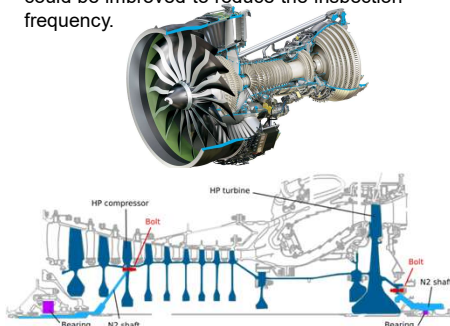
Analysis of Machining Processes to Improve Inspection Cycle Time

GE Aerospace



PROBLEM STATEMENT

Part number 2028M39P01, or the CF34 forward compressor shaft of a GE commercial aircraft engine, has increased cycle times due to a 100% quality inspection rate. Cycle times have a lot of variation, making it difficult to estimate a delivery time on the part, creating scheduling issues. The objective of this project is to identify which characteristics of the part do not comply with AS13002 standards, and how they could be improved to reduce the inspection frequency.



REQUIREMENTS

| # | Description |
|---|---|
| 1 | Evaluate inspection data on forward compressor shaft (2028M39P01 – CF34.) |
| 2 | Complete AS13002 inspection frequency chart and evaluate results against the current standard |
| 3 | Evaluate process capability for each inspection operation on the 2028M39P01 – CF34. |
| 4 | Document inspection reduction process to standardize this process for future parts. |

CONCEPTS

- Process stability is measured by a control chart, measuring how predictable a trend is
- Process capability is an assessment of the ability to meet a specification
- Ppk is a process performance index that considers process location as well as process variation to calculate how well a characteristic is meeting a specification.

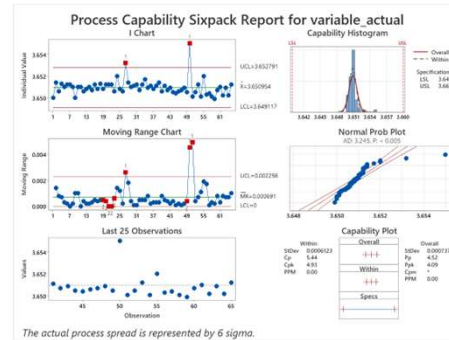
FINAL DESIGN, APPROACH, PLAN

The final approach was to run a Sixpack Report for each Tape-Controlled Characteristic. With the Sixpack reports generated, we are able to use it to assess multiple things about the process:

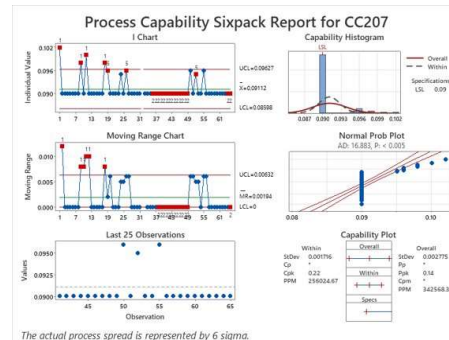
- The ppk will be assessed against the AS 13002 standard of 1.33 ppk
- The Histogram will be analyzed to determine if the process needs a shift.
- The I and MR charts will be used to find trends and anomalies in variation.

This information will help to determine sources of variation. With the sources found, that information can be given to GE to determine what improvements need to be made to their process. If these improvements are made, then they can reduce their inspections and in-turn reducing the lead times for parts to get to customers.

Example of Data that is In-Control and Capable



Example of Data that is Out-of-Control/ Not Capable



RESULTS

After discussing the priority characteristics with GE, the different measurement methods were analyzed for their procedure and accuracy. The characteristics that needed to have process shifts were brought to the attention of the Process Engineers and they adjusted the program to bring the data closer to the nominal value.

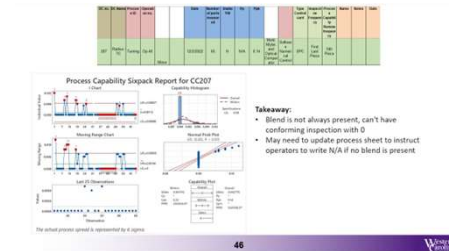
The majority of the deviation resulted from:

- Inaccuracies with Mold and Trace measurement
- CNC program adjustments
- Lack of offset probe
- Need for tighter tolerances
- Human Error

AS13002 Inspection Frequency Chart Sample

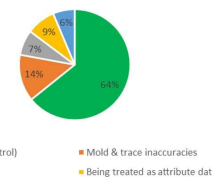
| DC # | DC Name | Process ID | Operation ID | DC Characteristic | Process Capability Study | | | | Measurement Means | |
|------|----------------------------------|------------|--------------|-------------------|--------------------------|--------------------------|------------|------|-------------------|----------------------|
| | | | | | Date | Number of parts measured | Stable Y/N | Pp | | Ppk |
| 3 | Dimension 11.030 +/-0.005 inches | Lathe | 75 | Minor | 5/7/2020 | 15 | Y | 0.76 | 1.96 | CMM |
| 44 | Dimension 17.250 +/-0.005 inches | Lathe | 85 | Minor | 5/7/2020 | 15 | Y | 2.22 | 0.39 | Mold / Vision System |
| 1 | Radius 12.250 +/-0.005 inches | Lathe | 82 | Minor | 5/7/2020 | 15 | Y | 0.61 | 0.96 | Mold / Vision System |
| 2 | Radius 17.125 +/-0.005 inches | Lathe | 75 | Minor | 5/7/2020 | 15 | Y | 0.88 | 0.83 | Mold / Vision System |
| 4 | Dimension 17.500 +/-0.005 inches | Lathe | 75 | Minor | 5/7/2020 | 15 | Y | 1.39 | 1.24 | Mold / Vision System |
| 87 | Dimension 18.500 +/-0.005 inches | Lathe | 75 | Minor | 5/7/2020 | 15 | Y | 1.10 | 1.05 | CMM |
| 123 | Radius 17.500 +/-0.005 inches | Lathe | 82 | Minor | 5/7/2020 | 15 | Y | 1.14 | 1.11 | Mold / Vision System |
| 137 | Dimension 17.500 +/-0.005 inches | Lathe | 82 | Major | 5/7/2020 | 15 | Y | 1.42 | 1.04 | Mold / Vision System |
| 180 | Radius 17.125 +/-0.005 inches | Lathe | 82 | Minor | 5/7/2020 | 15 | Y | 0.85 | 0.78 | Mold / Vision System |
| 203 | Radius 17.500 +/-0.005 inches | Lathe | 82 | Minor | 5/7/2020 | 15 | Y | 0.72 | 0.66 | Mold / Vision System |

Priority Characteristic Presentation for GE



Corrective Action Summary

| Corrective Action | Number of characteristics |
|---------------------------------|---------------------------|
| None (in control) | 61 |
| Mold & trace inaccuracies | 13 |
| Being treated as attribute data | 8 |
| Tool Shifts | 7 |
| N/A | 6 |
| Total | 95 |



SUMMARY AND CONCLUSIONS

After the team was given the data for OPs 30-60, they began to analyze the data using Minitab and formatting sixpack charts for every Tape-Controlled Characteristic. The team formatted the data and put the operations that needed the most attention into a slideshow and went over it with the GE team to discuss possible treatment for any operation that did not meet the 1.33 PPK value. The team continued to document and standardize the process until a final meeting with the GE lead machinists and engineers where they discussed final treatments to adjust the deviation in the TC characteristics that needed attention. The final step was to format all the data the team into a final packet so that GE had access to it in the future.

FUTURE WORK

The AS13002 standard is one that has recently been adopted by GE Aerospace. By documenting the process, and how Ppk values were not being met for characteristics, the team was able to help "standardize" this process for GE. Not only will this help decrease the inspection time of other similar parts, but also provide the sponsor with valuable information on where their inspection methods need to be improved. Mold & Trace training for operators is currently being planned by the Quality department to increase Ppk values for the necessary characteristics.

TEAM & ACKNOWLEDGEMENTS

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- Alex Justus, Mechanical Engineering
- Xavier Rouse, Engineering Technologies
- Jordan Villanueva, Engineering Technologies
- Kyle Parker, GE Aviation
- Michael Fisher, GE Aviation
- Nazmul Ahsan, Faculty Mentor
- Patrick Gardner, Capstone Instructor



References

1. Society of Automotive Engineers. (2015). *Requirements for Developing and Qualifying Alternate Inspection Frequency Plans (AS13002)*. SAE International. <https://www.sae.org>