Performance Estimation of Vacuum System Components including Crotch and Absorber

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Abstract

A vacuum system of the SPring-8(Super Photon Ring-8GeV) storage ring, which is under construction by RIKEN-JAERI Joint Team, has been designed so as to maintain the beam-on operating pressure of 1 nTorr or less. We put special emphasis on the vacuum system components including absorbers and chamber mounts. The absorbers are designed to trap efficiently various particles from the absorbers, to shut off synchrotron radiation and to reduce their RF impedances. The chamber mounts are designed to ensure the displacement and deformation of the chamber within the accuracy of 0.05 mm or less, even after each bake cycle. The design results of the absorbers and the chamber mounting systems are described. Calculated and experimental results are briefly discussed.

1 Introduction

The SPring-8 [?] is a highly brilliant synchrotron radiation source which is presently under construction, and scheduled for completion in 1997. The vacuum system forms approximately a 455-m diameter ring, and consists of two differently shaped aluminum-alloy chamber extrusions, two types of absorbers and various chamber components such as bellows, flanges and 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 1 nTorr or less. The main pumping system is based on non-evaporable getter (NEG) strips which are used in the straight and bending chambers. In addition to the NEG strips, a distributed ion pump is installed in the bending magnet chamber. Lumped NEG [?] 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. A photon emission for energies less than 10eV with a angular spread larger than 1.5mrad in the virtical plane is intercepted by a slight part of slot walls in the straight section chamber.

The important tasks for the vacuum system should be considered as 1) the design 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 mounts which can ensure the displacement and deformation of the chamber within the accuracy of 0.05mm 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 absorber design.

In this paper, we present the design results of the absorbers and chamber mounts.

2 Normal section sell

A layout of a normal section cell is shown in Fig.1. Chamber components such as bellows, flanges and valves are designed so as to minimize their impedances. The bellows are shielded by RF fingers, and changes in the cross-section of the chambers are provided by means of tapered transition instead of step chambers. The flanges and gate valves with RF contact are used. The RF contacts have the width larger than that of a normal chamber to avoid an interception with SR light. These details have been described elsewhere by S.H.Be et. al. [?].

3 Crotch and absorber

Crotches are placed just downstream of bending magnets (BM), and absorbers just upstream of BM's and at both ends of the straight section for insertion devices (see Fig.1). Thus synchrotron radiation is almost intercepted by the crotches and absorbers, and not intercepted by the vacuum chamber. Horizontal and vertical cross sections of the crotch are shown in Fig.2, and those of the absorber in Fig.3. The main bodies of the crotch and absorber are

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made of copper(OFHC-class1), and photon absorbers, C-1 and C-2 inserted in the crotch, are considered to be made of Glid Cop 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. [4].

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($\sim$ 1000 l/s for CO) for evacuating H_2 and CO gases, and a suptter ion pump (60 l/s) for CH_4 and inert gases, and a TMP (250 l/s).

The photon-beam power (or maximum power density) per a crotch and absorber is of up to several kW($\sim$ 30 kW/cm^2) as shown in Table 1, 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 are to be shielded against synchrotron radiation. As mentioned above, the crotches and absorbers are made of OFHC and their walls approximately 3-cm thickness. Therefore the photons of energies less than 80 keV are almost stopped at the walls, 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 wall, the attenuation along the direct photon path traversing the 3-cm thick wall 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

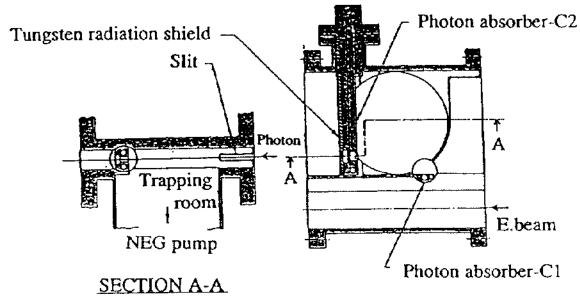

Fig.2 Horizontal and vertical cross sections of the crotch.

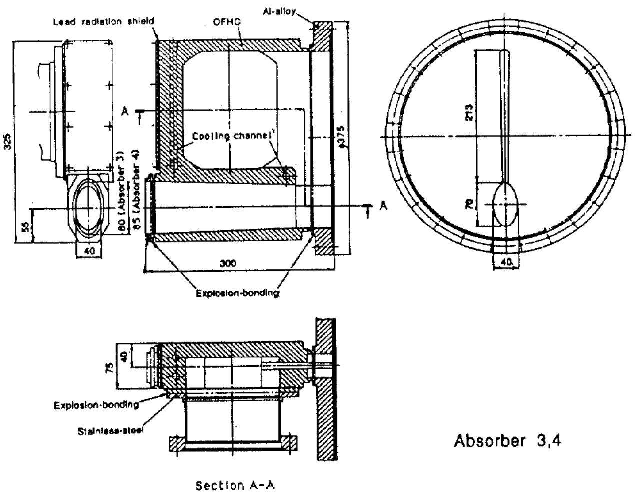

Fig.3 Horizontal and vertical cross sections of the absorber.

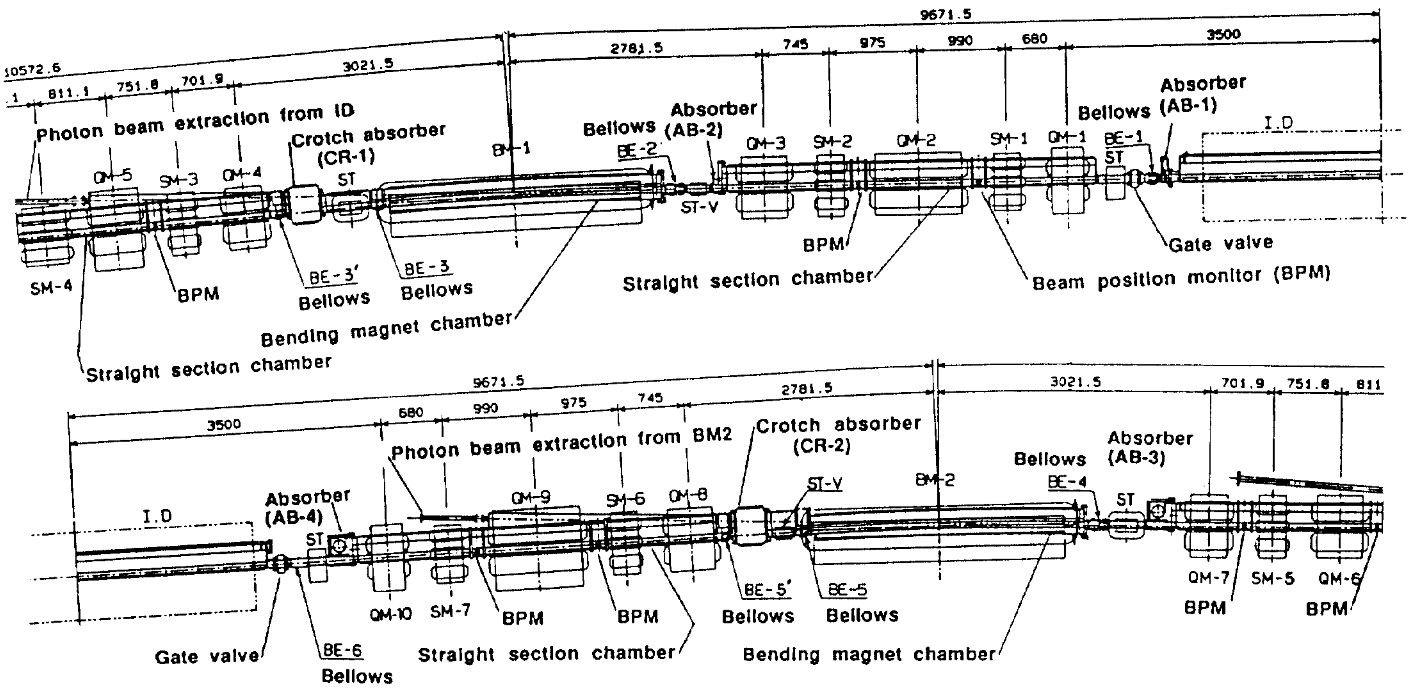

Fig.1 A layout of a normal section cell.

shielding is necessitated. The shielding for the crotches is provided with tungsten of a 3-mm thick layer on the photon absorber C-1 in the crotch as shown in Fig.2, and the lead shielding with a 4-mm thick layer for the absorbers is provied (see Fig.3). The attenuation with the additional shielding becomes of the order of 10^{-6} for the same photon energies.

Table.1 Absorbed powers and power densities.

Area	Absorbed (%)	Absorbed power (kW)	Max.power density (kW/cm2)
a) BM1 Radiation			
CR1	56.0	5.9	25.4
AB2	36.7	3.9	2.5
CR2	7.3	0.8	0.9
Total	100.0	10.6	
b) BM2 Radiation			
CR2	49.4	5.2	27.4
AB4	41.4	4.4	3.8
AB1	4.6	0.5	1.0
AB2	1.5	0.2	0.5
CR1	3.1	0.3	0.3
Total	100.0	10.6	

4 Chamber mounting system

A chamber mounting system is shown in Fig.4. As shown in this figure, the vacuum chamber for the straight sections consists of an electron beam chamber and a slot-isolated antechamber in which NEG strips are installed. The vacuum performance characteristics of this chamber with and without NEG strips have been presented elsewhere by S. Yokouchi et. al. [5].

The initial design of the cooling and bakeout system for the chamber was based on a water cooling system and flexible sheathed heaters, respectively. This initial design was abandoned because it is impossible to carry out the bakeout and NEG activation simultaneously. The present design is to be used the heated water system which has been employed at LEP [6]. The shape of the beam chamber was also changed from the initial race track shape to an elliptical one because of interference with the magnetpoles designed newly.

Due to the pressure difference between the atmospheric pressure and the vacuum, calculated deformation of the present chamber at the locations of BPM's was about 0.145 mm, while the deformation required for the BPM's must be within the accuracy of 0.05 mm or less. To suppress the chamber deformation, ribs are to be mounted on the chamber as shown in Fig.5. As shown in Fig.4, in the straight section, three mounts are used. The rigid mount does not allow chamber motion at the rigid point in any direction. The other two mounts are composed of a leaf spring and the support with a rotational bearing mounted near the location of BPM's. The former is to allow the chamber a slight chamber thermal expansion along the electron beam direction during the chamber bake cycle, and the latter is for supporting the chamber weight.

The performances of these mounting systems were experimentally confirmed that the chambers are not distorted in any manner, and that they return to their original locations within the accuracy of 0.03 mm at the BPM's after each bake cycle. Details of the experiments have been presented elsewhere by S.H.Be et. al. [3].

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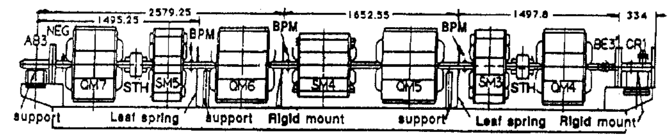

Fig.4 Chamber mounting system for the typical straight section.

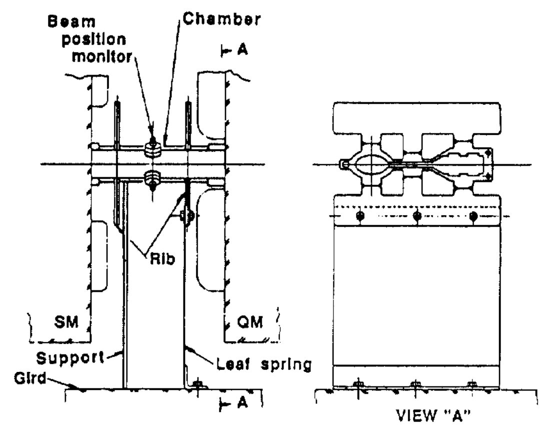

Fig.5 Details of mount of the chamber with ribs.

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