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Development of a circular flexure bender for a long, elliptically bent X-ray mirror

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Mechanical benders are classical instruments for shaping X-ray mirror surfaces with high precision. A circular flexure bender has been developed at SSRF (Shanghai Synchrotron Radiation Facility) for a 1200 mm-long hard X-ray mirror with an effective optical length of 1000 mm. Elliptical bending in the tangential direction is achieved using two actuators equipped with high-precision force sensors, transmitting torque through circular flexure hinges at both ends of the mirror. The mirror is oriented to reflect vertically and faces upward, requiring consideration of gravitational deformation. Slope profilometry measurements using a Long Trace Profiler (LTP) indicate a total slope error of 0.45 µrad (RMS), with mechanical error compensating gravity limited to less than 0.1 µrad. A liquid-metal-bath water cooling method is integrated to manage thermal loads. Finite element analysis (FEA) is conducted to evaluate thermally induced deformation, calculated at 0.2 µrad (RMS), and to optimize the flexure hinge design. The developed system provides stable, high-precision elliptical bending for long X-ray mirrors and is well adapted for advanced synchrotron radiation beamlines.

Footnotes

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