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THE INSTALLATION AND OPERATION OF TPS LASER PSD SYSTEM IN TPS STORAGE RING

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Abstract

24 sets of Laser PSD positioning system are parts of the TPS girder autoalignment system. Laser PSD positioning systems are installed in the straight section girders of TPS storage ring. The Laser PSD systems are assembled and calibrated in the Lab beforehand. The Laser and PSDs are assembled on girder and transported to TPS storage ring and Installed. During construction the system deviates from the normal position caused by variant temperature and external influence. For absolute position precision, another laser calibration system should be built to recalibrate the laser PSD system. This paper describes the installation of Laser PSD system in TPS storage ring and the status of the PSD system. A new absolute position calibration method for precision upgrade is also discussed.

INTRODUCTION

A precise auto-alignment scheme is developed to align and adjust the storage ring girders of Taiwan Photon Source (TPS). [1] Laser PSD system, part of auto-alignment scheme, is designed and developed to align two girders on both sides of the straight section. There are 6 sets of Laser PSD system for the 18m long straight section and 18 sets for 12m short straight section. To achieve high accuracy, a laser and position sensing device, PSD, with the accuracy of micrometer-scale has been designed and arranged for girder positioning [2-4].

The Laser PSD system is constructed by several main portions, including Laser, PSD, beam splitters and isolation tubes. The Laser with Gaussian distribution during working propagation distance, plays a role as a reference line of the girders of the straight-section, as shown in fig1.

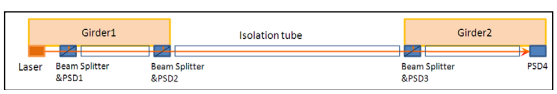

Figure 1: Architecture of Laser -PSD position system.

The PSD modules are adjusted and positioned within the error of micro-meter scale in advance. The PSD correction factors are calibrated. The absolute displacement accuracy of the Laser PSD system can be within 25 um by comparing with the Laser tracker. [5] After 24 sets of PSD system is assembled on girders in the lab, the girders system are transported to TPS storage ring and installed within the standard procedure for storage ring construction.

INSTALLATION OF LASER PSD SYSTEM IN TPS STORAGE RING

The Laser -PSD positioning system is constructed by several main portions, including Laser, PSD, beam splitters and isolation tubes. The Laser beam propagates in the isolation tubes, to prevent noise caused by temperature and flow of air due to the air conditioning system.

The first procedure of girder installation is to install the pedestals and positioning it in the tunnel. Followed by girders that are placed on the pedestals, and the isolating tube related fixtures which is positioned and assembled. The support of the isolation tube are adjusted and positioned in the straight section. The isolation tubes are connected and thermal insulation material are wrapped up around both sides of the tube to prevent air disturbance.

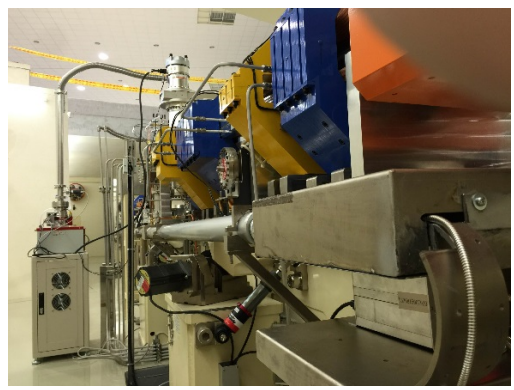

Figure 2: Laser potion and isolation tube of Laser -PSD system are assembled on the side of girder in lab. Then magnet girders are transported back and placed on pedestals in TPS tunnel.

Figure 3: The support of isolation tube are adjusted and positioned on the exact location of ground in the straight section of TPS storage ring.

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STATUS OF LASER PSD SYSTEM

Stability Improvements

In the TPS storage ring, variety of external force influences the Laser PSD system stability for example, the vibration of ion pump, air disturbance caused by air conditioner, mechanism interference etc. When 24 sets of Laser PSD systems are under operation in TPS storage ring, the stability of beam position on PSD is not as good as it is in the Lab. The problem of each section is different. The countermeasures that took place to improve the stability are as follows.

Fasten of Laser Fiber

When the air is let out from the air conditioner, the fiber of the laser moves due to the breeze, causing the beam position on PSD to fluctuate. Thermal insulation material is used to wrap around the fiber to avoid air disturbance and strain force.

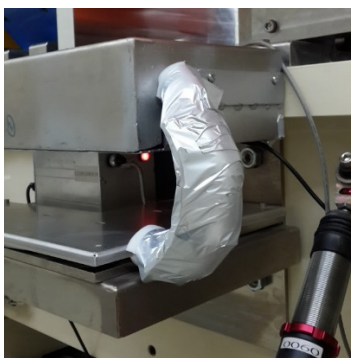

Figure 4: The Laser fiber is fastened by thermal insulation material.

Suppression of Vibration

The mechanism and water running through the pipes transmits the vibration to the PSD by isolation tube or other connected mechanism structure. To prevent the vibration, the isolation tube or PSD mechanisms can't be in straight contact with the vacuum pump, water pipe, cables and front-end components when installed. As shown in fig5, the sponge is used to suppress the vibrations, resulting in the improvement of beam stability.

Figure 5: When the sponge obstructs the water pipe vibration, the PSD stability is improved immediately.

Laser Beam Interference

The isolation tube are stuffed with sponge to prevent the stray light reflected by the inner surface of the tube. But sometimes the sponge tumbles down to interrupt the laser beam. Causing the accuracy of Laser PSD system to be destroyed.

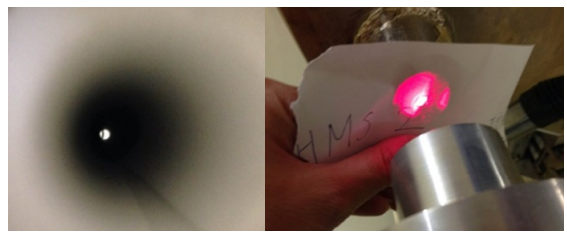

Figure 6: The sponge tumbles down to interrupt the laser beam.

Laser Damage

The relative coefficient between touch sensor and PSD are measured by touch sensor and formulized specifically for each Laser beam. Due to power decay or damage of some lasers, the formulized coefficient could not be used. The Laser are then been replaced, measured and formulized again for system correction.

Re-calibration for Absolute Displacement

After TPS storage ring has been installation, the absolute displacement of some PSD systems is over 25um by comparing to Laser Tracker. That means the calibration coefficients done in the past are not usable. The system deviates from the normal position caused by variant temperature and external influence during transportation and construction. The system should then be calibrated once more to match the differences.

The beam position relationship between PSD1, PSD2, PSD3 and PSD4 are described in the following two formulas.

$$\mathrm{PSD3} - \Delta G3 = C_1[(f_2\mathrm{PSD2} - O_2 - O_{x2}) - (f_1\mathrm{PSD1} - O_1 - O_{x1})] + (f_1\mathrm{PSD1} - O_1 - O_{x1})$$

$$\mathrm{PSD4} - \Delta G4 = C_2[(f_2\mathrm{PSD2} - O_2 - O_{x2}) - (f_1\mathrm{PSD1} - O_1 - O_{x1})] + (f_1\mathrm{PSD1} - O_1 - O_{x1})$$

In order to recalibrate the absolute displacement of the PSD system, a new calibration system should be set in the inner ring direction. A reference PSD is mounted on the front girder. The reference laser is adjusted so that it is parallel to girder partum plane by using the data of reference PSD. Then the reference PSD moves to the rear-end of the girder, the absolute displacements (ΔG_3 , ΔG_4) between two girders of straight section are then measured. The coefficient f_1, f_2, O_{1x}, and O_{2x} can be calculated for systems absolute displacement re-calibration.

Figure 7: The Architecture of the recalibration method.

For earlier stage of TPS girder auto alignment procedure, the PSD system play a limited role to connect the relative displacement of front and rear girders of straight section. The girder absolute displacements

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(ΔG_3 , ΔG_4) are filling measurement data of Laser tracker.

Based on Laser PSD data for straight section girders, the girders of the storage ring are aligned accurately and letting the storage ring to store beam successfully and rapidly.

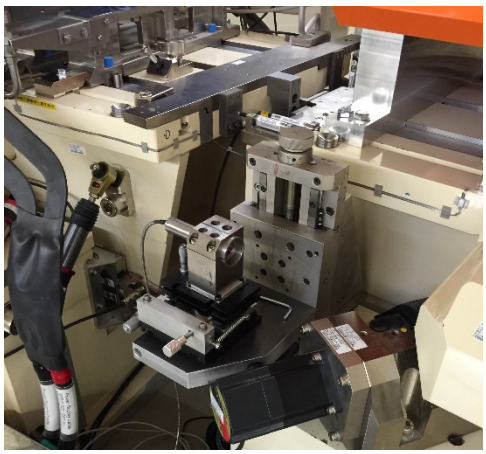

Figure 8: The reference laser is set on pedestal for recalibration.

Currently, 3 GeV electron beam is stored in the storage ring during the end of 2014. The girder displacement will not be adjusted for preventing magnet position variant. The PSD re-calibration data will be applied during the next stage of girder alignment.

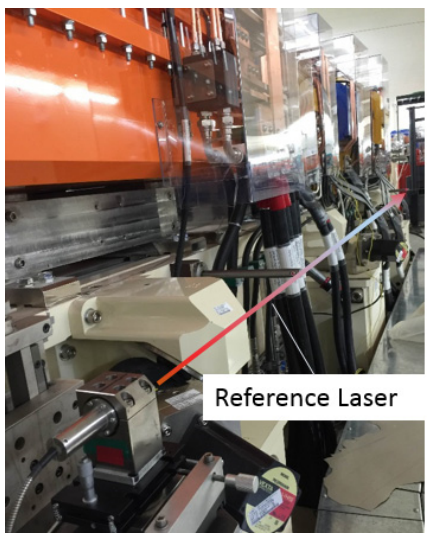

Figure 9: The reference PSD will be installed on girder for adjusting the reference laser to parallel to the datum plane of front girder.

Stability of Laser PSD System

After electron beam has been stored in the storage ring, the PSD system is applied to the monitor showing the displacements of the girder every single moment. The PSD3, PSD4 data signifies to the girder variation between the front and rear end of the girders. As shown in fig10, fig11, the PSD value variations are within +/-30 um during March, 2015. The variation value of 30um bundles of the Laser PSD contains system error, ground vibration, and girder system displacement. The environment of TPS storage ring is stable and only varies within of 30um.

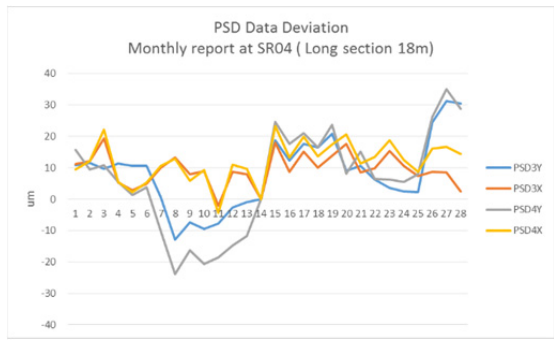

Figure 10: The PSD value variation of long section in March, 2015.

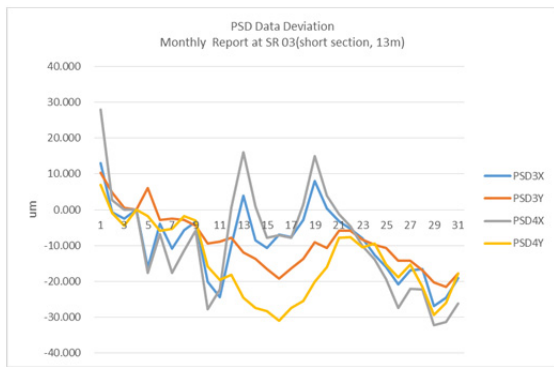

Figure 11: The PSD value variation of short section in March, 2015.

SUMMARY

24 sets of Laser PSD systems are installed in TPS ring. For system stability, several countermeasure are applied. Including fiber fasten, vibration elimination, air disturbance elimination. The system variation is around 30um within one month. For the next stage of auto alignment procedure, the absolute position of PSD system will be recalibrated and applied.

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