Mechanical Design of Secondary Source Slits for Hard X-ray Beamlines at Taiwan Photon Source

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MECHANICAL ENGINEERING DESIGN OF SYNCHROTRON RADIATION EQUIPMENT AND INSTRUMENTATION

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Abstract

The secondary source slits have been developed for specific hard X-ray beamlines at Taiwan Photon Source. Especially for Coherent X-ray Scattering and X-ray Nanoprobe beamlines, severe specifications of the slits are more necessary to define proper beam sizes in horizontal and vertical directions at sample. The opening size of each pair of slits assembled orthogonally is usually needed to range within several microns, so the UHV-compatible piezo-driven stages with closed-loop system were adopted for the purposes of fine adjustment, precise positional accuracy and repeatability. To reduce X-ray scattering effect, the rectangular single-crystal film was bonded on the edge of the slit blade. The machined rotary weak-link structure and piezo-driven actuators were used to slightly adjust parallelism of each pair of the blades with the method of single-slit diffraction. To enhance structural and thermal stability, the granite plinths with specified shape were designed and the precise temperature controlling system will be set up recently. The overall design, mechanical specifications and procedure of testing for secondary source slits will be introduced in this paper.

I. Design of secondary source slits

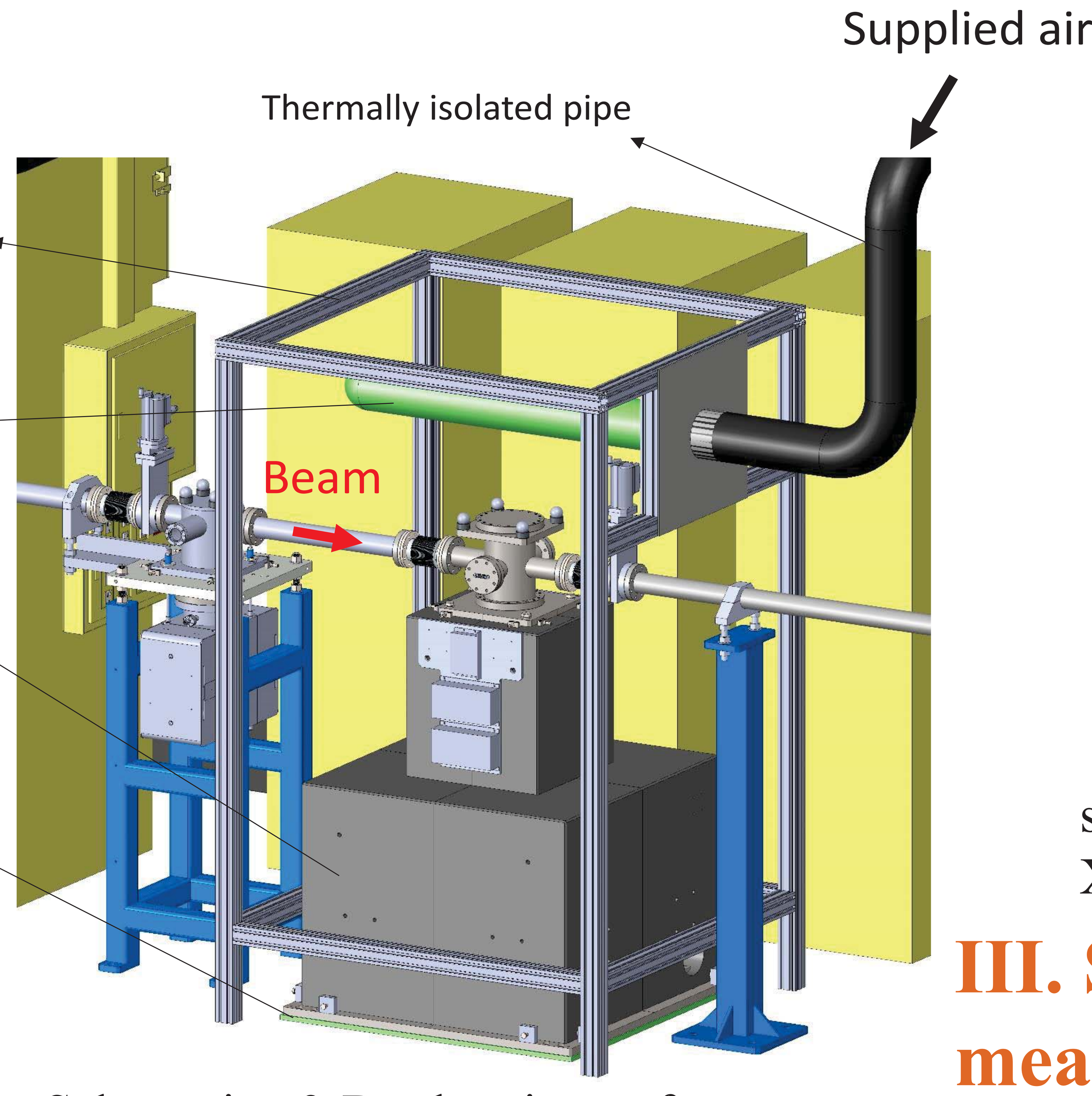

Figure 1: Schematic 3-D drawing of secondary source slits.

Figure 2: On-site view of secondary source slits installed in the Coherent X-ray Scattering beamline at TPS.

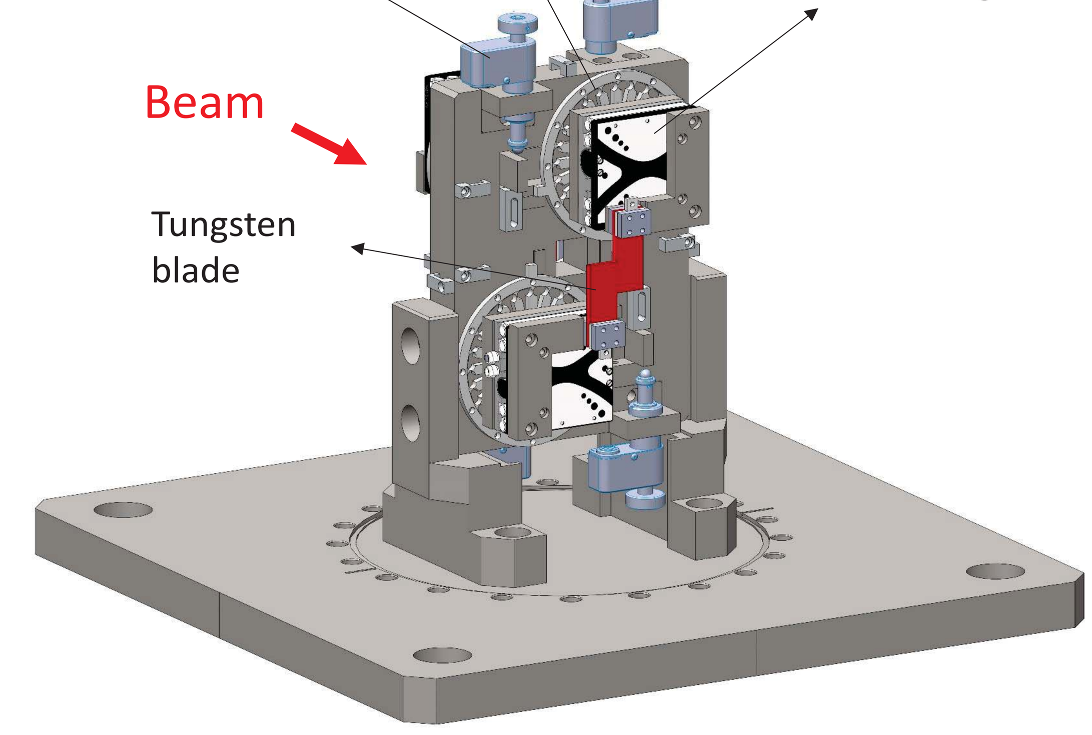

Figure 3: A 3-D model of main mechanism for secondary source slits.

II. Finite-element analysis

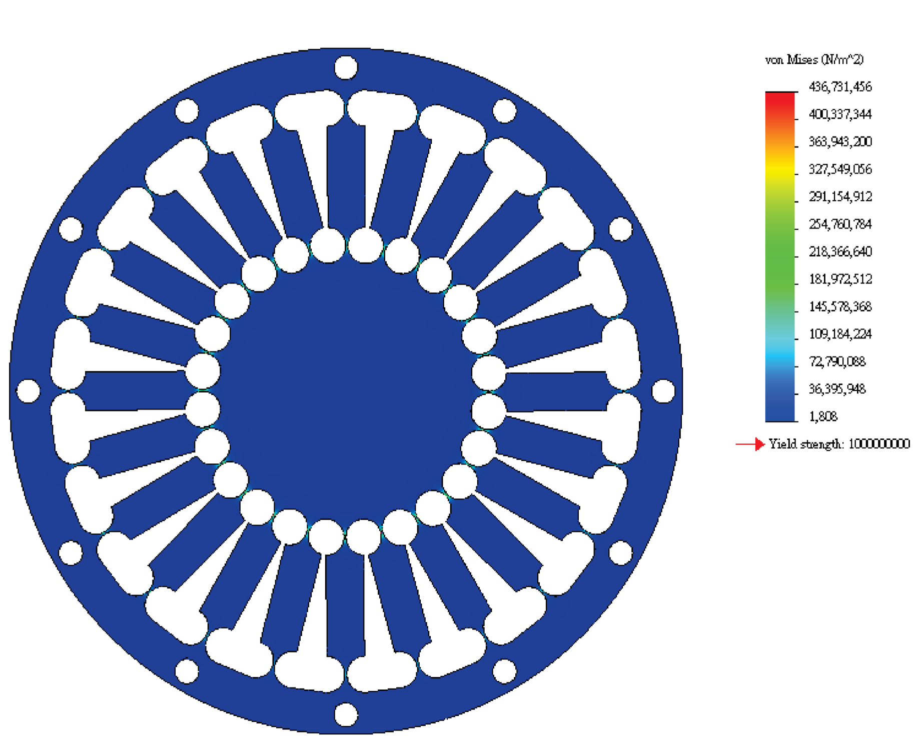

Figure 4: Result of finite-element analysis for rotary weak-link mechanism.

III. Single-slit diffraction and measurement of parallelism

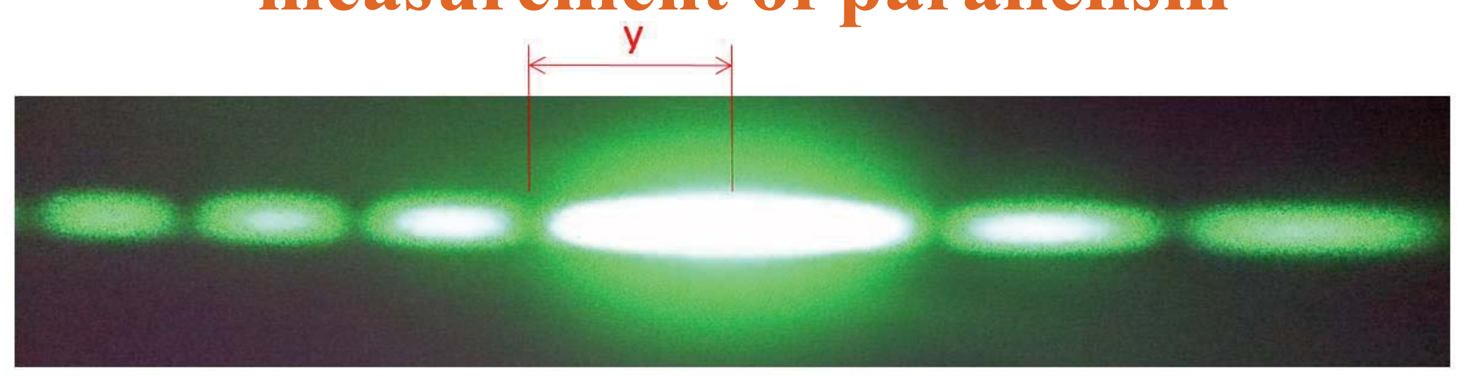

Figure 5: Diffraction pattern observed in the test of parallelism for horizontal slit.

Equation of Fraunhofer single-slit: $y = \frac{m\lambda D}{a}$

y: Displacement from centreline for minimum intensity
m: *Order*
λ: Wavelength of light
a: Width of slit

Table 1: The overall specifications of secondary source slits

Item	Specification
Vacuum	$\leq 10^{-9}$ mbar
Helium leak rate	$\leq 5\times10^{-10}$ mbar·l/s
Material	Tungsten carbide (Type WF20: 86.4% WC, 11.5% Co, 2.1% Others) GaAs single crystal
Maximum opening size	13 mm (H) × 13 mm (V)
Position resolution	≤ 0.006 μm
Position repeatability	≤ 0.018 μm
Positional accuracy	≤ 0.2 μm
Parallelism between blades	≤ 1 μm
Range of rotary adjustment	± 0.21 degree

IV. Precise temperature controlling system

Figure 6: A compact-type air handling unit for precise temperature controlling system.

Conclusion

The system of mono beam secondary source slits has been designed, fabricated, tested, and installed on the Coherent X-ray Scattering beamline at TPS. UHV-compatible piezo-driven actuators were used to control opening sizes in horizontal and vertical directions and adjustment of parallelism between two blades on each pair of slits respectively. A set of testing procedure based on Single-Slit Diffraction was realized to measure the parallelism between blades, and the design value of parallelism was reached successfully. To reduce the influence of ambient temperature, the precise temperature controlling system will be applied to provide air with constant temperature for enclosed system of secondary source slits. On-site test will be made to acquire more results during the beam time of TPS. According to the results, upgrade will be considered to reach better performance for system of secondary source slits in the future.

Reference

[1] D. Shu *et al.*, “Development and applications of a two-dimensional tip-tilting stage system with nanoradian-level positioning resolution”, *Nucl. Instr. And Meth. A*, vol. 649, pp. 114-117, 2011.