AEROTECH

Top 3 Ways to Increase Your Positioning System's 3D Accuracy

By: RJ Hardt, President of Peak Metrology

Positioning systems are used to automate almost every high-precision manufacturing process. Many of these processes occur in 3D. Some examples include positioning a part's surface in 3D to be 100% inspected and laser cutting a feature along a complex 3D path. For these types of processes, it's exponentially harder to achieve manufacturing tolerances in terms of microns and nanometers due to the additional errors that positioning systems exhibit within a 3D space. However, when speaking in terms of spatial positioning accuracy, or 3D accuracy, there are some fundamental considerations that can be taken to increase a machine designer's chances of successfully meeting tolerance goals.

1: Add More Stiffness – A Mechanical Engineer's Best Friend

Stiffness is to a positioning system as sleep is to a new parent. There are ways to compensate for the lack of it, but the job becomes much harder without it. Adding stiffness to a mechanical design will increase the motion repeatability which in turn makes achieving high 3D accuracies much easier. As the term implies, non-repeatable motion is motion that cannot be predicted and compensated by software calibrations and correction tables (see #3).

Furthermore, there are many directions in which stiffness needs to be improved in order to achieve high 3D accuracy goals. There are error motions in 6 Degrees Of Freedom (D.O.F) for EACH motion axis you add to a positioning platform. What if your process requires 6 motion axes? Well, now you now have 6 D.O.F times 6 axes, or 36 sources of error to worry about! Adding more stiffness can reduce the 5 sources of spatial positioning error shown below.

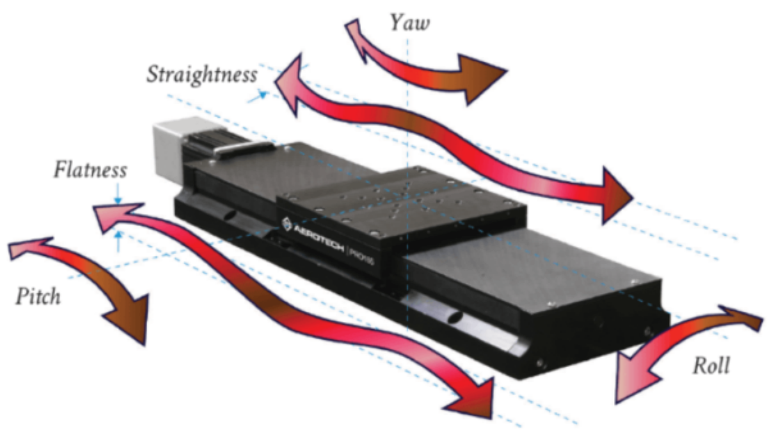

Figure 1. *Showing 5 of the 6 potential sources of error on a single linear axis of motion. The 6th error is the "on-axis repeatability" or the accuracy of the feedback device used to measure the position of the axis itself.*

2: Add Feedback at the Work Point – Accurate Information Where We Need It

Another way to successfully increase your positioning system's 3D accuracy is to incorporate feedback mechanisms that reduce the amount of abbe error. Reducing abbe error is as easy as reducing the distance between the positioning mechanic's feedback device and the working point in space that you are using for your process. For example, say you have an XY positioning system carrying a part, and say that you care what happens to that part at a point in space that is 100mm above the XY positioning system. Adding a second feedback source that is 100mm above the XY mechanics will provide valuable information to the motion axes and allow them to compensate for abbe errors that may be present.

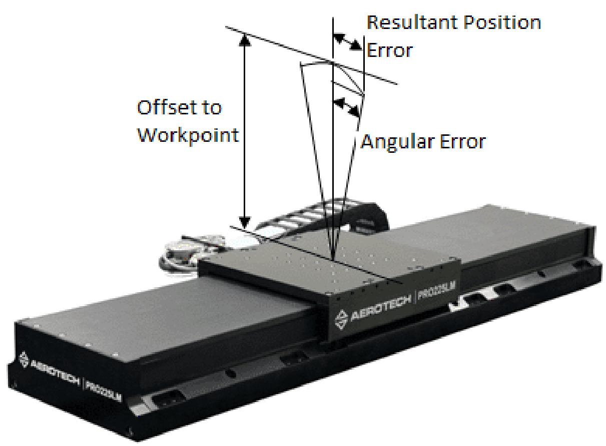

Figure 2. *A graphical representation of abbe error at a work point offset.*

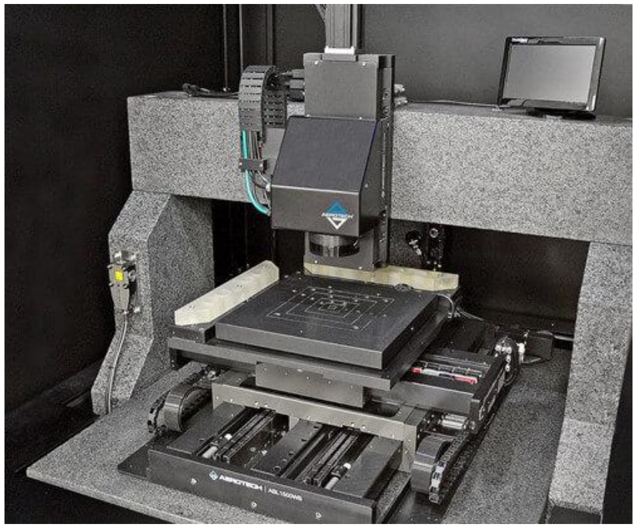

Figure 3. *An XY positioning system using interferometer feedback at the working plane to minimize abbe error influences at the work point.*

3: Using Calibration and Correction Tables – The Useful Last Resort

When all else fails we can try to correct for 3D positioning errors by using calibration techniques and correction tables. These methods are counted on by many designers to correct for inherently limiting mechanics and drive mechanisms. In practice, a high-resolution measurement device would be used to measure the actual position of a motion axis as it is commanded through travel. The difference between the actual measurement and the commanded measurement is calculated and added to a correction file. Now, the next time the axis is commanded to move the same distance it will correct itself based on the actual measurement that was taken by the external measurement device. Calibration is an offline process and only works on repeatable errors.

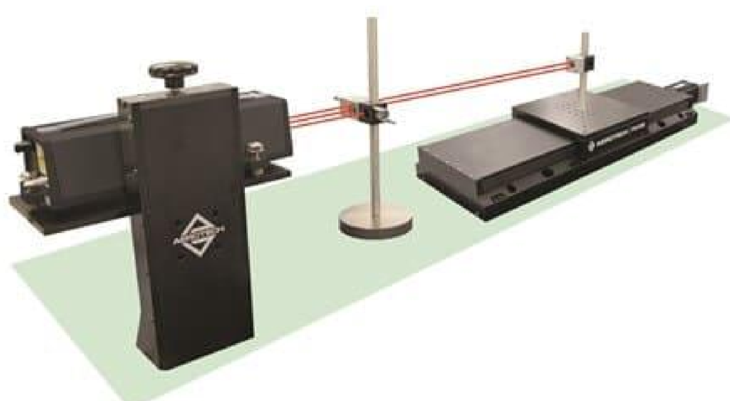

Figure 3. *Showing a linear axis of motion being calibrated by a laser interferometer at a specified working height.*

Conclusion

Now that you are aware of these three ways to improve 3D accuracy the next conversation you have with a motion control and positioning vendor will be more meaningful. Make sure you understand the consequences of choosing mechanical designs that aren't stiff, specifying equipment without a second source of feedback, and using a positioning system that is not calibrated at the work point you care about. If you need any further assistance to achieve better 3D positioning accuracies within your process we are here to help.

About the Author

RJ Hardt is the President of Peak Metrology, an Aerotech company focused on surface metrology equipment. He has over a decade of experience working directly with customers implementing motion control and automation technologies