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Straightness error modeling and compensation for gantry type open hydrostatic guideways in grinding machine

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Abstract:

This study presents an approach to model and compensate the vertical straightness error of gantry type open hydrostatic guideways. The straightness error is measured at different measurement points on the beam using a laser interferometer. To investigate different trends in the straightness error, a static analysis model is established, based on the error averaging effect considering the guiderail profile error. The linear deviation of the slider is computed and the vertical straightness error is calculated using a least-square method. The simulation results indicate that the measurement points have a big impact on the straightness error. The minimum value appeared when measurement point located at the middle of the X beam. And more closer to Y guide rails, higher value will be. The positions of the measurement points are chosen according to the change trend of the vertical straightness error. Finally, vertical straightness error is compensated and the compensation results are compared between different coordinate values. Experimental results show that the straightness error model and error compensation strategy help to effectively improve the accuracy of gantry type open hydrostatic guideways in grinding machines.

Keywords: straightness error, error compensation, open hydrostatic guideways, error averaging

1. Introduction

Due to the increasing demand of machine tools, the research of key units with high accuracy becomes one of the critical issues in the field of CNC high-precision machining. The straightness errors in the machine tools are one of the important factors that directly influence the accuracy of the machined components. Currently, there are mainly two types of guide systems applied in grinding machines: rolling and hydrostatic or aerostatic guideways. The straightness error of rolling guideways can up to a high precision level, but their accuracy cannot be preserved for long due to the wear of the guiderails under long-time working conditions [1]. While aerostatic guideways do not suffer from this problem, their stiffness is limited due to the compressibility of gas [2], and hence their application in precision machine tools is restricted. Hydrostatic guideways overcome both of these problems and can maintain a high accuracy of motion because of very low friction. This is a major reason why hydrostatic guideways are widely applied in ultra-precision machine tools and coordinate measuring machines [3-6]. The straightness error of these machines directly influence the accuracy of the machined or measured parts [7]. So, methods improving the straightness error have become increasingly important. The approaches to improve the motion accuracy of hydrostatic guideways be classified into two categories: (1) improve the