Reducing control delay times to enhance dynamic stiffness of magnetic bearings

B. Denkena[1,2], B. Bergmann[1], J.-P. Schmidtmann[1,2]

[1] Institute of Production Engineering and Machine Tools (IFW), Hannover University, Garbsen, Germany

[2]Cluster of Excellence PhoenixD (Photonics, Optics, and Engineering–Innovation Across Disciplines), Gottfried Wilhelm Leibniz Universität Hannover, Hannover, Germany

schmidtmann@ifw.uni-hannover.de

Abstract

The research vision of the cluster of excellence "Photonics Optics Engineering – Innovation Across Disciplines" (PhoenixD) is to provide solutions for resource- and cost-effective manufacturing of high precision optical systems. This is achieved by combining established and newly developed additive manufacturing processes. In all process steps, the workpiece has to be actuated and aligned in respect to the individual process module. Currently this is done by combining a long stroke actuator for feed movement and a short stroke actuator for precise alignment. In PhoenixD, a novel linear actuator is developed that can be used within multiple process steps. The actuator provides the main feed movement, transportation between single process steps and inline alignment of the workpiece during the processes. Active magnetic bearings are used for the linear actuator guidance. Magnetic bearings have several advantages in comparison to roller bearings, hydrostatic and aerostatic bearings. Due to the absence of friction, magnetic bearings provide high precision. They also enable a spatial fine positioning ability so that separate fine positioning stages are unnecessary. Furthermore, stiffness and damping can be adapted in the process. However, the dynamic stiffness of magnetic bearings is limited due to time delays between the spatial deflection of the carriage by a disturbance force and the bearing's corresponding reaction to restore the spatial alignment. The time delay is caused by the position and current control systems, analog-to-digital conversion, bus communication and the switching frequency of the DC current controller. Therefore, in this work, measures to reduce delay times are identified first. An experimental setup consisting of one electromagnet, a fast DC current controller and a real-time prototyping system is introduced. Using the setup, relevant parameters to achieve low delay times are identified and achievable delay times are measured. The results and potential for stiffness enhancements of magnetic bearings are then discussed with regard to the actuator for optics manufacturing in PhoenixD.