Mechanical Design of the Beam Diagnostics Straight Section on the SPring-8 Storage Ring

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1. Introduction

In order to obtain information about the behavior of the stored beam in the SPring-8 storage ring, following diagnostic devices will be installed in one of the 6.5-m long straight sections with high betatron functions (for insertion devices) : beam position monitors (BPM's), beam scrapers, beam intensity monitors, and a beam shaker. The design of this beam diagnostic system is presented.

2. Layout

Figure 1 shows a schematic layout of the diagnostics straight section. The beam chambers are made of 2-mm thick stainless steel tubes, having elliptical aperture with 90-mm major and 40-mm minor axes, and are bakeable at 150°C at maximum by using electrical heaters. Each chamber is terminated by two ICF 152 flanges. The whole system is evacuated by two sputter ion pumps whose pumping speed should be decided so as to maintain the beam-on pressure of 10^{-7} Pa or less. During the bakeout, the movable roughing pump system, which consists of a turbo molecular pump and a rotary pump, is used.

At the center of this straight section (Twiss parameter a should be equal to zero), a dummy pipe about 600 mm long will be attached to reserve the place for a short insertion device (for future use to deduce information from synchrotron radiation).

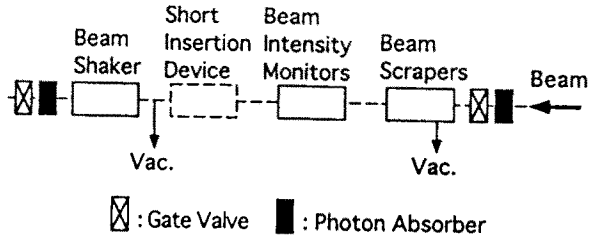

Fig. 1. The beam diagnostics straight section.
(not drawn to scale)

3. Beam position monitor

Three or four BPM units will be installed in the section (not shown in Fig. 1). Each BPM has four button type electrodes welded to a beam chamber. To measure the beam position precisely, the position sensitivity and the offset of the electrical center of each BPM should be calibrated before installation [1].

4. Beam scrapers

Two horizontal and two vertical scrapers will be mounted to measure the storage ring dynamic aperture. The horizontal scraping blades are about 200 mm in length and 20 mm in diameter, and the vertical scraping blades are about 140 mm in length and 20 mm in diameter. Each blade is made of copper with water-cooled. The scraping blade position is controlled with a high precision linear-motion transfer feed through which is driven by a stepping motor. High precision limit switches are used to determine absolute blade positions. Between the blades and the bore of the beam chamber, spaced contact fingers made of beryllium-copper alloy is inserted to guide the long blades and to obtain the required setting precision of the blades. The setting precision and repeatability should be better than 2 μm.

5. Beam intensity monitors

In the storage ring, the electron beam intensity will be measured by using a pulsed current transformer (CT) unit and a DC current transformer (DCCT) unit. The CT unit is employed for measuring the intensity of very short beam pulses with high accuracy. For the measurement of average beam currents, the DCCT unit is used. The dynamic range of the DCCT should cover from about 1 μA for minimum sensitivity to above 100 mA for the maximum operating current.

5.1. Vacuum chamber

The top view of the beam intensity monitoring assembly is shown in Fig. 2. This assembly will be installed downstream of the beam scrapers. A 20-mm long ceramic ring is welded to the stainless steel beam

chamber to prevent the wall current from flowing along the vacuum chamber. The ceramic ring is followed by a bellows to minimize the stresses on it. Four stainless steel rods, which are connected to both ends of the chamber, keep the rigidity of the assembly. The wall current should flow along the rods and the outer magnetic shield made of iron sheet (described later). On the vacuum chamber, electrical heaters and thermal insulators are placed for bakeout. The CT and the DCCT cores are water-cooled during bakeout so that the temperature of these cores does not exceed 80°C.

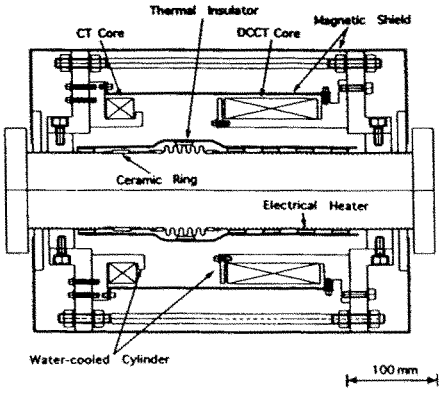

Fig. 2. The top view of the beam intensity

To limit the RF leakage, the gap of the ceramic ring is narrowed about 1 mm by coating the surface with Mo-Mn alloy (about 50 μm thick), and covered with two copper sheets that are isolated from one side by Kapton film and in galvanic contact with the chamber on the other side (not shown in Fig. 2) [2]. The total capacitance of the gap will be about 1 nF. And further, the DCCT is surrounded by iron shield to reduce the influence of low frequency fields from the beam. The shield is designed to have a gap so that the DCCT can pick up the DC component of the beam current signals. On the inner surface of the shield, a vinyl sheet that contains ferrite powder is glued to reduce the excess electromagnetic fields from the beam.

5.2. Magnetic shields

The current transformers have high sensitivities to the radial magnetic fields. The stray magnetic fields near the transformers cause drift of the outputs. To reduce the stray fields from nearby bending and quadrupole magnets, the assembly is designed to be surrounded by cylindrical shields [2], [3]. The outer shield is made of 3-mm thick iron sheet. Iron is easy to form the cylindrical shape and available with cheap price. The inner cylinder is made of 1-mm thick 45 permalloy (permalloy B) sheet, and has a saturation flux density of about 1.5 T. The magnetic permeability of this inner shield is greater than 4.5 x 10^3, and so this shield should work more effectively than the iron shield.

6. Beam shaker

In the downstream part of the beam diagnostics straight section, the beam shaker unit will be located. The beam shaker will be used as a component of the tune measurement system. In addition to that it will shake the beam to improve the single bunch purity when necessary during the single and/or multi single bunch operations.

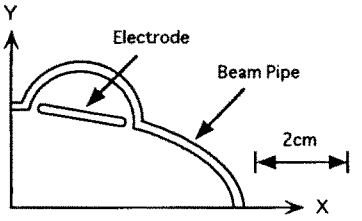

Fig. 3. Cross sectional view of one quadrant of a shaker stripline unit.

The beam shaker unit has four stripline electrodes made of stainless steel. Figure 3 shows the cross sectional view of one quadrant of the unit. Each electrode is 900 mm in length, and supported by two N-type coaxial feed throughs at both ends. For the requirements on impedance of the storage ring vacuum chamber, the housing of the strips is machined out of a stainless steel block to have the same inside geometry of the beam chamber. Each strip is also designed to have 50-ohm characteristic impedance.

As in many other electron storage rings, the diagnostic devices mentioned above will be installed in the SPring-8 storage ring. Detailed designs of them are now in progress.

Acknowledgments

The authors wish to thank Drs. A.Ogata, M.Tejima, T.Ieiri, and T. Honda of KEK for their helpful suggestions in designing the beam intensity monitoring assembly and beam shaker unit.

References

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[2] A. Ogata and M. Tejima, private communication.

[3] T. Honda et al., in Proc. of the 9th . on Accelerator Science and Technology, Japan, 1993, p. 345.