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ASSEMBLY PROCESS AND INSPECTION RESULTS FOR W100

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Abstract

The 100 mm periodic permanent magnet wiggler (W100) was installed in the 31st straight section of the TPS storage ring in September 2020, during a prolonged shutdown of the TPS. It provides photon energy ranging from 5 to 50 keV for user experimental applications. The mechanical structure of W100 requires assembly and connection of the upper and lower magnetic arrays, each approximately 500 mm in length. Precise control of the gap between the magnetic arrays and accurate adjustments are required. This report primarily describes the assembly process of various components of W100 and the inspection items along with the results.

INTRODUCTION

The Taiwan Photon Source (TPS) is an advanced 3 GeV photon source facility operating at the National Synchrotron Radiation Research Center (NSRRC). One of the insertion devices (IDs) in Phase-II, the 100 mm periodic permanent magnet wiggler (W100), was installed in the 31st straight section of the TPS storage ring in September 2020. It provides photon energy ranging from 5 to 50 keV for user experimental applications. The mechanical structure of W100 requires assembly and connection of the upper and lower magnetic arrays, each approximately 500mm in length (as shown in Fig. 1 [1]), allowing precise control of the gap between the magnetic arrays and accurate adjustments.

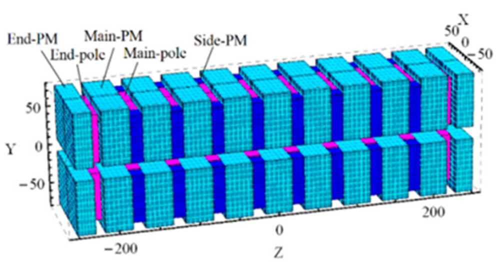

Figure 1: Magnetic arrays of the W100 [1].

The mechanical components of W100 can be divided into five main parts [2], as shown in Figure 2:

1. Frame base
2. Frame
3. Cross beam
4. Motor drive and safety protection device
5. Positioning and levelling adjustment device

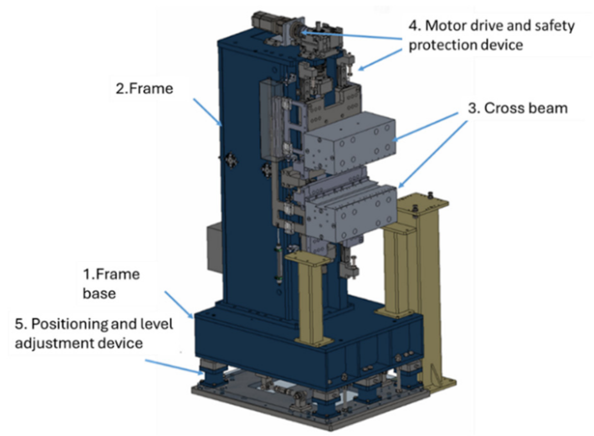

Figure 2: Mechanical components of the W100.

We control servo motors to drive ball screws, achieving the opening and closing of the upper and lower magnetic array cross beams. The main mechanical specifications of W100 are shown in Table 1. This paper describes the assembly steps of each component of W100 and the results of the inspections, serving as a reference for the subsequent development of other insertion devices.

Table 1: W100 Specifications

W100 Specifications	
The minimum gap in the Y direction (mingap)	14 mm
The maximum gap in the Y direction (maxgap)	≥ 150 mm
The precision of gap positioning (with closed-loop control)	14±0.005mm
The resolution of gap position reading	< 1.0 µm
The time-varying error in gap position fluctuations (fluctuation at a gap with motor off)	< 2.0 µm
The maximum gap variation within the entire length range of the magnet under magnetic conditions (for mingap ≤ gap ≤ maxgap)	± 25 µm
The flatness of upper and lower beams within the entire length range of the magnet (for mingap and maxgap)	≤ 0.02 mm
The gap between the upper and lower beams along the X and Z axes varies within the entire length range of the magnet (for gap= mingap)	≤ 0.025 mm

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ASSEMBLY PROCESS

After all components of W100 are prepared, we first inspect their accuracy to ensure they meet specifications before proceeding with assembly. The following is a step-by-step assembly process for each component of W100:

1. The frame is flipped and laid flat on the levelling feet, then adjusted for horizontal alignment.
2. The linear guide rail is bolted onto the frame and tightened. Optical collimators and gauges are then used to check the straightness and parallelism after installation.
3. The ball screw is installed on the support units and adjusted to ensure uniform height and parallelism with the guide rail, as shown in Fig. 3.
4. The ball screw housing is mounted on the screw nut, and shim pads are used to ensure that the ball screw housing mating surface is flush with the guide rail slider.

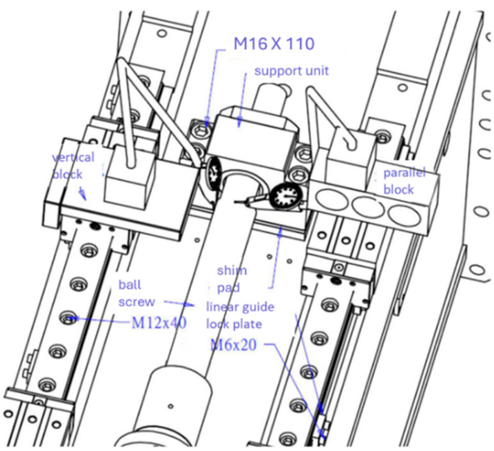

Figure 3: Installation of the ball screw and housing.

5. The upper backplate is installed on the slider, and the side keys are adjusted to be perpendicular to the direction of slider movement, as shown in Fig. 4.

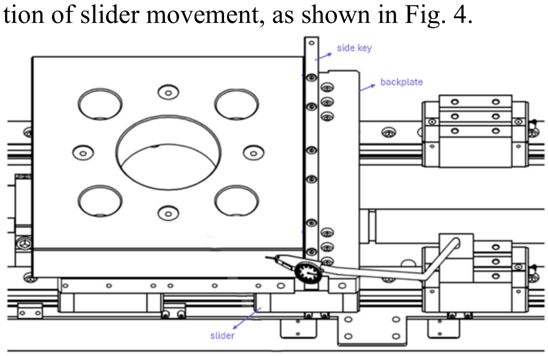

Figure 4: Installation of the backplate.

6. The lower backplate is installed on the slider, and the side keys are adjusted to be parallel to those on the upper backplate.
7. Upper and lower cross beams are installed on the backplate, ensuring that the mating surfaces of the two sets of cross beams are parallel according to the specifications.
8. The glass scale body and read head mounting bracket are installed on the backplate and adjusted to ensure that the glass scale motion is parallel to the guide rail, as shown in Fig. 5.

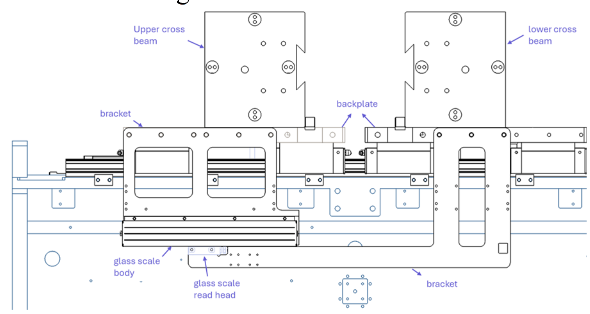

Figure 5: Installation of the glass scale mounting brackets.

9. Upper and lower T-shaped stop blocks and stop screws are installed on the frame and backplate.
10. O-shaped and 8-shaped mounting plates are installed on the backplate.
11. The micrometers are installed on the fixed plate, and the limit switches are mounted on the bracket and locked onto the frame.
12. The potentiometer is installed on the frame and adjusted to be parallel to the guide rail.
13. The reducer is installed on the frame, and a coupling is used to connect the reducer to the ball screw.
14. The servo motor is installed on the frame, and a torque limiter is used to connect the reducer to the servo motor, as shown in Fig. 6.

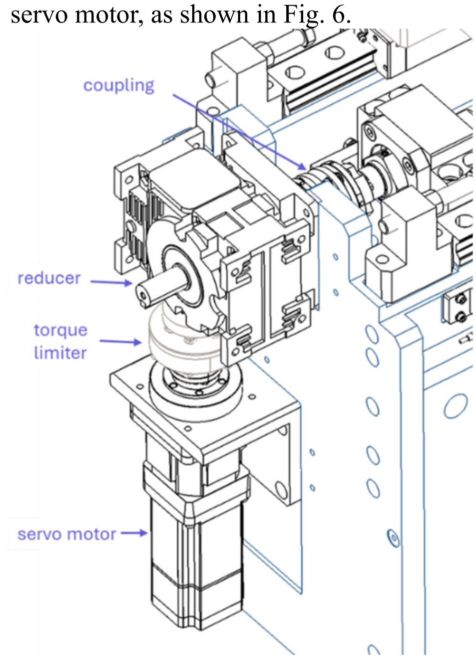

Figure 6: Installation of the servo motor and the torque limiter.

15. Block stoppers for the ball screw housing, reducer and servo motor are installed on the frame.
16. Join the upper baseplate with the lower baseplate and lock them onto the wedge base, wedge, and Pilloballs mounting bracket, as shown in Fig. 7.

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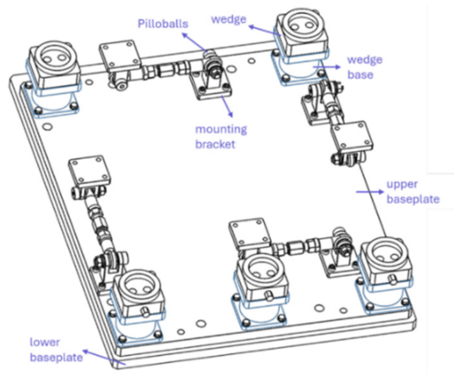

Figure 7: Assembly of the baseplates.

17. The frame base is installed on the wedge and adjusted horizontally, then the Pilloballs and mounting brackets are installed and tightened.
18. After flipping the frame upright, it is installed on the frame base and secured.
19. After powering the servo motor, a trial run is conducted to confirm there are no abnormalities or abnormal sounds.
20. The parallelism of the upper and lower cross beams during operation is measured to confirm compliance with the specifications.
21. Adjustment of the open and closed limit switch positions and adjustment of the stop screw height.
22. The fiducial markers for alignment are installed on the frame and the stop blocks are attached, as shown in Fig. 8.

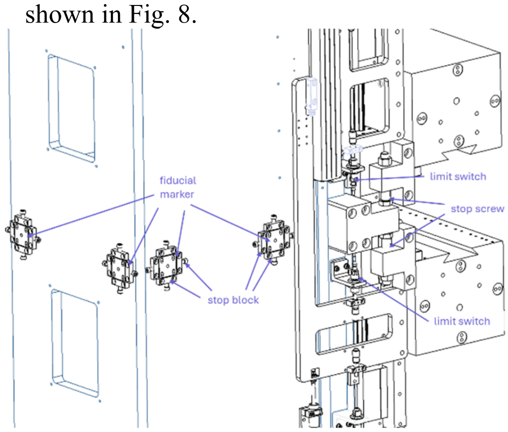

Figure 8: Alignment of the fiducial markers.

23. Installation of the frame back hole cover, glass scale guard cover, and limit switch micrometer guard cover.
24. Final appearance inspection and touch-up painting.
25. The magnetic arrays are installed on the upper and lower cross beams.

INSPECTION RESULTS

After the assembly of W100, we inspected the parallelism of the upper and lower cross beams, the angular variation of the cross beams during the opening and closing process, and the straightness of the upper and lower cross beams with respect to the side keys. The measurement instruments and inspection results are presented in Table 2. These inspection results all meet the mechanical specifications.

Table 2: Inspection Results of The W100

Inspection items	Inspection instruments	Specifications	Results
The parallelism of the upper and lower cross beams	Mitutoyo indicators	≦25μm	upper cross beam:7μm lower cross beam:7μm
The angular variation during opening and closing process	Agilent 5529A Dynamic Calibrator	≦25μm (pitch) ≦12μm (roll)	≦1μm (pitch) ≦1μm (roll)
The straightness of the upper and lower cross beams and the edge keys	Elcomat 2000 Autocollimator	cross beam≦10μm side keys≦20μm	upper cross beam ≦ 4.4μm lower cross beam ≦ 3.2μm upper side key ≦ 12.6μm lower side key ≦ 18.7μm

SUMMARY

This paper details the mechanical assembly process of W100, which involves connecting upper and lower magnetic arrays, precise gap control, and adjustments. The assembly process comprises meticulous steps ensuring accuracy and compliance with specifications. After assembly, inspections validate the parallelism, angular variation, and straightness of the magnetic cross beams. Inspection results confirm alignment with mechanical specifications, ensuring the functionality and reliability of W100 for experimental research at TPS.

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