

PHOTON BEAM POSITION MONITOR WITH HYDRAULIC LEVEL SYSTEM

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Abstract

In a synchrotron radiation source like the Pohang Light Source (PLS), a great effort has been made on beam stability improvements. For the beam line user-side orbit feedback, Photon Beam Position Monitor(PBPM) provides more practical information on the position and angle of the electron beam at the center of the bending magnet, compared the closed orbit data. For improvement of the orbit stability, PBPMs are used in PLS. However, the ground of PLS moves about 2mm every year. Therefore, we plan to measure the vertical orbit drift and angle variation considering the floor uneven settlement and the support thermal deformation by use of PBPM with Hydraulic Level System(HLS).

INTRODUCTION

Pohang Light Source (PLS) with beam energy of 2.5 GeV has provided the stable beam to the users during last 10 years. As the number of beamline requiring the micro-spot high resolution photon beam such as ID (Insertion Devices)has been increased, the stabilization of the electron beam orbit drift is strongly required. Therefore, in a synchrotron radiation source like PLS, a great effort has been made on beam stability improvement in various related field such as RF, magnet power supply, diagnostics, etc. For the beamline user-sided orbit feedback, PBPM provides more practical information on the position and the angle of the electron beam at the center of the bending magnet, compared the closed orbit data. For improvement of the orbit stability, PBPMs are used in PLS. However, the mechanical motions of main storage ring machine components such as girder, magnet, vacuum chamber, etc., have been known very important factors having potent influence on the beam trajectory. Therefore, it is necessary to measure and understand the real time movement behaviour of the storage ring components, the beamline components and their bases, i.e., the tunnel floor and the experimental hall floor. There has been a big amount of uneven settlement at the storage ring floor slab along its circumference at PLS. The amounts were almost 3mm per year at the beginning stage of measurement and it tends to converge to 2mm per year. These measurements were performed by the conventional optical surveying method at every machine shutdown period (2 times a year). To understand the real orbit drift, we have to consider the real impact of this floor uneven settlement on the beam operation. Therefore, we plan to measure the vertical orbit drift and angle variation considering the floor uneven settlement and the

support thermal deformation by use of PBPM with HLS (Fogale, Nanotech, France).

SYSTEM

PBPM

Fig. 1 shows the wire type photon beam position monitor with hydraulic level system. Here, the material of the wire is tungsten with 0.5mm diameter and 90mm length. In order to improve the electric conductivity, the



Figure 1 : Installation of Photon Beam Position with Hydraulic Level System. HLS are installed on the floor and support.

wire for PBPM is coated with gold. There is a diaphragm with 60mm horizontal aperture which can block off the miscellaneous light. Additionally, the monitor can vertically move and the moving range is ± 20 mm. There is generally the cooling system in the blade type PBPM, but it is structurally impossible that the cooling system is installed in the wire type PBPM. Therefore, the heat transfer analysis is very important. We have studied the effects using heat-power theoretical method and ANSYS analysis code. These methods involved radiation for cooling method. PBPM are installed to diagnostic beamline about 14m away from source point. The source of diagnostic beamline is bending magnet and PBPM's wire size is 90mm x 0.5mm at 14m away from source. Then, total power become to about 9.57W. When the radiation is involved by power-heat theoretical method, the temperature of the tungsten wire is saturated at 819°K.

We also performed the heat-power analysis by ANSYS code. As the results, the maximum temperature of the tungsten wire is acquired about 1066°K. This is a bit greater than the results of theoretical method. We can estimate the tungsten wire is under safe at this temperature. Another analysis with ANSYS code is performed in order to know the structure deformation by

heat-power. Therefore, we can get the results of structure deformation in X, Y direction. The maximum deformations of X-direction and Y-direction are 1.5um, and 2.1 um at temperature of 1066°K respectively. As the results of the heat-power analysis, we conclude that the wire type PBPM can be operated without the cooling system, because the ratio of 2×10^{-5} of the deformation length to the wire length can be acceptable for PBPM. The tungsten wire are not fixed in Z-direction to reduce equivalent stress.

HLS

As measurement principle of HLS, the sensor electrode and the targeted object make up a condenser the inverse capacitance of which is measured. Thus, according to used sensor, the electronics provides an output voltage proportional to displacement the potential of the target object is taken as reference. For the record of the real time of floor and support movement, 5 HLS are installed in the storage ring and experimental hall; 1 HLS is installed on the floor of the storage ring under beam source (bending magnet), 2 HLS are installed on the floor of the experimental hall under PBPM respectively, and 2 HLS are attached on the support of PBPM. The support material is used the granite in order to minimize the

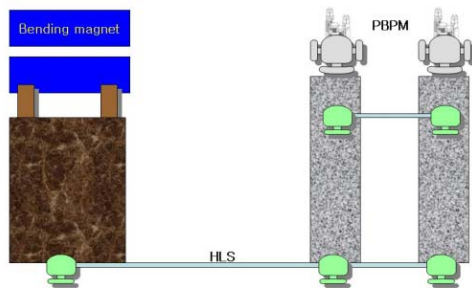


Figure : 2 HLS installation map

thermal deformation. The installation map is shown in Fig. 2. Therefore, we can measure the floor settlement between beam source and beamline. Furthermore, it is able to be monitored the deformation of the PBPM support which is caused by the temperature difference. According to installing HLS, we can analysis practical orbit drift considering the floor settlement and the support deformation.

STATUS AND RESULT

We measured the beam profile of the 1C diagnostic beam line with PBPM. As we expect, the profile of the beam is Gaussian except the edge. The photon current from each wires is detected by a picoammeter (keithly 6485). Two current signals from the top and below wires are then fed into a position processing system in order to obtain a signal proportional to the beam displacement and the angle variation. For the position and angle signals

processing, we use the method of difference over sum^[1]. We have calibrated the PBPM at the diagnostic beam line 1C1. When the monitor is calibrated, we move the vertical position and can acquire the position signals. According to the fitting curve, the sensitivity of PBPM is 0.276. As determining the sensitivity of PBPM, we begin to collect the data from PBPM. The resolution of PBPM signals is very important in order to measure precise displacement and angle variation. We plan to control the orbit stability of below 1 μm. Therefore, the resolution of PBPM requires the resolution of submicron in order to control the orbit stability of below 1μm. As the results of measurement, we get good values that the resolutions of the vertical displacement and the angle variation are 0.5μm and 0.01 μrad respectively. Although the beam motion at monitor is small at short period, the beam motion is a little large at long period. When we perform the measurement of the vertical displacement and angle variation during 24 hours, the vertical displacement is comparatively stable within 2 μm, but the angle variation of 8 μrad is fairly large compared to the vertical displacement. It is the first time to measure the angle variation at PLS. From these results, we can know that the measurement of angle is very important, because the angle variation of 8 μrad gives the vertical displacement of 160 μm to beamline user with 20 m long. Fig. 3 shows the vertical displacement and angle variation from Dec. 18 to Dec. 22. The both of the displacement and angle have the trend to decrease with time in general. But especially, there is the fluctuation per day in the angle variation. As shown Fig. 3, there is the vertical displacement of 12.4

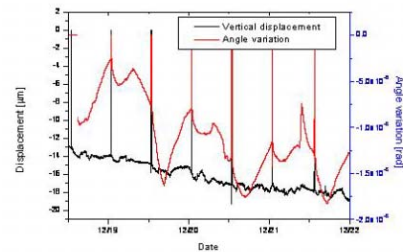


Figure 3 : The vertical displacement and angle variation from Dec. 18 to Dec. 22. There is the fluctuation per day in the angle variation.

μm during 5 days. Therefore, we can know there is averagely the vertical displacement of 2.5 μm per day. According to install HLS, we plan to analysis the practical orbit drift considering the floor settlement and the support deformation. But we have many problems after installing HLS at the beginning. During the operation of HLS, many factors were found to be harmful to the accuracy of the data, such as dirt or condensing water on the surface of sensor, water leakage in tube. With many efforts of removing harmful factors, we can perform the normal operation of the HLS. Fig. 4 shows

the variation of the floor on the basis of storage ring floor. When we measure the relative variation of the floor on based the storage

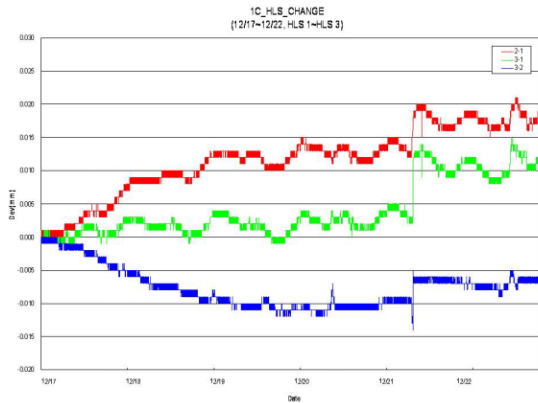


Figure 4 : The relative floor variation measured at 3 floors on based the storage ring floor. The maximum floor variation of 1’st PBPM(2-1) is 20 μ m, that of 2’nd PBPM is 15 μ m.

ring floor, the maximum floor variation of 1’st PBPM(2-1) is 20 μ m, and that of 2’nd PBPM(3-1) is 15 μ m. According to relative variation between 1’st PBPM and 2’nd PBPM, the floor settlement of 2’nd PBPM is less than that of 1’st PBPM. Fig. 5 shows the relative variation of the support. The maximum variation is 13 μ m that contains both of the floor settlement and thermal deformation. Therefore, considering 10 μ m of the relative floor variation in Fig. 4, we can estimate the support variation of 3 μ m to be pure variation by thermal deformation. Fig. 6 shows the temperature distributions at

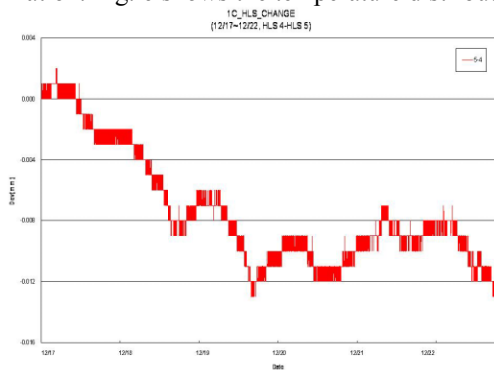


Figure 5 : The relative variation measured at 2 supports. The maximum variation is 13 μ m that contains both of the floor settlement and thermal deformation.

the spots where are installed HLS. As shown in Fig. 6, the temperature of storage ring is very stable, but other temperatures are a bit unstable. Especially, the temperatures of experimental hall repeat rise and fall per day. This is very similar pattern to the angle variation as shown in Fig. 3. Since the coefficient of expansion for granite to be the support material is 8.3 μ m / $^{\circ}$ C-m, the

temperature difference of 1 $^{\circ}$ C cause the angle variation of 4 μ rad. Therefore, in order to measure the precise angle variation, we had to consider strict temperature control around PBPM.

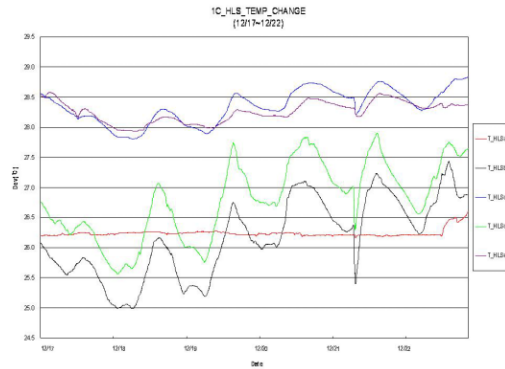


Fig. 6 The temperature variation around 5 HLS. HLS_a is the temperature around storage ring floor, HLS_b and HLS_c are the temperatures around 1’st PBPM and 2’nd PBPM floor respectively. HLS_d and HLS_e are the temperatures on 2 supports 1m away from the floor respectively.

SUMMARY

We will need to implement orbit feedback systems in order to achieve the orbit stability of <1 μ m. For this, we need to analysis the data of PBPM with HLS carefully. According to the data above, the maximum floor variation is 20 μ m during 5 days. Therefore, the floor of PBPM averagely goes up 4 μ m per day. If the floor rises, the orbit of beam seems to descend in appearance. As shown in Fig. 3, the orbit of beam goes down 2.5 μ m per day averagely. However, the real orbit of beam goes up 1.5 μ m per day because the floor goes up 4 μ m per day. To make matters worse, the operator will try to descend the orbit of 1.5 μ m per day. Then, the user of beam line will suffer worse photon beam position of 5.5 μ m per day. Therefore, for the beam line user-side orbit feedback, we can conclude that PBPM with HLS provides more practical information on the position and angle of the elector beam compared the closed orbit data.

REFERENCES

[1] B. G. Sun, J. H. Liu, et al. “Development of a Split Photon Beam Position Monitor for HLS”, High Energy Physics and Nuclear 2004, Vol. 28, No. 2, pp210-214.