Vacuum Chamber and Crotch Absorber for the SPring-8 Storage Ring Vacuum System

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Abstract
The whole vacuum system for the SPring-8 storage ring is planning to be completely installed in the ring by October 1996. The vacuum chamber for the straight sections consists of a beam chamber and a slot-isolated antechamber in which NEG strips are installed. To suppress the chamber deformation at the BPM station due to the pressure difference between the atmospheric pressure and the vacuum, ribs are mounted on the chamber. In the bending magnet chamber, a distributed ion pump is also installed. The crotch and absorber have been designed to reduce their RF impedances and the radiation level outside the vacuum chamber. In this paper we present details of the final design for the vacuum chamber, crotch and absorber. The chamber supporting system and the structure of ribs are also described.

I. INTRODUCTION

The SPring-8 [1] is a highly brilliant synchrotoron radiation source which is presently under construction, and scheduled for completion in 1997. The vacuum system [2] forms a ring of 1436m in circumference and consists of two differently shaped aluminum-alloy chamber extrusions, crotches, two types of absorbers and various chamber components such as bellows and gate valves.

To achieve a beam lifetime of approximately 24 hours, the vacuum chamber with its pumping system should be designed so as to maintain the beam-on pressure of 1nTorr or less with a circulating current of 100mA. The main pumping system is based on non-evaporable getter (NEG) strips [3] which are used in the straight and bending chambers.

In addition to the NEG strips a distributed ion pump is installed in a bending magnet chamber. Lumped NEG (LNP) [4] and sputter ion pumps are used at the crotch and absorber locations.

In our vacuum system, synchrotron radiation (SR) is almost intercepted by the crotches and absorbers placed just downstream and upstream of bending magnets. An only photon emission for energies less than 10eV with a angular spread larger than 1.5mrad in the vertical plane is intercepted by a slight part of 10mm photon beam slot walls of chambers. The important tasks for the vacuum system should be considered as 1) the design [5] of crotches and absorbers a) in which photo-electrons, reflected photons and SR-induced outgasses are efficiently trapped and b) which can withstand the high photon beam power, and 2) the design of the chamber supports which can ensure the displacement and deformation of the chamber within the accuracy of 0.03mm or less for a beam position monitor (BPM), even after repeated bake cycles. To avoid the excessive production of ozone and corrosives in the air surrounding the vacuum chambers, synchrotron radiation shielding is considered in the crotch and absorber design.

We are planning to manufacture only one cell to estimate the performance of the vacuum system from various points of the view in advance of manufacture of the whole vacuum system composing of 48 cells.The manufacture of the one cell has already been started.

In this paper the crotches, absorbers, vacuum chambers and their supporting structures are described.

II. CROTCH AND ABSORBER

Crotches (CR) are placed just downstream of bending magnets (BM),and absorbers (AB2,3) just upstream of BM's and AB1,4 at both ends of the straight section for insertion devices to absorb the radiation that passes between the CR and the electron beam. An about 50% of the bending magnet radiation is absorbed by the absorbers [2]. Thus synchrotron radiation is almost intercepted by CR's and AB's, and not intercepted by vacuum chambers. Isometric views of the CR and AB1,2 are shown in Figs. 1 and 2, respectively. Structure of the AB3,4 following the CR is similar to that of the CR.

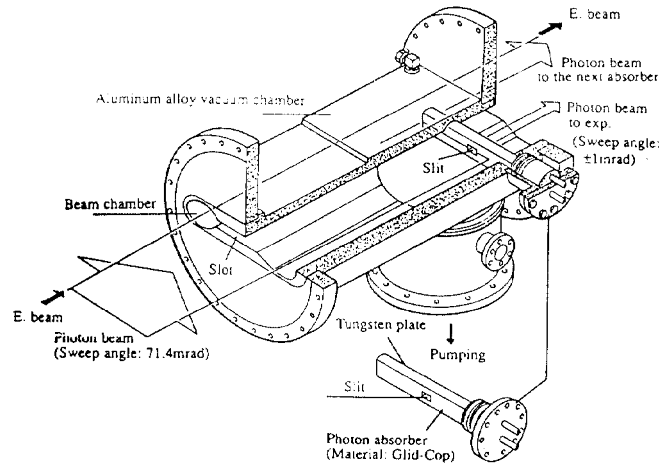

Fig1. Isometric view of the crotch

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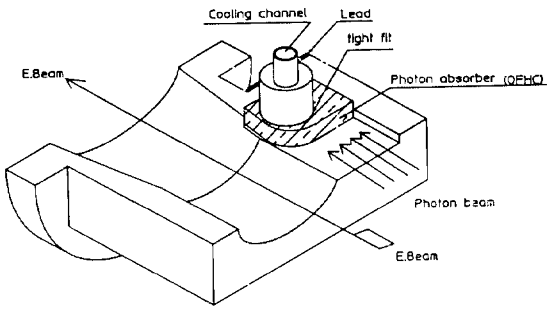

Fig2. Isometric view of the absorber

An initial design for main bodies of the AB3,4 and CR was based on OFHC copper. This initial design was abandoned and present one changed to be an Al-alloy extrusion. As the body materials the copper is better than the Al-alloy because of lower photodesorption rate compared to that of the Al-alloy. Regardless of this matter, the reason that we choose the Al-alloy is reduction of the cost due to an easiness of fabrication. If we compare two cases, an activation interval of the LNP to be used at the crotch and AB3,4 locations becomes shorter than that in the case of using the copper because of an earlier decrease of pumping speeds due to higher photodesorption rate of the Al-alloy. This brings an increase of the pressure. At the beginning of the machine operation, this becomes some problem but would not cause a critical one.

The number of photon absorber inserted in the CR was also changed from two photon absorbers to one. This is for reducing the SR power and its density irradiated at the CR by increasing the SR that passes between the CR and the electron beam. Thus the thermal load, in particular power density that was a critical problem in the initial design is relaxed, and we can make the CR design easy.

The photon absorbers are made of Glid Cop (Al and Al_2O_3 dispersion strengthened copper) because of the high allowable thermal stress of 60 kg/mm^2, compared to 10 kg/mm^2 of OFHC. The thermal analysis results of the crotch have been described elsewhere by Y.Morimoto et. al.[6].

The crotch and absorber have the structure in which particles such as reflected photons, photo-electrons and SR-induced outgasses are efficiently trapped, and are also designed to reduce their RF impedances. SR-induced outgasses are evacuated locally by the high capacity pumping system before the outgasses have a chance to bounce into the beam chamber The pumping system is composed of a lumped NEG pump($\sim$500 l/s at the CR and 350 l/s at the AB for CO) for evacuating H_2 and CO gasses, and a sputter ion pump (60 l/s) for CH_4 and inert gasses.

The photon-beam power (or maximum power density) per a crotch is of about 5 kW ($\sim$30 kW/cm^2) and the energetic photon spectrum is extended to energies in the several 100 keV range. To avoid the formation of ozone and nitrogen oxides in the air surrounding the vacuum chamber, the crotches and absorbers have been designed to be shielded against synchrotoron radiation. As mentioned above, the photon absorbers are of approximately 3-cm thickness. The photons of energies less than 80 keV are almost stopped at the photon absorbers, but those higher than about 100 keV are escaped from the crotches and absorbers. Owing to the normal incidence of the synchrotron radiation on the photon absorber, the attenuation along the direct photon path traversing the 3-cm thickness is of the order of 10^{-3} at the photon energies of 200 keV. To reduce further the radiation level outside the vacuum chamber, additional shielding is necessitated. The shielding for the crotches is provided with tungsten of a 3-mm thick plate on the photon absorber as shown in Fig.1, and the lead shielding with a 4-mm thick plate for the absorbers is provied (see Fig.2). The attenuation with the additional shielding becomes of the order of $10^{-6}$for the same photon energies.

III. VACUUM CHAMBER AND ITS SUPPORTING SYSTEM

A. Vacuum Chamber

The vacuum chamber for the straight sections consists of a beam chamber and a slot-isolated antechamber in which NEG strips are installed.

The bending magnet chamber includes a rectangular pump channel, a beam chamber and a slot-isolated antechamber in which NEG strips are installed. The separation wall between the beam chamber and the pump channel is perforated, allowing the chamber to be evacuated by means of a pump, the so-called distributed ion pump (see Fig.3).

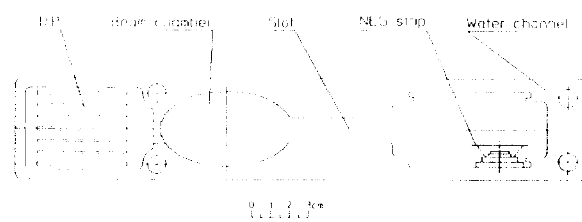

Fig.3 Cross section of the bending magnet chamber

These chambers are 6063 T5 aluminum extrusions and contain water channels for cooling and bakeout. A 150℃ bakeout is achieved with portable water-heating units. The chamber is covered with thermal insulation to reduce heat losses. The LNP, gauges and bellows are baked with heating electrical tapes, and valves baked with mantle heaters.

The aluminum end flanges are joined to the chamber extrusion with incomplete penetration weldments not to appear the weld bead on an inside surface of the beam chamber for low RF impedance.

Chamber deformation at the locations of BPM's due to the pressure difference between the atmospheric pressure and the vacuum is about 0.14mm, while the deformation required for the BPM's must be within the accuracy of 0.03mm or less. To suppress the deformation, two ribs are mounted just beside the BPM on the chamber as shown in Fig.4. The BPM is installed to the chamber with a laser beam welding (Fig.5).

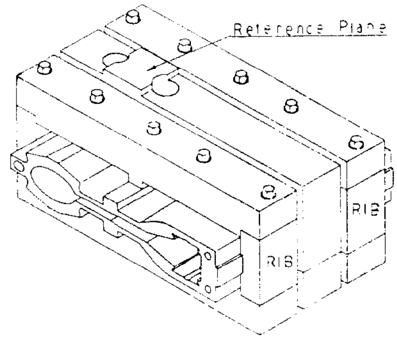

Fig4. Chamber with ribs at the BPM station

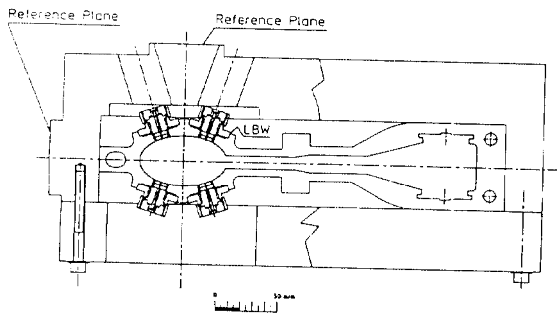

Fig.5 Mount of the BPM

No	Part Name	Specification	Note
16	BPM Electrode		
15	Connection	3/8"	
14	Flange for NEG		ICF152
13	Feedthrough for NEG	B6N	
12	Connection	1/2"	
11	Bellows	BE7	
10	RI Support		
9	Rib		
8	Base		
7	Pumping system		
6	Straight Chamber	A6063	
5	Flange for IG		ICF70
4	Support for AB4		
3	LE Support		
2	HI Support		
1	Absorber	AB4	
SSC3 Support		Scale	
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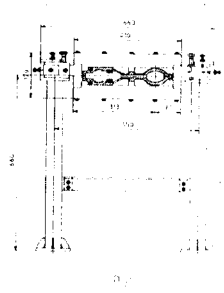

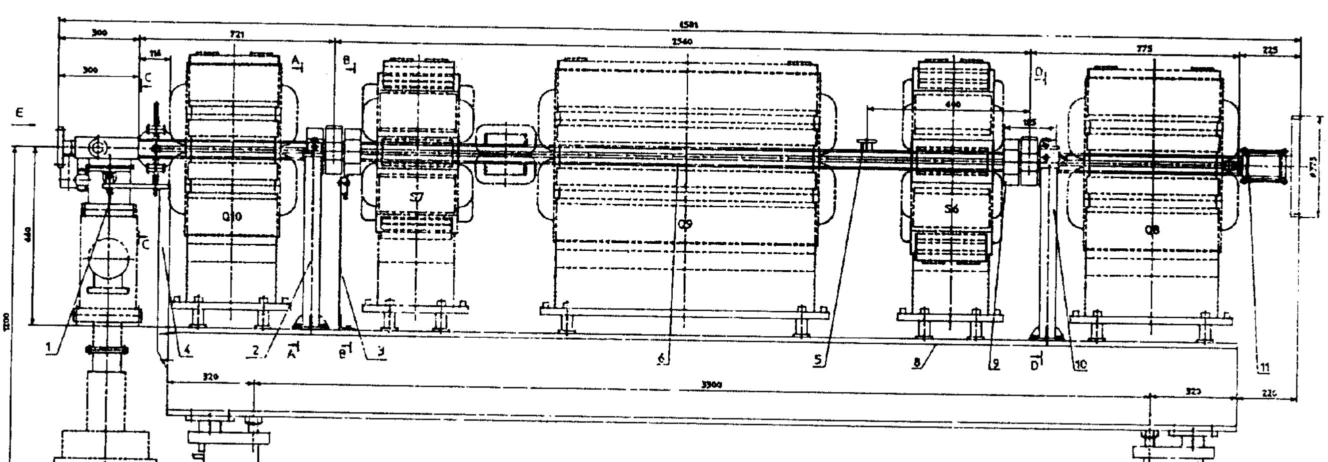

Fig.6 Chamber supporting system for the typical straight section

B . Chamber Supporting System

A chamber supporting system for the typical straight section is shown in Fig.6. Two or three supports per a section depending on the place of the section are used.One support is rigid and does not allow chamber motion in any direction. It is located near the end of the chamber. One of other two supports is composed of a leaf spring and the support with a rotational bearing allowing a chamber thermal expansion along the electron beam direction during the chamber bake cycle. Its position is located near the another end of the chamber.

The last one, which is used for the longest one of three straight sections, is located approximately at the both center of the section and for supporting the chamber weight. The performance of the supporting system has experimentally been confirmed [7]. The bending magnet chambers use three supports. Two sliding slot guides are located at the ends of the chamber to allow thermal expansion in the approximate beam direction. The center support is rigid one and constrains the chamber in any direction during the bake cycle.

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