SUPPORT SYSTEM OF THE SSRF STORAGE RING

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Abstract

Because of the higher ground vibration in the site, it is necessary to have a high performance support system for the SSRF storage ring to minimize the vibration amplitude for the main components. Based on a series of analyses and prototype tests, the support system structure of the magnet-girder assemblies (MGAs) and dipole-concrete assemblies (DCAs) were decided, including the girder, the adjustment and the associated parts. Some new techniques were adopted in the manufacturing of the girder to get high precision and small deformation during long period operation. A new type of concrete material was developed to increase the damping effect under the collaboration between SSRF and the industry. The performances of the MGAs and DCAs were tested in detail after assembly and installation, and the results have shown that both MGAs and DCAs have good mechanical stability. The detail design, fabrication and performance of the system are described in this paper.

INTRODUCTION

The electron beam stability for the third generation synchrotron light source is one of the most important requirements because the mechanical vibrations can be amplified on the electron beam closed orbit more than 10 times by the quadrupole magnets [1]. The Shanghai Synchrotron Radiation Facility (SSRF) is a third generation light source, which comprises a 3.5GeV electron storage ring, injected from a 150MeV linac through a full energy 0.15-3.5GeV booster synchrotron, and an initial complement of 7 beam lines [2]. The storage ring is 432m in circumference and consists of 20 similar cells, each cell including three magnet girder assemblies (MGAs) and two dipole concrete assemblies (DCAs) (see Figure 1). The mechanical stability problem deserves more attention because the ground vibration at the SSRF site is much higher than at other light sources. The RMS displacement is about 150nm in quiet time and above 250nm in noisy time, respectively. It is necessary to design the GMA with low vibration amplification for SSRF.

STABILITY OF MGA

In the R&D period, each cell of the storage ring was designed to have three parts, one short and two long. Vibration measurements on the R&D MGA prototype were carried out by Shanghai Jiaotong university in 2001[3]. The results show that the lateral first eigenfrequency of the prototype is only 5.9 Hz.

In order to improve the first eigenfrequency, the following changes are made:

(1) Each cell is divided into five parts: three MGAs and two DCAs. The heaviest and longest MGA (the middle one in Fig.1) is modified from 20.5 ton weight (including 16.5 ton magnets) and 5800mm length to 8.8 ton weight (including 6.0 ton magnets) and 4100mm length (see Figure 2). This MGA has four quadrupoles, including Q260-002, Q260-003, Q320-002 and Q320-002, three sextupoles and two corrector magnets.

(2) The structure of the girder is redesigned. By changing the support system from "six-strut" to the wedge jack mechanism, the contact surface among the components of the system has increased obviously, and the stiffness of the whole MGA is improved remarkably.

(3) The residual stress of the girder is eliminated by vibration processing and thermal annealing after weld to assure its long-time mechanical stability.

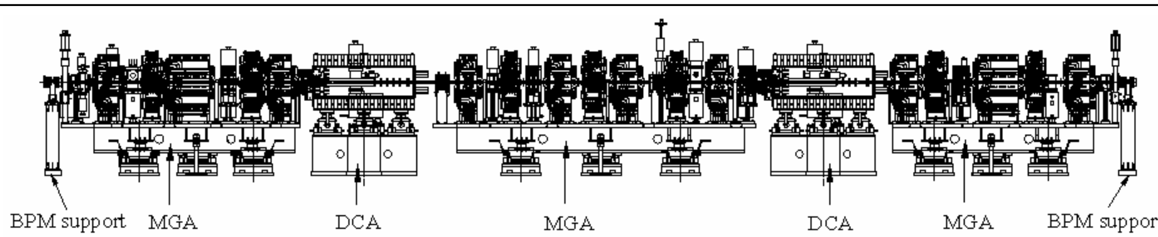

Fig. 1 A cell of the storage ring

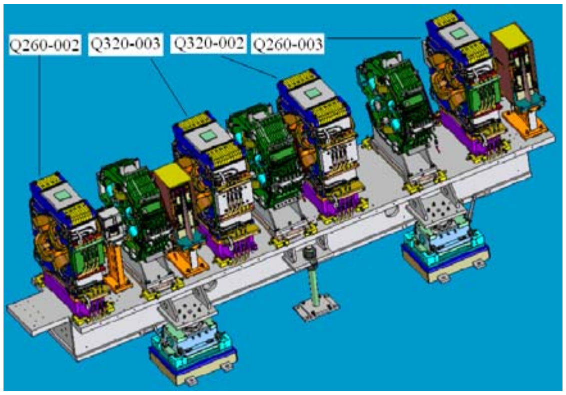

Fig. 2 MGA structure

(4) The structure of the MGA is optimized by finite element analysis.

(5) Three assistant supports are used to connect the GMA to ground tightly after alignment.

The girder is a box-structure welded from Q235A steel plates. The adjuster unit contains a spherical bearing mounted on a wedge block adjuster. The bearing with flange is fixed to the leg of the girder. The flange can rotate 7 degrees in any direction. The range of adjustment for the wedge block is ±7mm. There are two base plates under the wedge block to adjust the position in horizontal plane by blots. The adjustment range for the girder is ± 10mm in horizontal direction. Self-lubricating plate is used between friction couples to reduce the force needed in alignment.

The vibration measurement was performed to understand the mechanical stability of the MGA. In the vibration measurements, we use the DH5920 data acquisition system from the Jiangsu Donghua Measurement Technology Co., Ltd., China and the 941-B seismometers from the Institute of Engineering Mechanics, China Earthquake Administration, with sensitivity of 23V·s/m and frequency range of 1-100Hz. Figure 3 shows the lateral displacement PSD. It indicates that the first eigenfrequency is 21.9Hz. Table 1 lists the detail measurement values in different condition. In the lateral direction, the girder-floor, chamber-floor and magnet-floor displacement amplifications in 4~50Hz range are 1.13, 1.26 and 1.29, respectively. The Q values of the girder, the vacuum chamber and the magnet in the first eigenfrequency are 11.9, 35.3 and 34.8, respectively. These results show that the vibration of the vacuum chamber and the magnet is larger than that of the girder. In the vertical direction, the displacement amplifications are no more than 1.05 and the Q values are no more than 1.8, except that of the vacuum chamber. These results indicate that the vibration in the vertical direction for magnets is much smaller. It is necessary to suppress the vibration in vacuum chamber to decrease it’s influence to BPM measurement.

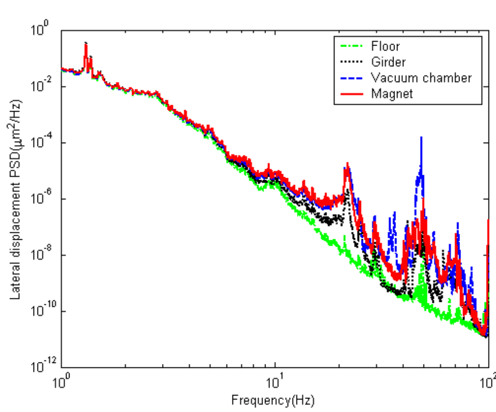

Fig. 3 Displacement PSD in the lateral direction

Tab. 1 Measurement result for MGA

		Lateral				Vertical			
		Daytime		Night		Daytime		Night	
Frequency range (Hz)		2-50	4-50	2-50	4-50	2-50	4-50	2-50	4-50
Floor	Displacement	81.1	19.5	49.5	11.9	18.8	52.5	79.5	14.9
Girder	Displacement	88.1	22.1	54.8	13.5	18.9	52.6	80.4	15.0
	Ratio	1.09	1.13	1.11	1.13	1.00	1.00	1.01	1.02
	Q value	11.9		10.3		1.8		1.1	
Vacuum	Displacement	87.6	24.6	53.1	14.6	19.0	54.1	80.5	15.5
chamber	Ratio	1.08	1.26	1.07	1.23	1.00	1.03	1.01	1.04
	Q value	35.3		25.3		5.7		5.8	
Magnet	Displacement	89.8	25.2	55.2	14.9	19.9	55.2	84.4	15.7
	Ratio	1.11	1.29	1.12	1.25	1.06	1.05	1.06	1.05
	Q value	34.8		28.2		1.6		1.1	
Measurement time									
(Mar. 6th, 2007)		Daytime: 15:41:11 - 16:01:11				Night: 22:01:12 - 22:21:12			

STABILITY OF DCA

Every cell in the SSRF storage ring has two DCAs, each consisting of a 6 ton dipole, three adjustment units and a concrete base (1460mm×930mm×540mm). Figure 4 shows the structure. The concrete base is also used to support the GMA under the adjustment units. By considering SSRF's high ground vibration, it is better to have the concrete with damping effect. A new type of polymer modified concrete (PMC) with damping performance is developed under the collaboration between the Shanghai Baoye Construction Corp., Ltd. and the Shanghai Institute of Applied Physics. The damping ratio is -------------

Fig. 5 shows the lateral transmissibility curves measured for the DCA. We can see that the Q value of the DCA is decreased from 36 to 18 by the PMC and the first eigenfrequency has no change. The mechanical stability of the DCA is improved obviously.

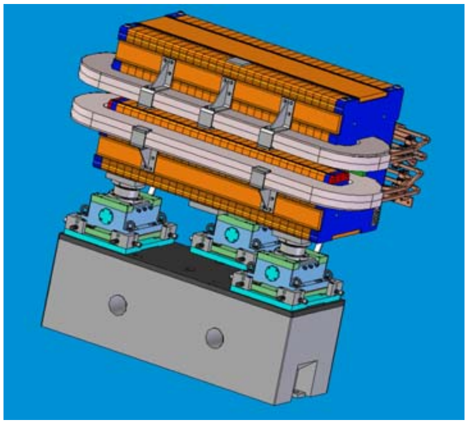

Fig. 4 DCA structure

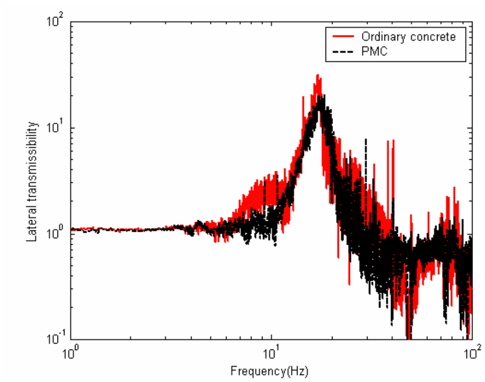

Fig. 5 Lateral transmissibility of DCA

CONCLUSIONS

In order to improve the mechanical stability of the support system of the SSRF storage ring, some new techniques were adopted, which include structure optimization for MGAs, and development of a new type concrete material for DCAs. Measurement results show that these ways have obvious effect on the mechanical stability.

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