VIBRATION MEASUREMENTS IN U7 UNDULATOR BEAMLINE AT THE PLS

Y. C. Kim, H. J. Shin, M. K. Lee, K. R. Kim, and C. W. Chung
Pohang Accelerator Laboratory, POSTECH, Pohang, Korea, 790-784

Abstract

We have performed a series of vibration measurements around a water-cooled toroidal focusing mirror in U7 undulator beamline, in order to investigate and resolve the vibration induced fluctuation of photon beam intensity. Several modifications of the mirror cooling system were made to reduce the mirror vibration, and the effect of the cooling water flow was investigated by measuring the vibration with and without the water flow. In this report, we present the results of the vibration measurements and the works to improve the beam stability through the modifications of the mirror cooling system.

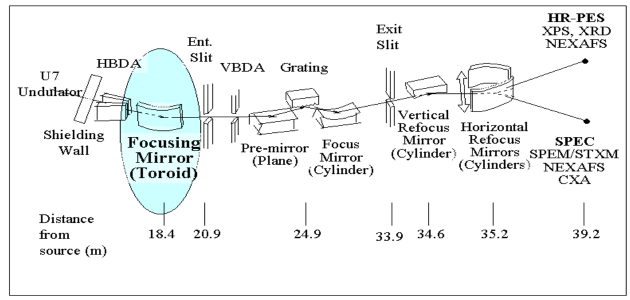

Figure 1 Schematic view of U7 undulator beamline

1 INTRODUCTION

The U7 beamline is for high resolution spectroscopy and spectromicroscopy and uses soft X-ray radiated from an U7 undulator. For spectromicroscopy at the lower photon energy the beam sizes for horizontal and vertical directions at the detectors would be about 55 ㎛ and 140 ㎛, respectively. And the higher the photon energy is, the smaller the beam size is. This photon beam again can be focused onto a sample using an X-ray lens to a size of about 0.1 ㎛. There are many sources to cause the photon beam fluctuation, such as the instability of electron beam in the storage ring, the vibration of optical components in the beamline, etc [1]. Among these sources, we focused on the vibration of major optical component so as to define the source of fluctuation of the photon beam. We measured the vibration at the top of toroidal focusing mirror chamber, vertical plate holding mirror manipulator, and other optical components and studied the source and amplitude of vibration. Cooling system for the major optical components in the beamline was then modified to reduce the flow induced vibration.

2. VIBRATION MEASUREMENT

2.1 Under the Existing Cooling System

There are many optical components along the U7 beamline as shown in Fig. 1. Among those components the toroidal focusing mirror, which focuses the photon beam from the U7 undulator onto an entrance slit, is considered to be the main cause of the photon beam intensity fluctuation at the endstation. The mirror, however, is installed in a vacuum chamber and it is not possible to measure the vibration of mirror directly. So the measurements were performed at the mirror chamber, at the mirror manipulator holding plate which stands vertically outside the chamber and holds the mirror with horizontal arms, and at the other major components around the mirror chamber using the accelerometer (DYTRAN 3100B) and FFT signal analyzer (Scientific Atlanta SD390-4).

The signals of vibration in the x- direction (horizontal and perpendicular to the beam path) from the mirror chamber and the plate for the mirror manipulator were fed into FFT analyzer and the spectra were obtained. These two spectra show almost the same characteristics. Figure 2 shows the spectra of the motions of the plate for mirror manipulator in the x-direction, with and without cooling water flow. The outstanding frequency components in Fig. 2 are categorized as follows:

- The lower two frequencies of 9.625 Hz and 10.25 Hz shown in Figure 2 (above) are considered to be the dominant natural frequencies of mirror system structure.

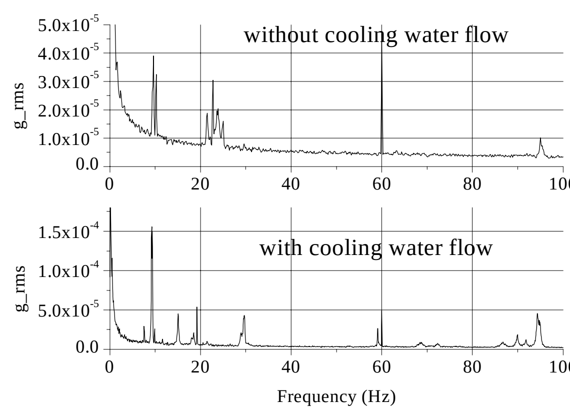

Figure 2 Frequency spectra of horizontal motions of the plate for manipulator with and without cooling water flow

- The frequencies of 7.56 Hz, 9.25 Hz, 9.87 Hz, 15.06 Hz, 19.25 Hz, 29.68 Hz shown in Fig 2 (below) are considered to be due to the cooling water flow.

A printed graph of signal from beam intensity monitor was obtained without any data file. The beating phenomenon was shown in the graph. Two dominant frequencies that produce the phenomenon of beats were calculated. Two calculated frequencies of 9.25 Hz and 9.625 Hz are considered to be the forcing frequency from the cooling water flow and the natural frequency of the mirror system, respectively, as mentioned above. To avoid this beats and to reduce the overall amplitude of vibration the mirror manipulator supporting structures including the plate for mirror manipulator were replaced with different shaped and more rigid ones. The spectrum of frequency response function (FRF) of mirror manipulator supporting structure and the spectrum of horizontal vibration of the structure are shown in Fig. 3. The resonance frequencies

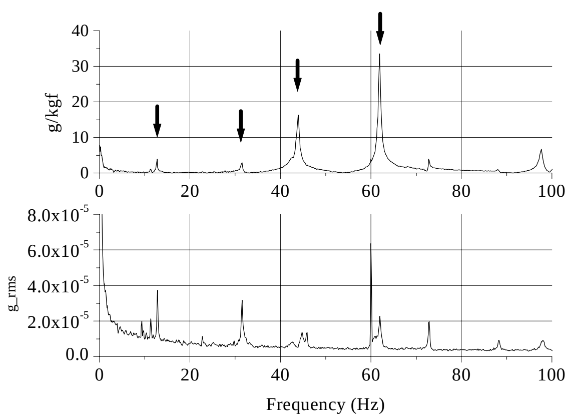

Figure 3 Spectrum of FRF of manipulator supporting structure (above) and spectrum of vibration of the plate for manipulator (below)

of the supporting structure are shown in Fig. 3 (above), which are 11.38 Hz, 12.75 Hz, 31.5 Hz, 43.87 Hz, 61.87 Hz. The vibration amplitude of frequency of 9.38 Hz, which is the most dominant low frequency in displacement amplitude, reduced to almost one eighth of that of 9.25 Hz which is also the most dominant frequency in Fig. 2. It is known that to keep the rms amplitude less than 1 μm is typical stability requirement of beamline components [2]. In the signal shown in Fig. 2, considerable noise signal near zero frequency are found due to accelerometer characteristics. Excluding this noise roughly, overall rms amplitude was calculated to be around 1 ~ 4 μm. Considerable reduction in overall rms amplitude of vibration is estimated from Fig. 3.

2.2 Verification Test for Optimised Cooling System Configuration

To define the effect of cooling system on the mirror motion, simple tests were performed. Test setup includes the following 4 different cases; 1) The case that water flows from the existing main cooling header into a small box that has a role of mirror in the test, and flow out to the existing return header through the small SUS pipes. 2) The case that has flexible hoses in the middle of supply and return pipes in the same configuration as above. 3) The case that has separate cooling circuit with an independent cooling pump. Water supply and return is made through the flexible hoses from the pump to the small box and vice versa. 4) The case that is the same as above case 3) except the addition of a buffer tank in the supply line between the cooling pump and the small box. The flexible hoses were also used to provide a path of supply and return between these components. The test setup are shown in Fig. 4. For all cases, the small box was set on the concrete floor without any constraints in the horizontal direction. Hence, the only y-direction

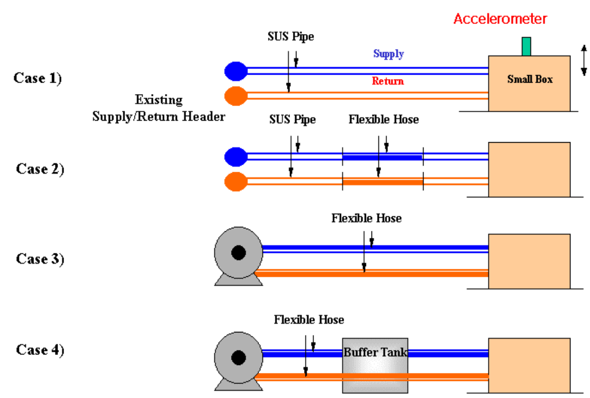

Figure 4 Test setup for 4 different cases

measurements will be effective in the analysis. The results of this test measurement are shown in Fig. 5 and 6.

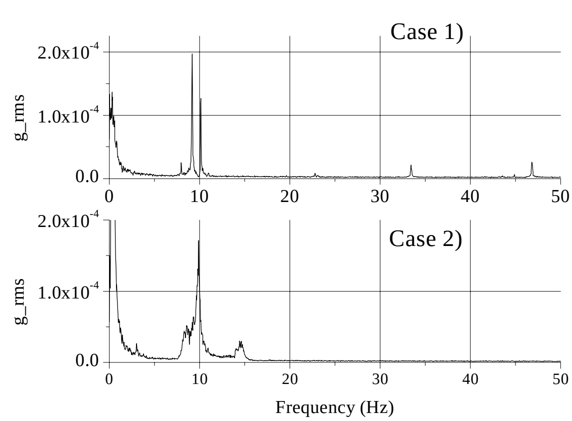

Figure 5 Frequency spectrum of vertical motion of the small box in the test setup for the case 1) and case 2)

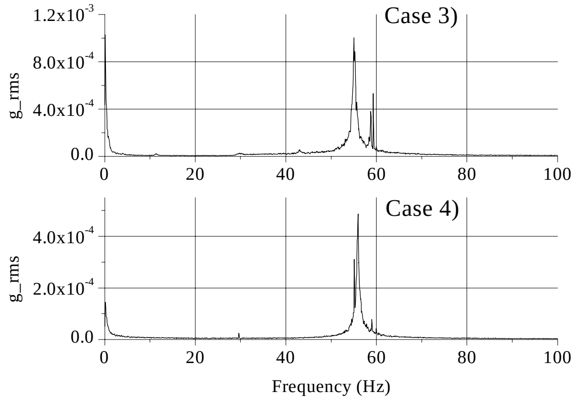

Figure 6 Frequency spectrum of vertical motion of the small box in the test setup for the case 3) and case 4)

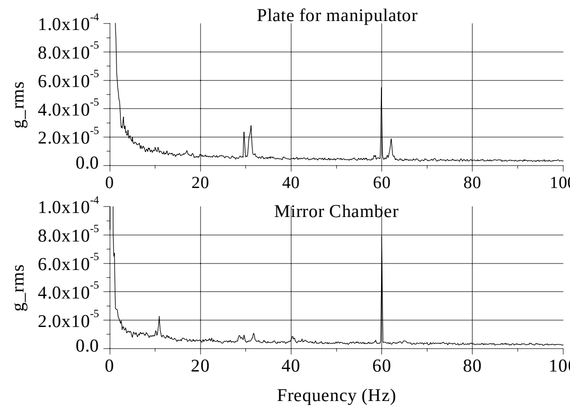

Figure 7 Spectra of horizontal vibrations of mirror chamber (below) and plate for mirror manipulator (above) after modification of cooling system

Frequencies of around 9 Hz in Fig. 5 are considered to be due to the water flow in the pipe and hose, which are also shown in Fig. 2. Frequencies around 55 Hz with quite a big amplitude are shown in Fig. 6. These frequency components are from the pump running near the small box. The vibration of the pump and the fan propagated through the floor and flexible hoses to the small box. But frequencies of around 9 Hz which is directly caused by the pressurized water flow as shown in Fig. 5 are almost diminished. Therefore, separate cooling system could be an alternative possibility to reduce the vibration due to water flow provided the vibration of pump could be isolated.

2.3 Measurement After the Modification of Cooling System

Since there are no outstanding vibration sources in the U7 undulator beamline except cooling water flow, water cooling system was modified to a stand-alone cooling system with an independent pump and a buffer tank directly connected to optical components via flexible hoses. The diagram of the modified cooling system is the same as the case 4) in Fig. 4 if small box is interpreted as an optical component to be water-cooled. Buffer tank is placed on the roof of storage ring tunnel near this beamline so as to circulate cooling water with gravity. Results of the vibration measurement at the mirror chamber and at the plate for manipulator are shown in Fig. 7. Vibrations of frequencies less than 30 Hz are greatly diminished or reduced in amplitude.

3. SUMMARY

Vibrations of the toridal focusing mirror chamber and the plate for manipulator were measured and quantified in the frequency range below 100 Hz during maintenance period and normal operation period. The frequency components affecting the beam intensity fluctuation were identified and the amplitude of the fluctuation were reduced by modifying the mirror manipulator supporting structure. To suppress the vibration from the cooling water flow, test experiments were performed with 4 different cases of cooling system configuration. The use of a buffer tank showed no outstanding frequencies around 9 to 10 Hz, which are dominant frequencies in vibration in displacement. Referring to the results the cooling system for the major components including toroidal focusing mirror was modified. The vibration of the same components after the cooling system modification results in much reduction in amplitudes. For better review of correlation between the motion of the mirror and photon beam intensity fluctuation, we are preparing the non-contact vibration measuring devices such as laser vibrometer to measure the mirror vibration directly through the view port of vacuum chamber.

REFERENCES

[1] PAL Annual Report, 1999/2000, p67
[2] L. Zhang, “Vibration at the ESRF”, EPAC96