

Application of Vibration Wire Measurement Technology in Pre-alignment Unit of HEPS Storage Ring

The High Energy Photon Source (HEPS), a major national science and technology infrastructure project during the 13th Five-Year Plan period, will become one of the brightest fourth-generation synchrotron radiation sources in the world upon completion. As the core component of HEPS, the alignment precision of the pre-alignment units in the storage ring is critical for ensuring long-term stable beam operation. The storage ring consists of 48 periods with 288 pre-alignment standard units, including the three-magnet units, five-magnet units, and eight-magnet units, and the pre-alignment accuracy requirement of 0.03 mm between magnets. To verify whether the pre-alignment accuracy of the magnetic centers of the magnets meets the physical design requirements, this paper selected one three-magnet unit and one five-magnet unit from the HEPS storage ring and employed the vibrating wire technique to measure the magnetic center. The paper elaborates on the vibrating wire method for measuring the magnetic centers of quadrupole magnets and the magnetic center scanning process. Addressing the limitations of traditional vibrating wire sag correction, a laser measurement method for wire sag was proposed. A calibration measurement system using laser displacement sensor was established to directly measure wire sag at each magnet gap, enabling precise fitting sag of the wire. Experimental results demonstrate that the three-dimensional magnetic center coordinate deviations obtained from vibrating wire scanning are better than 0.01 mm for the three-magnet unit and 0.015 mm for the five-magnet unit, both meeting the HEPS storage ring's experimental pre-alignment precision requirement of 0.03 mm. This research validates the effectiveness of the laser displacement sensor system for wire sag correction and provides valuable reference for high-precision magnetic center measurements in other large-scale scientific facilities.

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Session Classification: Poster

Track Classification: Accelerator: 02: Accelerator technology