Air Turbine Thermal Stability

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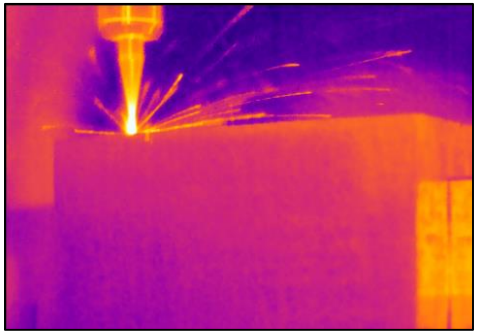
Overview

An investigation into temperature change of the Air Turbine Spindles over long running periods is required.

A test was carried out at the Technicut TECH-CENTRE, running the spindle freely without a cut for two hours before taking a one minute cut. Measurements of the tool length and temperature were taken in order find any change in temperature and gauge length of the cutting tool assembly.

Recorded data showed minimal change in both the temperature and tool length indicating that there is little concern over thermal growth while running the Air Turbine Spindles for prolonged periods of time. All cutting was dry (without coolant) to simulate worst case cutting conditions.



Thermal Imaging taken During Test

Equipment and Setup

Equipment:

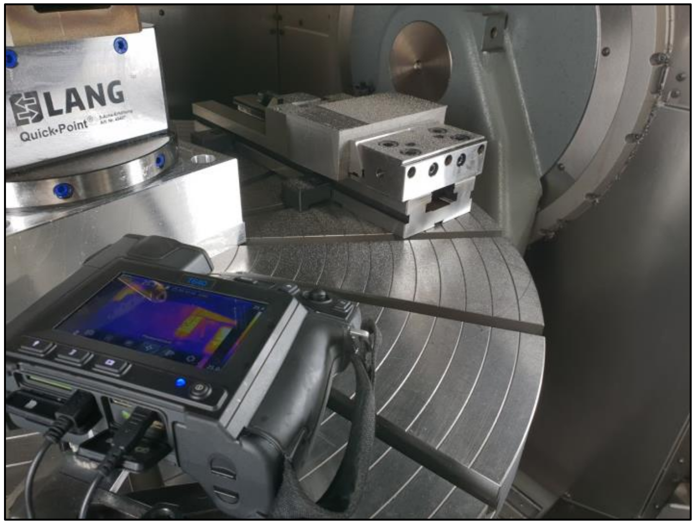
- Hermle C52U MT
- BLUM Laser Tool Measurer
- FLIR T640 Thermal Imaging Camera
- Air Turbine 660HSK-A100 50,000 RPM
- Machine Vice
- Titanium 6Al-4v Test Piece
- 1mm Technicut Ball Nose Tool

FLIR T640 Thermal Imaging Camera

Setup:

The thermal imaging camera was clamped to the machine bed with the lens aimed towards the titanium workpiece. With the Air Turbine in the spindle the tool was measured using the BLUM Laser Measurer.

1mm ball Nose tool used during machining



Experimental setup

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Method

- In order to assess the temperature change through long running periods the Air Turbine Spindle was setup in a Hermle C52U MT 5 axis machine tool with a Ø1mm ball nose tool.
- An initial datum tool length measurement was taken.
- The Spindle was run freely without a cut for a two hour period with temperature readings taken every 20 seconds.
- After this two hour period the tool length was measured using the BLUM Laser installed in the machine.
- Following this a one minute cut was made in Ti 6Al-4V at the parameters in the table below.
- Tool length measurements were taken again immediately after cutting.
- Finally this process was repeated 6 times to take the total running time to approximately 12 hours.

Feed (mm/min)	Speed (rpm)	Feed per Tooth (mm/tooth)	Cutting Speed (m/min)	Axial DOC (mm)	Radial DOC (mm)
2000	50,000	0.02	157	0.2	0.4

Measurements

Two types of measurement were taken with the aim of showing temperature change and its affect on machining:

- Firstly, a thermal imagine camera was set up in the machine for temperature recording.
- Also, the BLUM laser measurer fitted inside the machine was used to take five tool length measurements before and after cutting to check for thermal growth of the spindle. Five measurements were taken and an average taken to account for measurement variation.

The aim was to show any increase in temperature over time by the spindle running continuously. Also, the tool length measurements would show if the size of the tool increased as a result of thermal expansion.

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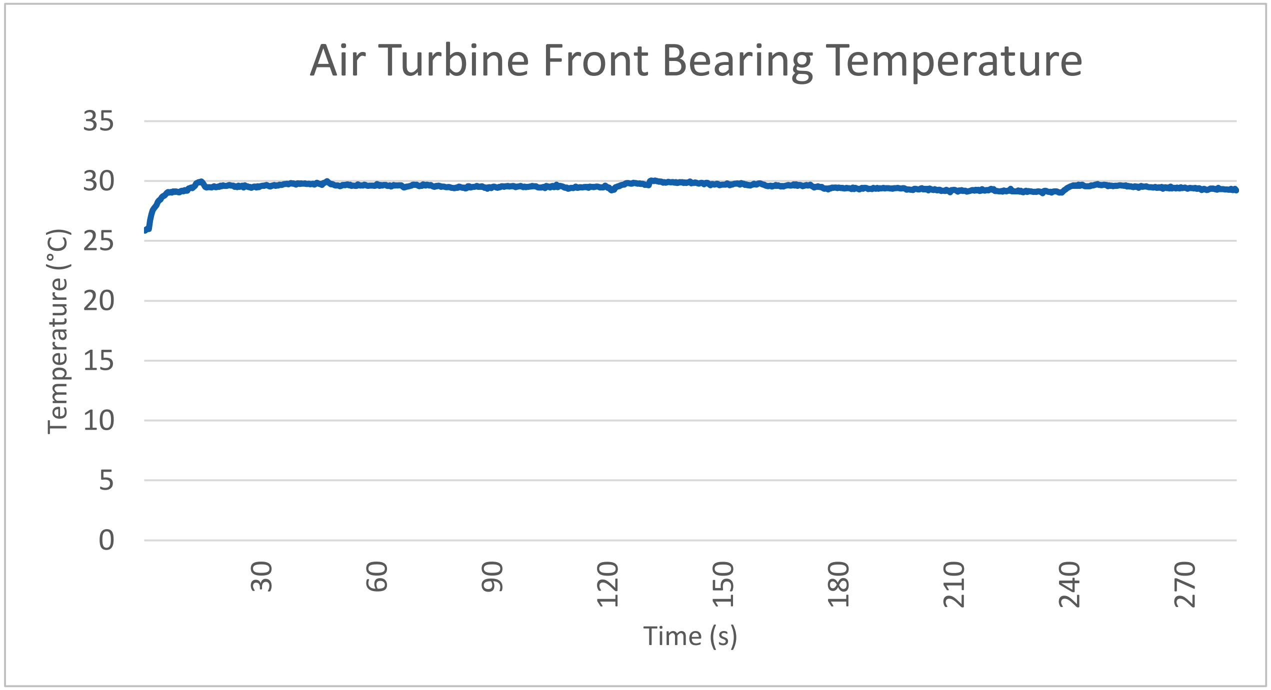
Results - Temperature

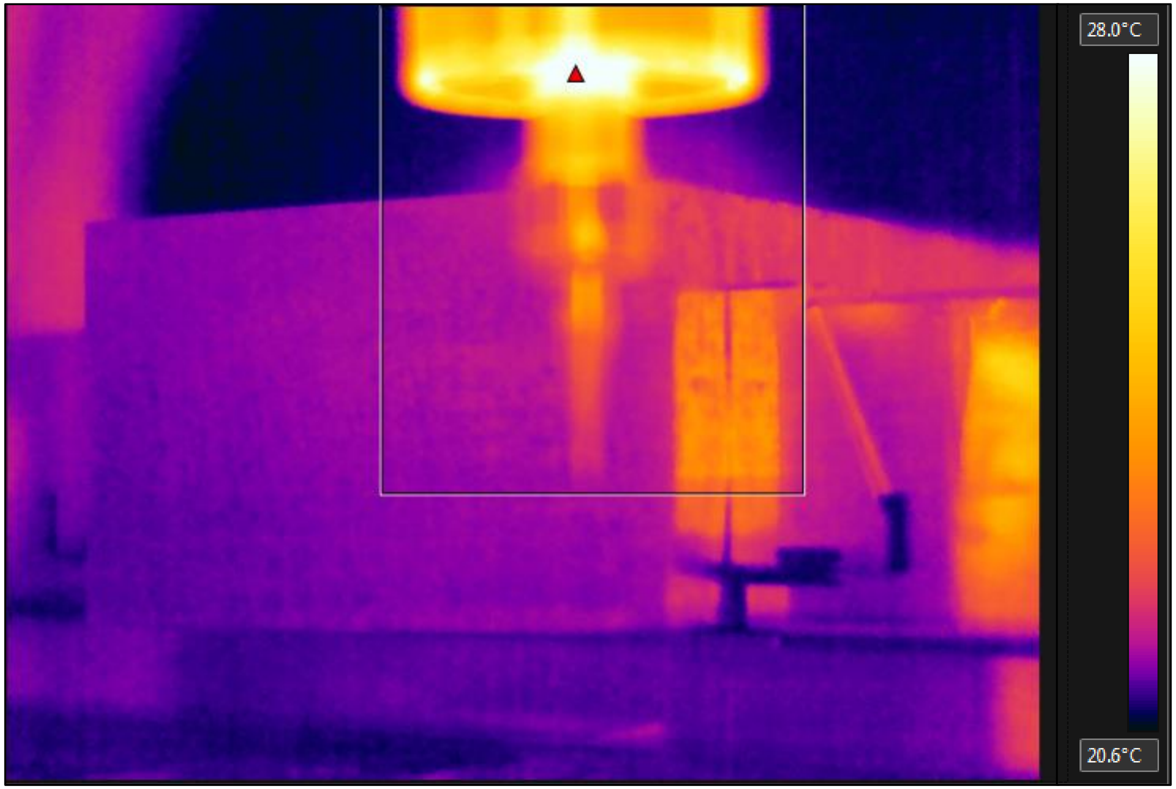
The camera was able to record continuously for the first 4.5 hour period.

Below is a graph showing the temperature at 20 second intervals, as can be seen there was a small temperature rise at the start as the spindle went from ambient 26°C to a steady state operating temperature around 30°C.



Results - Temperature

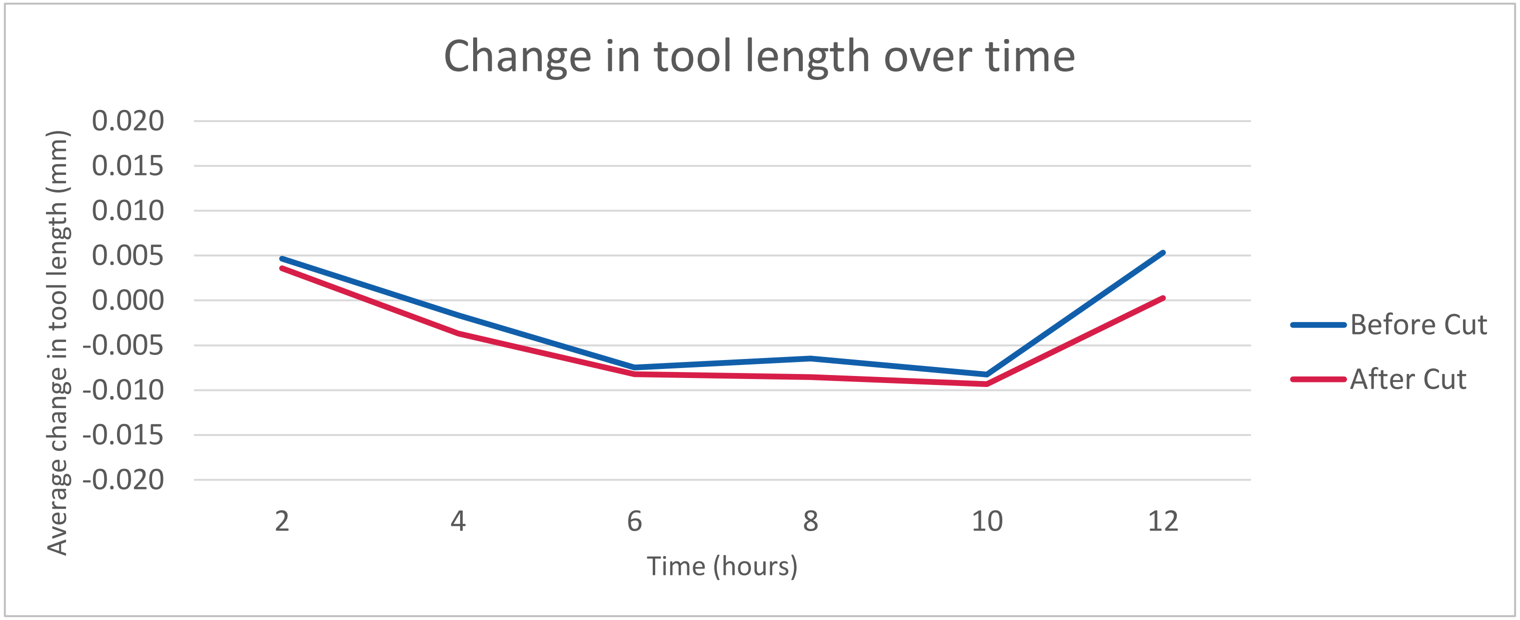
The image below shows where the maximum temperature reading was taken, highlighted by the red triangle. This is the location of the front bearing of the spindle. The image was extracted after the Spindle reached steady state operating temperature.



Results - Tool Length

Below is a graph showing the average change in tool length from the original measurement taken at the start of the test. Five measurements were taken before and after the programmed cut in order for an average to be calculated. The accuracy of the Blum Laser is ±2.5µm.

The maximum change was -9µm, taken after the cut at 10 hours. The gradual reduction over the test could be explained by tool wear due to dry cutting titanium. The small increase towards the end is due to built up cutting edge which was observed at the end of the test.



Conclusion

The results showed negligible change to the temperature and tool length over a 12 hour continuous run.

Observing the temperature data that was recorded for 4.5 hours, and the tool length measurements taken, there is no reason to believe that the steady state temperature would vary further beyond this time period.

For applications requiring very high dimensional accuracy, it could be recommended to carry out a warm up cycle of 10 minutes running of the Air Turbine Spindle before starting processing to ensure the spindle has reached a steady state operating temperature similar to the warm up cycle of a conventional machine tool spindle.

Where permissible, the use of coolant will further help control thermal expansion of the Air Tubine Spindle, cutting tool and workpiece.

Overall, this test gives confidence in thermal and dimensional stability running the Air Turbine Spindle for a long period of time.

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