Front End

1. Introduction

At the end of FY 1998, we completed installation of beamline front ends consisting of eleven bending magnet (BM) and sixteen insertion device (ID). Among these, twenty-two beamline front ends are under successful operation at the maximum beam current of 70 mA. During this year, the front end group was almost completely occupied in construction, commissioning, maintenance and routine inspection. However, we have also been making efforts to drive forward R&D on (1) handling the intensive heat load, and (2) monitoring the X-ray beam position of ID beamline.

2. R&D

2.1 Handling the Intensive Heat Load

We have been continuing R&D on enhancement of the cooling channel heat transfer and on the volumetric heating [1, 2]. For the former, we prepared several kinds of interior configurations for test tubes: single wire coil attached, double wire coil attached, spline-shaped grooved and screw-shaped grooved tubes. The Nusselt number, which represents the heat transfer coefficient as a non-dimensional number, and a pressure loss were measured for each test tube. Considering that the pressure loss should be within the permissible range, we found that the test tube attached with a single copper wire coil, whose diameter is 1.5 mm and pitch is 10 mm, could provide the best conditions. We will continue this experiment on tubes with other shapes.

The volumetric heating technique is to expand the volume of energy deposit in depth by using low-Z materials in order to mitigate high temperature and high thermal stress near the surface. Although this compact design is more practical with this technique than the grazing angle design, we have to pay much attention to the strength of the joint between the low-Z material and the copper cooling holder because of different thermal expansion coefficients. We have applied a graphite block to the irradiated body in eleven standard undulator beamlines. They work without any serious trouble, but we tested a beryllium pre-slit to achieve a stronger joint. According to the various strength evaluations and microscopic observations of the joint, the beryllium pre-slit is superior to the that made of graphite. We will try to apply this technique to masks and absorbers.

2.2 Monitoring the X-ray Beam Position of ID Beamline

At present, we basically install one X-ray beam position monitor (XBPM), which is operated in photo-emission mode for each ID beamline. The XBPMs of this type have been operated with a resolution of less than 3 μm and 1 μm in the horizontal and vertical directions, respectively, as standard deviations. The current signal is, however, influenced by the synchrotron radiation (SR) from BMs installed in the upstream and downstream side of the ID as the ID gap is changed. To solve this problem, we have been trying to implement the photo-conduction mode XBPM, which utilizes a CVD diamond as a semiconductor detector. Because this mode can obtain many current signals against high-energy photons, the influence of the background of the SR from BMs would be lowered to a negligible level. During this year, we measured basic properties of the photo-conduction mode detector in BL01B1 [3]. We also measured the spatial distribution of the figure-8 undulator in BL27SU. It was confirmed that it can also be used as a beam profiler [4].

3. Construction

The front ends for BL16XU, BL16B2, BL20B2, and BL29XU were constructed during the summer shutdown period. We installed the new type pre-slit in BL29XU, whose irradiated body was made of beryllium. The wire coil filled method was adopted for all of the cooling channels of masks, absorbers and XY slits assembly for BL16XU and BL29XU. During the winter shutdown period, we constructed four BM beamline front ends: BL02B2, BL04B2, BL28B2 and BL40B2. The key feature of these front ends is to tightly close the aperture size of the SR in the horizontal direction by the masks, unlike the principle of the standard type front end. This is the reason why there is no need to introduce the standard size SR (2.1 mrad) to the optics of these beamlines and it is preferable from the viewpoint of shielding to handle the unnecessary part of SR inside the storage ring. Consequently, the size of the SR introduced in the transport channel is 0.73 mrad and 1.2 mrad for BL02B2 & BL04B2 and BL28B2 & BL40B2, respectively. We changed the actuator of the axis adjustment filter (ADJFIL) from the stepping motor drive to the pneumatic one. Furthermore, the front end beryllium windows in BL47XU were changed from the standard type to the polished type, which has a purity of more than 99.8 % and a roughness of less than 0.25 μm as Ra (average roughness by center line) in compliance with the wishes of the users.

4. Commissioning

We first confirmed the agreement between the front end axis and the light axis for the commissioning of a front end channel. This task was done by observing the light axis with the ADJFIL and the screen monitors at the beam current of about 1 mA so that we could judge whether the alignment accuracy of the front end components to the light axis is acceptable. The positional error between them at the most downstream side position, located at about 34 m from the light source for ID beamlines and about 27 m for BM beamlines, is usually less than 1 mm. As for ID beamlines, the second step is to align the axis of the front end slits, which usually consist of the pre-slit and XY-slits assembly, with the light axis. This work was achieved by the thin-foil (graphite or gold) I_0 monitor and its specific I/V converter, installed just downstream of the front end Be window [5]. By inserting the detector head into the light axis and scanning the front end slits in both horizontal and vertical directions, we could get information on the spatial distribution of the radiated power by measuring the photo current. Thanks to the auto scanning plot program developed by the SPring-8 control group, the time required for the measurement could be shortened. After introducing monochromatic X-rays to the experimental station, the XY slit assembly will be aligned with the light axis more precisely by the SPring-8 optics group. The final step is to commission the XBPM for the ID beamline, which has four CVD diamond blades with evaporated films (Ti). We routinely (1) check whether current signals from the four blades indicate normal conditions, (2) move the blade center to the light axis so that four signals are equal, and (3) set up the horizontal and vertical correction factors by moving the blades slightly in both directions.

5. Front End Exclusive Cooling System

At present, the cooling water for the front end components is supplied from the circulating system, called the L1 System, which is also connected to the magnet, vacuum, and SSBT cooling systems of the storage ring. In such a jointly used circulating system, the drastic changes of the heat load on the front end components, which occur due to the operation of the ID gap, will cause fluctuations in the cooling water temperature of the L1 system. This causes the temperature of the magnet to fluctuate, which is one of the reasons for beam instability. The key feature of the ID for a long straight section, such as BL19IS, is the ability to provide ultra-high brilliance beam. To bring out this feature as much as possible, beam stability is indispensable; accordingly, the front end cooling system should be separated from the L1 System. Furthermore, the performance of the ID has remarkably advanced due to recent progress in insertion device technology, and the heat load to be handled by the front end components has significantly increased. For example, the total power of an ID, which was estimated to be at about 3 kW at the planning stage of the L1 System, has been increased by four times for the standard undulator and by seven times for the figure-8 undulator. Consequently, although the number of operating beamlines is about one third that of total beamlines, the amount of cooling water used by the front end components exceeds the allocated amount. To solve these problems, it has been decided that a new circulating system for the exclusive use of the front end cooling system, called the FE Exclusive System, should be constructed [6]. The FE exclusive system will be divided into four blocks (A, B, C and D), each of which has an independent circulating system, in the same way as the L1 System. Because there are more operating beamlines in A (BL01B1~BL12IN) and D (BL37IN~BL48IN) blocks than in B (BL12B2~BL24IN) and C (BL25IN~BL36IN) blocks, the former blocks (A, D) will be completed by the end of the 1999 summer shutdown period and the latter blocks (B, C) by the end of the 2000 summer shutdown period. During the 1998 winter shutdown period, all necessary holes through which cooling pipes pass between the inside and outside of the storage ring were cored in the shielding wall of the roof for all blocks.

References

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