Recent Development in the Body Diagonal Displacement Measurement and the Sequential Step Diagonal Displacement Measurement (or Laser Vector Technique)

For years, the *Body Diagonal Displacement Method* defined in the ASME B5.54 [1] or ISO 230-6 [2] standard has provided a quick check of volumetric error. It has been successfully used by companies as Boeing Aircraft Company and many others for years with good results. Since these measurements are relatively simple and quick to make, cost and machine downtime are minimized. However, the relationships between the body diagonal displacement errors and the 21 rigid body errors have not been made clear. Furthermore, the importance of angular errors has been mistakenly inflated and a few special examples in 2D and 3D are used to dispute the validity of the body diagonal displacement measurement [3].

Recently we have derived the relations between the 21 rigid body errors and the measured body diagonal displacement errors [4]. Based on these relations, it is clear that 1) In the body diagonal displacement measurement all of the 9 angular errors are cancelled except 1 roll and 1 pitch angular errors. Hence angular errors are negligible. 2) All of the linear errors, including 3 displacement errors, 6 straightness errors and 3 squareness errors are in the equations. And 3) Substituting the values in the special examples in 2D and 3D cited in [3] into the equations, it becomes obvious these are special cases and of no significance in most of the real machines.

Experimental verification has been performed on many CNC machining centers, in contrary to the statement in [5], all of the linear errors, including 3 displacement errors, 6 straightness errors and 3 squareness errors, have been reduced considerably by the 3D volumetric compensation obtained by the sequential step diagonal displacement measurement or vector technique.

It is concluded that the sequential step diagonal measurement is a valid measurement and its application in the 3D volumetric compensation in CNC machining centers will reduce the displacement, straightness and squareness errors and achieve higher 3D volumetric positioning accuracy,

References

[1] Methods for Performance Evaluation of Computer Numerically Controlled Machining Centers, *An American National Standard*, ASME B5.54-1992 by the American Society of Mechanical Engineers, p69, 1992.

[2] ISO 230-6: 2002 Test code for machine tools – Part 6: Determination of positioning accuracy on body and face diagonals (Diagonal displacement tests)", *an International Standard*, by International Standards Organization, 2002.

[3] Renishaw presentation entitled "Laser diagonal measurement", 10-Jan-2005.

[4] C. Wang, et al, 3D Volumetric Positioning Errors of CNC Machining Centers Theoretical Derivations and Laser Vector Measurement, in the Proceedings of the International Dimensional Workshop, Nashville, TN, May 9-13, 2005.

[5] Renishaw presentation entitled "Laser step diagonal test", 10-Jan-2005.