The Repeatability and Working Volume Capabilities of the Pyramid Fixture in 5-Axis Machining.

TUS

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Aim of the Project

The Aim of this project is to validate the 5 axis capabilities of a pyramid fixture. The project will focus on the repeatability and working volume capabilities at each of the three faces.

Background

The pyramid fixture base was completed by previous students. It was then assembled with the addition of Schunk Pot and vises along with lifting handles.

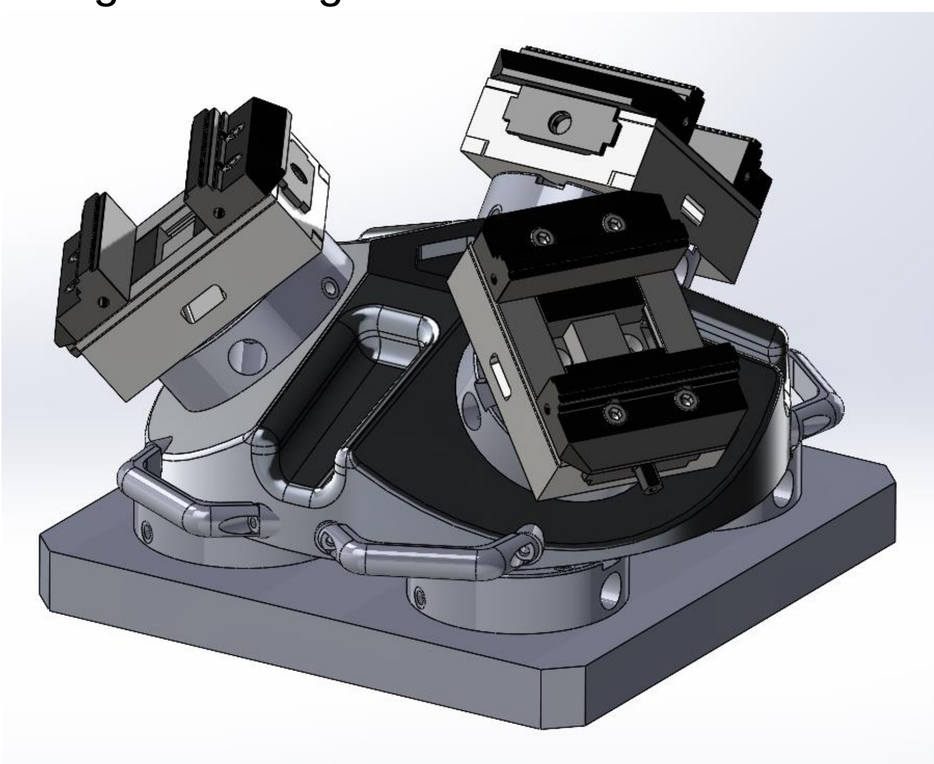

Figure 1: Pyramid Fixture

Manufacturing processes experience two types of variation: natural randomness (common cause) and unexpected disruptions (special cause). Common cause variation is unavoidable, while special cause needs correction.

Process variability is the total effect of both variations. Repeatability measures how consistently a process can be reproduced. High variability leads to low repeatability, and vice versa. To achieve high repeatability, manufacturers focus on reducing process variability.

Background

A 5-axis CNC machine's working envelope is its machining reach, defined by X, Y, Z axes and two rotary axes (B & C in the case of the Spinner) for tilting and rotating the table.

Table 1: Spinner CNC Specifications

Axis	Travel
X	620mm
Y	520mm
Z	420mm
B	360°
C	-90° /+110°

This allows machining complex shapes from various angles unlike 3-axis machines. The maximum travel distances of each axis and machine limitations determine the overall working volume.

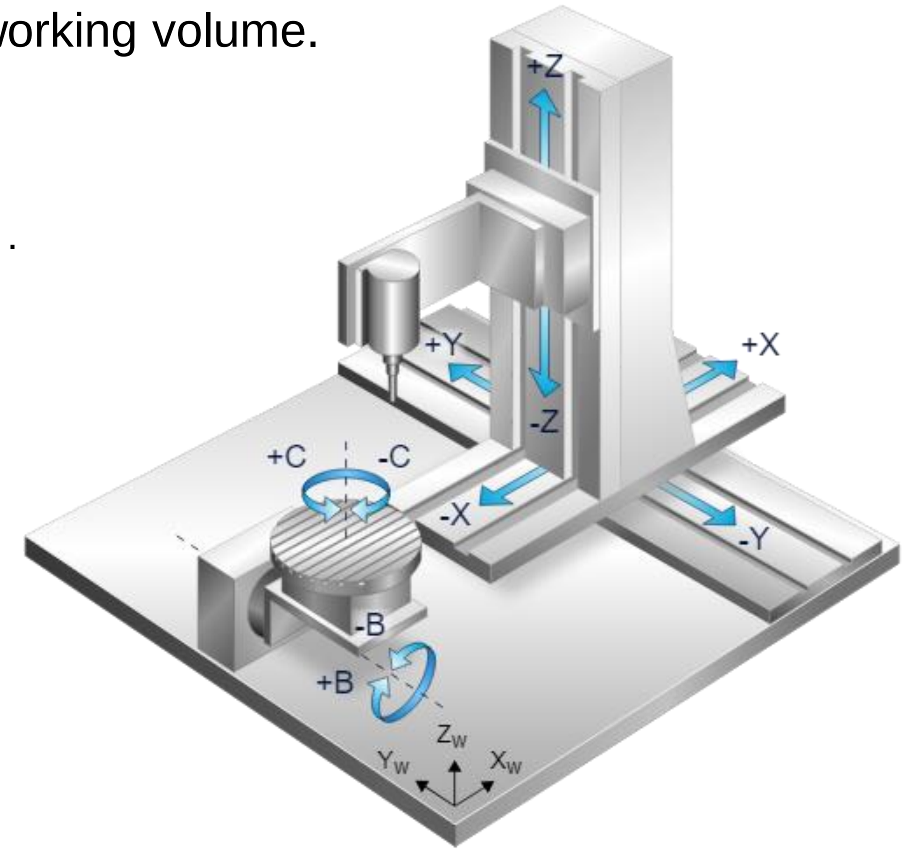

Figure 2: Spinner CNC Configuration

ISO 10791-7:2020 is a standard referred to in many research papers for evaluating the machining capability and repeatability of parts produced on a 5-axis machining center. This standard specifies the types of test pieces and their dimensional tolerances.

Test Piece Design

In designing the test piece, the focus was to create a part that would test the limits of the remaining tilt relative to the working faces of the fixture since the table needs to tilt to 40.5° to bring them perpendicular.

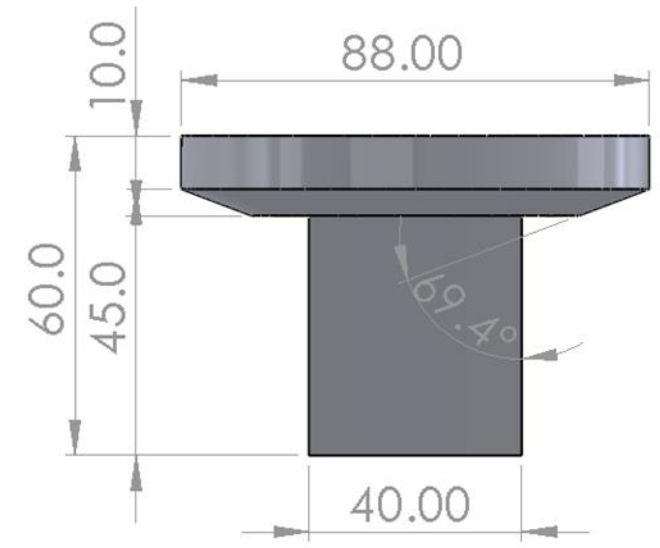

Figure 4: Final Design of Test Piece

After ten iterations for a test piece the final design shown in figure 4 was settled on. It's based on the cone frustrum design from the ISO standard with a chamfered edge of 69.4° from the z axis.

Conclusion

The machine simulation shows that the total working volume by tilt on each of the working faces of the pyramid fixture is 138.8° around z.

Due to persistent CAM software bugs and this ultimately leading to time constraints the machining and thereby the repeatability objectives were not completed.

References

- Cameron A. MacKenzie, X. L., 2020. Distinguishing between common cause variation and special cause variation in a manufacturing system: A simulation of decision making for different types of variation. International Journal of Production Economics, Volume 220.
- Gebhardt, M., Knapp, W. & Wegener, K., 2013. 5-Axis Test-Piece – Influence of Machining Position. ETH Zurich.
- International Standard, 2020. Test conditions for machining Part 7: Accuracy of finished test pieces, s.l.: ISO 10791-7:2020.

Simulation

A full multipart setup machine simulation is then done in SolidCAM to show the effectiveness of the test piece solution.

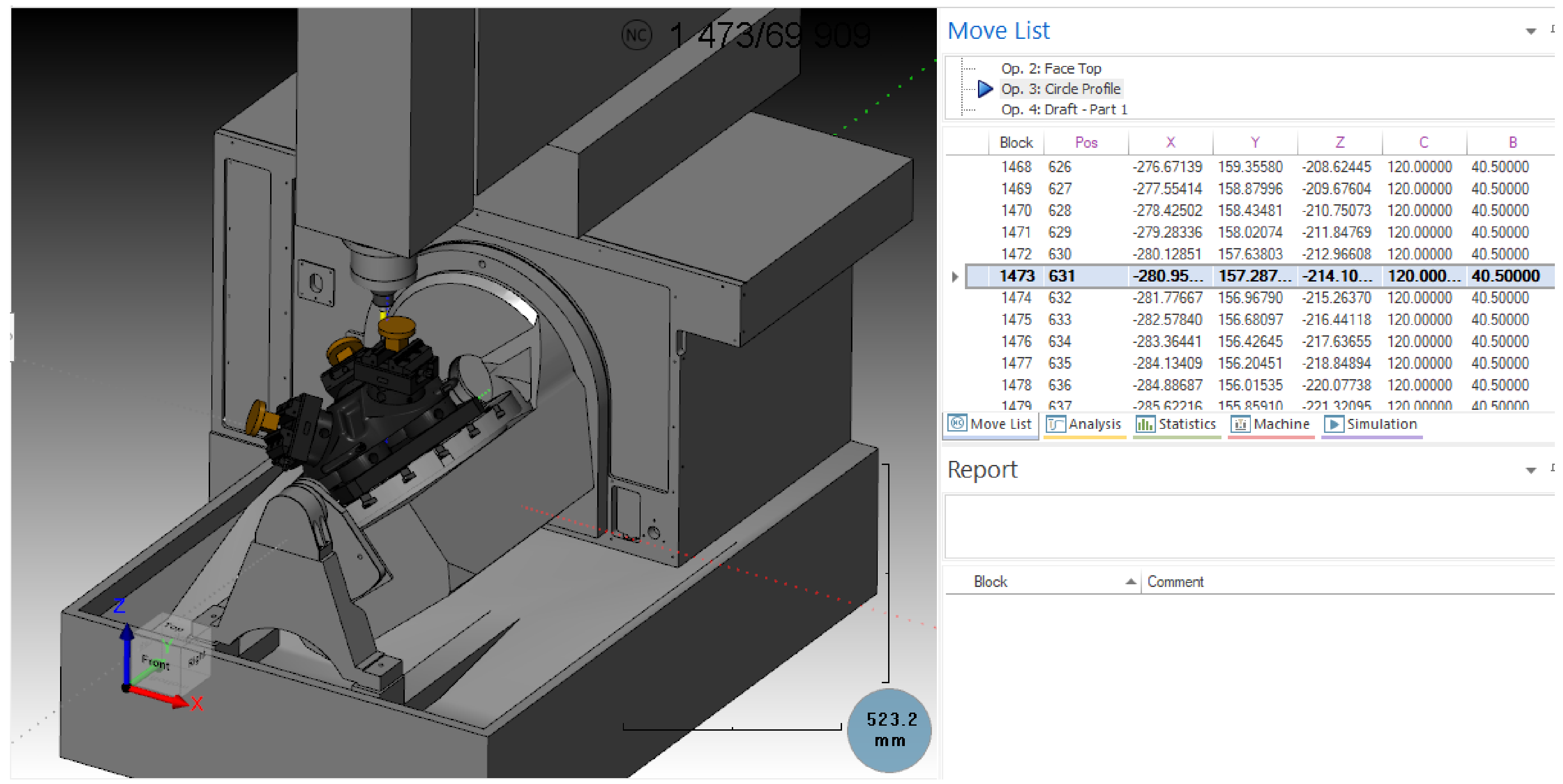

Figure 5: Machine Simulation