

Innovations and Industrial Technologies 2025

In-Process Measurement of Buttress Threads Using a Touch-Trigger Probe on a CNC Machine Tool

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ABSTRACT

This research investigates the accuracy and reproducibility of a novel measurement procedure for pitch diameter using a touch-trigger probe in a production environment. The study was conducted on a CNC machine with the strain gauge probe. Various thread types and machine tools were tested to assess the performance of the measurement system. The validation process involved comparing probe measurements with the three-wire method, known for its precision in pitch diameter evaluation. The analysis revealed that the accuracy of the developed procedure is satisfactory, with a repeatable error spread of ± 0.015 mm. The method was subjected to statistical analysis including the Shapiro-Wilk test, ANOVA, and Tukey HSD post hoc tests to determine the normality of error distribution and to identify significant differences between thread types and machines. The study highlighted that measurement accuracy is influenced by the thread angle and Z-axis positioning, with a notable impact on the results. The measurement uncertainty of the proposed method is slightly below 0.01 mm. The findings indicated that the method provides reliable measurements of the manufacturing tolerance range of ± 0.07 mm. The research underscores the importance of balancing measurement accuracy with operational efficiency and suggests that while automatic corrections based on this procedure may require slight adjustments, the overall performance is solid for production applications.

MATERIALS AND METHODS

- 4 types of BUTTRESS threads
- Pitch diameter: min. $\varnothing = 103,165$ mm – max. $\varnothing = 114,640$ mm
- Pitch diameter tolerance $\pm 0,07$ mm
- Flank angles: $3^\circ/30^\circ$, $7^\circ/45^\circ$
- 6 CNC Machines
- 1043 repetitions
- Strain gauge touch-trigger probe with stylus with ruby ball tip $\varnothing = 1$ mm

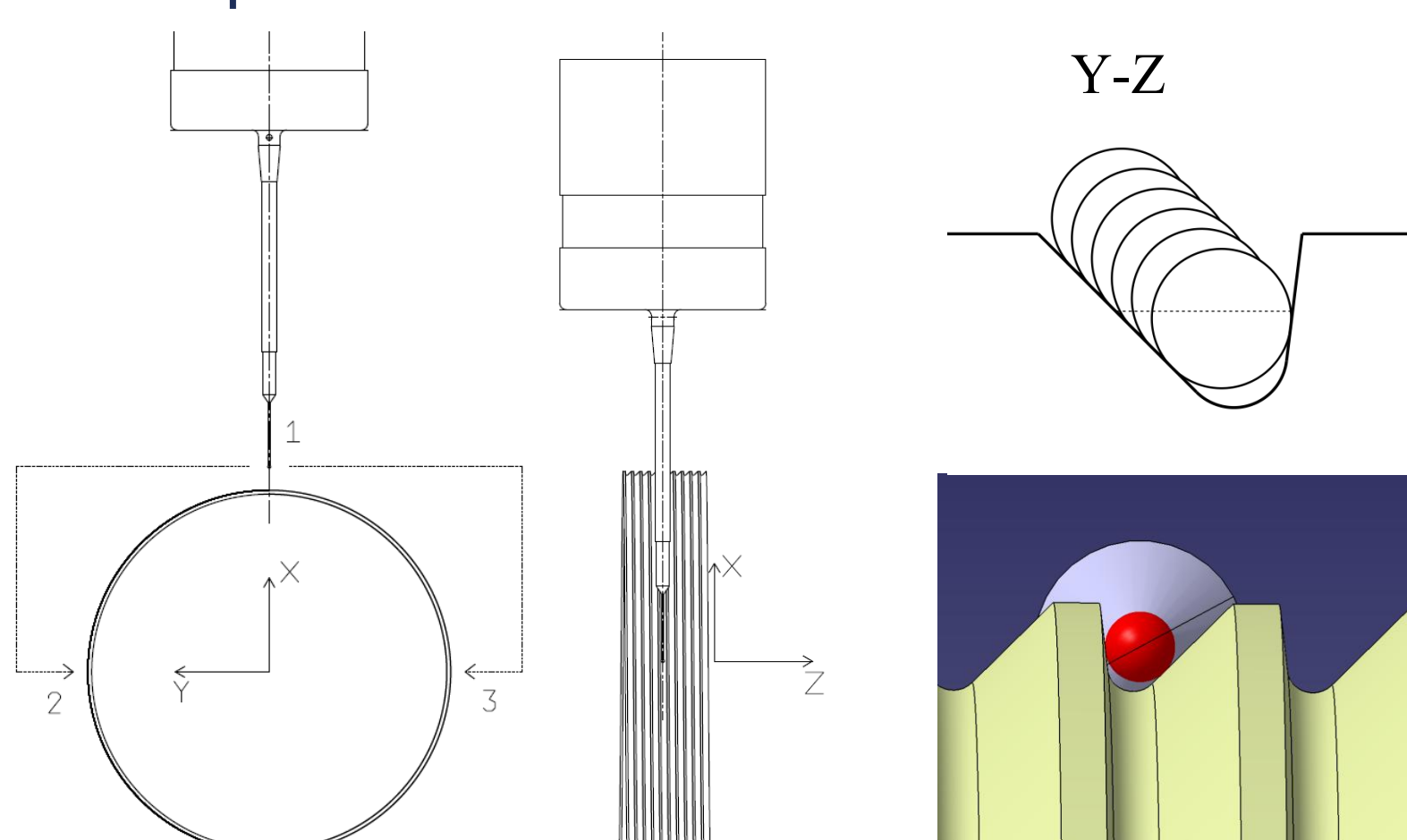


Fig 1. Measurement strategy with a description of CNC machine axis.

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CONCLUSIONS

- The developed measurement procedure using the strain gauge touch-trigger probe demonstrated satisfactory accuracy and repeatability, with an error not exceeding ± 0.015 mm — compared to three-wire measurement.
- The estimated measurement uncertainty of proposed method is below 0.01 mm.
- The thread flank angle significantly affects measurement accuracy—smaller angles lead to larger errors.
- The Z-axis positioning step has a notable impact; finer steps can improve accuracy but increase measurement time.
- Statistical analysis (ANOVA, Tukey HSD) confirmed the stability across different machines and thread types.
- The method enables effective real-time measurement and automatic correction during production.
- Results obtained with the probe show a linear correlation with the three-wires method.
- The procedure meets aerospace industry quality requirements, validated on over 1000 production parts.
- Implementation in production reduces human error and increases CNC machine utilization efficiency.

RESULTS

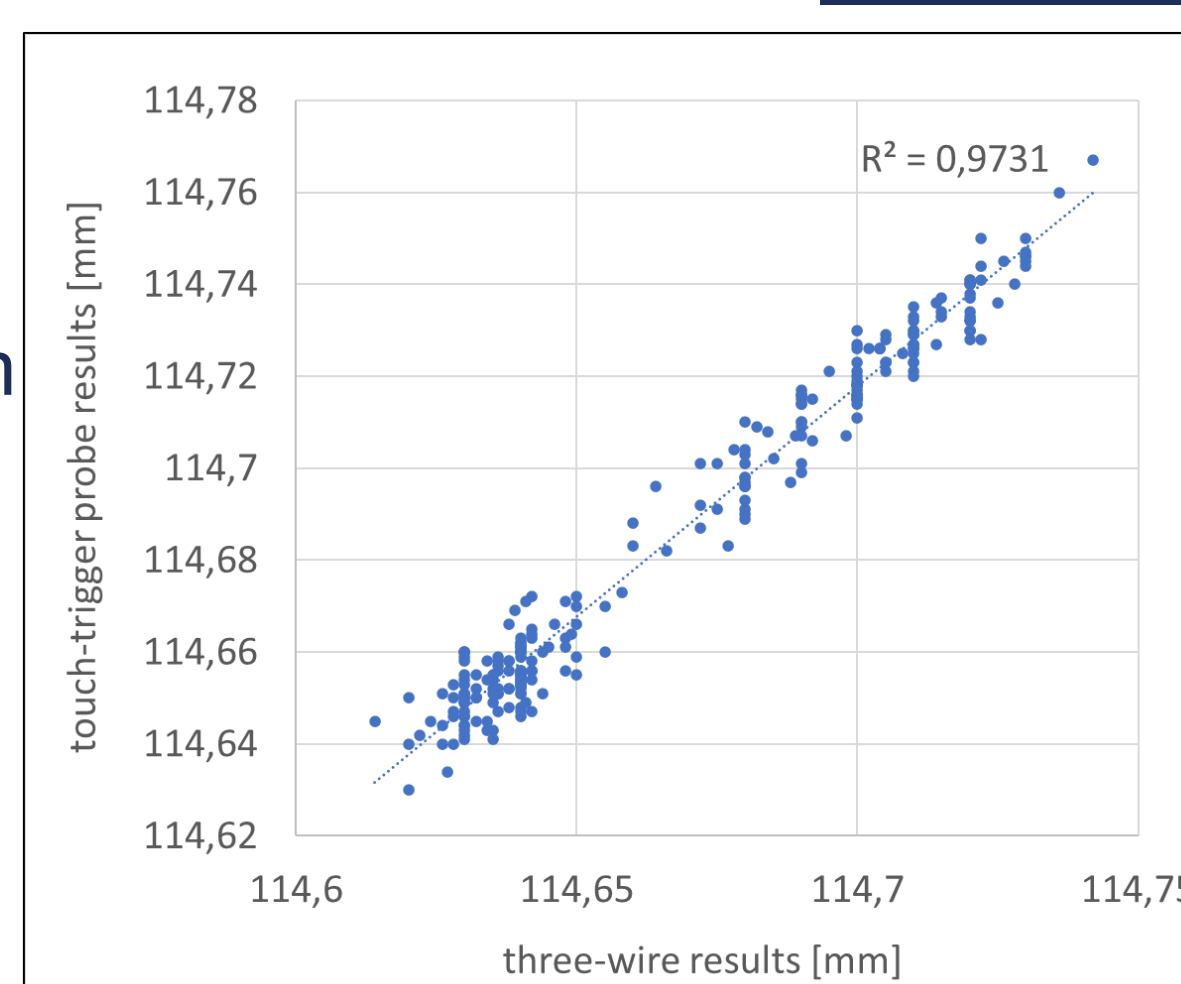


Fig 2. Correlation graph of the three-wire method with a probe for measuring the pitch diameter of THREAD1.

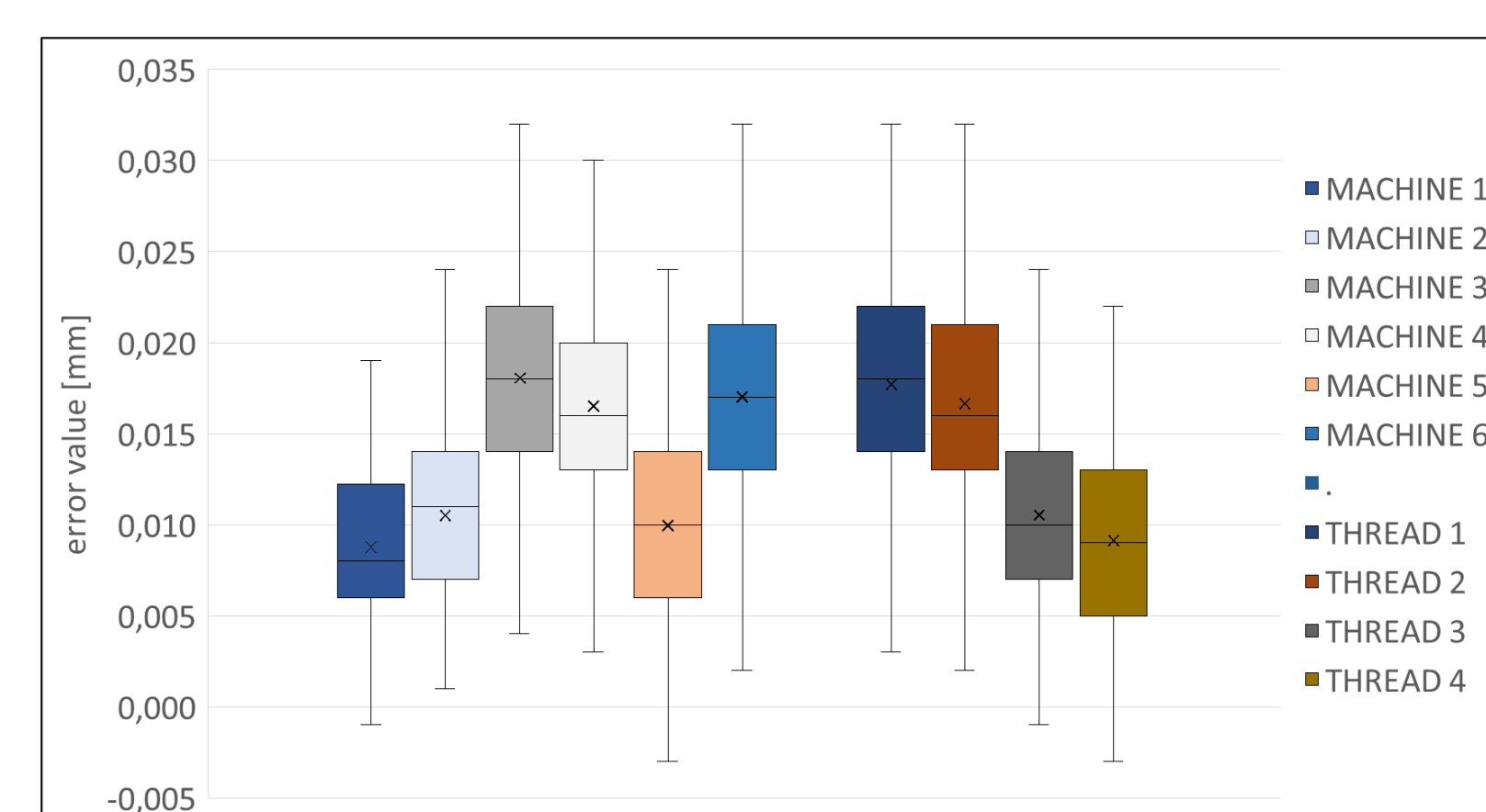


Fig 3. Graph of measurement errors obtained for individual machines and thread types.

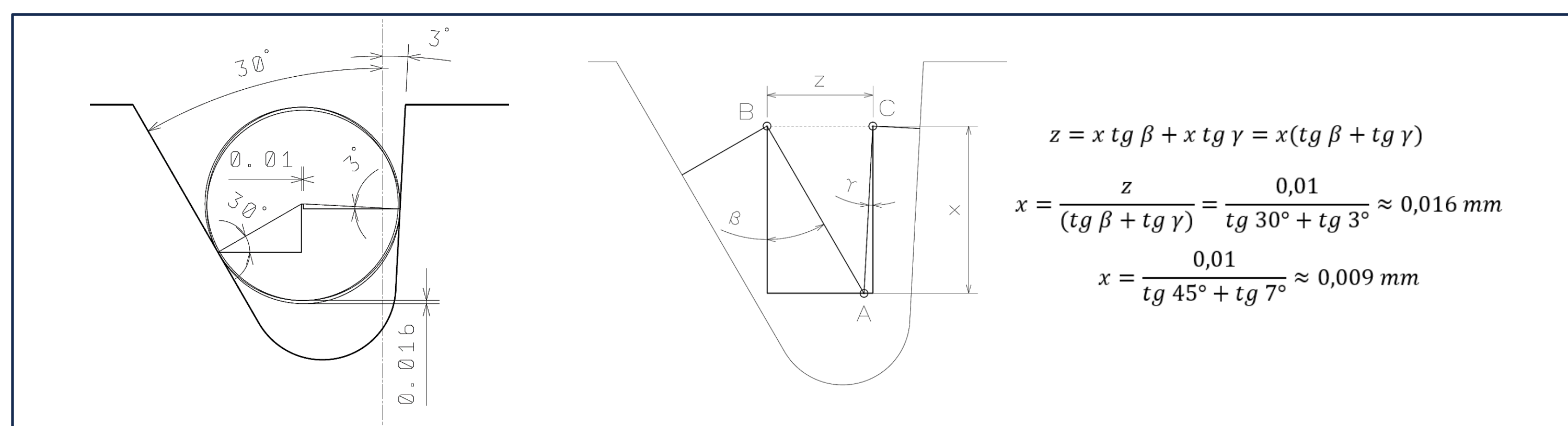


Fig 4. An auxiliary sketch for determining the overall error resulting from the "z" positioning accuracy.