A MECHANICAL INSTALLATION PROTOTYPE FOR THE SSRF STORAGE RING

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Abstract

The engineering design of the mechanical system for SSRF storage ring was finished. The first group components in each system, such as the magnets, vacuum chambers, BPMs, girders and other hardware, were fabricated and tested, respectively. In order to check the overall design and the installation procedure, a lattice cell prototype was installed by using these components. Based on it, the related utility system was installed and checked. The dynamic properties of the girder-magnet assembly were also tested in this prototype. Most of the design was confirmed during the installation, but still some problems were found. The modification for the overall design and some components design has been made before their mass production. The detail design and installation of the cell prototype and the test results are described in this paper.

INTRODUCTION

The Shanghai Synchrotron Radiation Facility (SSRF) is a 3.5GeV, 300mA light source currently under construction [1]. The engineering design for the mechanical system was finished and the fabrication for the first group of components in each system, such as the magnets, vacuum chambers, BPMs, girders and others, was completed. The mass production for the components will be started. In order to check the overall design and the installation procedure, a lattice sector prototype was installed by using the first group of components in the tunnel.

MECHANICAL STRUCTURES FOR THE STORAGE RING

The physical study in the storage ring led to an optical design composed of four super-periods, each divided into five sectors. Each of the twenty sectors contains 10 quadrupoles, 7 sextupoles, 4 static correctors and 3 dynamic correctors distributed on three girders, as well as 2 dipoles isolated from the girders by its own supports. The structure of a typical sector in the storage ring is shown in figure 1.

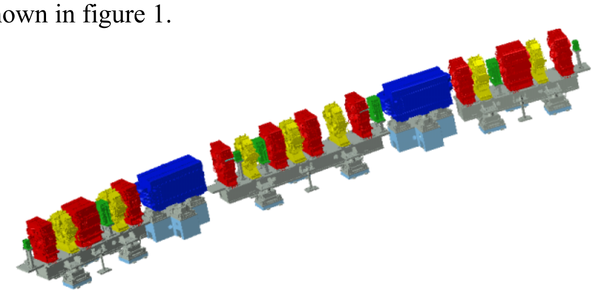

Figure 1: A typical sector in SSRF storage ring.

The support system for quadrupoles and sextupoles is composed of three parts, the girder, the adjuster unit and the concrete pedestal. Each girder is supported by three adjuster units on the pedestals. The girder is a box-structure welded from Q235A steel plates. Each adjuster unit contains a spherical bearing mounted on a wedge block adjuster, shown as figure 2. The bearing with flange is attached to the bottom of the leg in the girder. The flange can rotate 7 degrees maximum in any direction. The range of adjustment for the wedge block is ±7mm. There are two base plates under the adjuster unit to adjust the position in horizontal plane by blots. Self-lubricating plate is used in friction couple to reduce the force between slip surfaces. A concrete pedestal with damping effect is set on bottom of the adjuster unit. The pedestal can be set on the same height by adjusting the space to the floor. It is fixed on the floor tightly using the anchor bolts and a kind of non-shrinking concrete. For the dipole, the steel girder is eliminated and the magnet is supported on a higher concrete pedestal by the same adjuster unit.

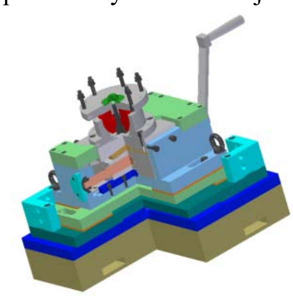

Figure 2: Girder adjuster.

The magnets are fixed on the girder by bolts. The precise position of the magnets on the girder is aligned by shimming in vertical direction and by bolt screw in horizontal direction.

There are three pieces of stainless steel vacuum chambers connected by two RF shielded bellows in one sector. The 6m bending chamber is supported on the first and the second girders, and the 5m bending chamber is on the second and the third girders. Only the 3m straight chamber is supported on the middle girder itself. Figure 3 shows the relation between chambers and girders. Each chamber is fixed on a stiff support near the downstream

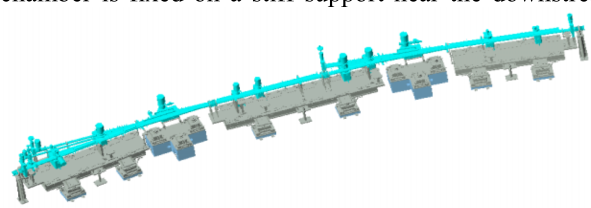

Figure 3: Vacuum chambers on girder.

BPM block and the other parts are supported by spring plates. It can let the chamber expansion easily along the longitudinal direction to the fixed point. Care should be taken during the girder re-alignment after the chamber is installed in order to avoid any damage to the chambers.

SECTOR INSTALLATION

In order to check the overall design for the machine and the fabrication quality for the system components, as well as confirm the installation procedures, it is decided to install a lattice sector prototype just after the first group of components finished. Based on the sector machine, the related utility system will also be installed to check the relation in machine, utility system and building. If any problems are found in this period, it is still possible to modify the related design and to correct the fabrication technique before the mass production started for hardware.

The installed components include the magnets (quadrupoles, sextupoles, dipoles and correctors), the vacuum chambers (with absorbers, bellows gauges and pumps) and the support components (girders, adjustment units, concrete pedestals and chamber supports) for one full sector. There is only one pare of BPMs welded on the chamber. A front end prototype for insertion device is also made and installed.

The installation procedure for the sector is as follows:

(1) Install the utility system in the tunnel, including the cooling water pipes and valves, the cable tray and the ventilation conduit. The cooling water pipes and the cable tray are pre-installed to fit the site condition and are moved out before the sector installation.
(2) Locate and fix the pedestals on the floor within the precision of 3mm in horizontal direction and 1mm in vertical direction, respectively. Mount the adjuster units on the pedestal.
(3) Position the quadrupoles and sextupoles on their own girders, align the magnets to the expected values within0.05mm in both horizontal and vertical directions.
(4) Move and position the girder-magnet assemblies to the tunnel using the 16T crane in the experimental hall. Align the assemblies to the expected values within 0.1mm in transverse direction and 0.5mm in longitudinal direction based on the control network in the tunnel.
(5) Disassemble the top side of the magnets. Position the vacuum chambers with all its attachments (absorbers, gauges, pumps and valves, etc) in vacuum condition using a dedicated hanging tool. Adjust the chamber location to the magnet.
(6) Vent the chambers with pure N_2. Connect the chambers using the bellows. Do leak check and start pumping.
(7) Disassemble the top side of the magnets. Position the vacuum chambers with all its attachments (absorbers, gauges, pumps and valves, etc) in vacuum condition using a dedicated hanging tool. Adjust the chamber location to the magnet.
(8) Vent the chambers with pure nitrogen. Connect the chambers using the bellows. Do leak check and start pumping.
(9) Position the dipoles using a dedicated tool and do alignment for them to the expected values.
(10) Reassemble the top pieces of the magnets.
(11) Survey for all the components. Adjust if necessary.
(12) Set the prototype of the front end to its location.
(13) Reset the cooling pipes and cable tray in the tunnel. Connect the plastic tubes and cables to the components.

Figure 4: The vacuum chamber installation.

Figure 5: The dipole installation.

All the above procedures are carried out and completed for the sector in one month. Figure 4 and figure 5 show a vacuum chamber and a dipole magnet in positioning. Figure 6 shows the sector in the tunnel after installation. All the magnets are positioned and aligned to its expected value smoothly. There is no leak be found after the chamber installed and adjusted under vacuum condition. The installation procedure has been confirmed in the work. There are still many problems be found during the installation period. One kind of problems is the miss position, such as the screw holes on the girder surface, the connection points on the bottom of the diploes, etc. Another kind of problems is the interface between hardware, such as between the chamber support and the magnet adjustment bolt, between the support of front end and the ring girder, between the chamber rib and the dipole coil, between the pump bake-out feedthrough and the chamber support, etc. All the problems have been solved by modifying the design and correcting the fabrication before mass production of the components. This test installation work ensures us that the engineering design for the machine will fit the requirement and the mistakes will be leave as less as possible.

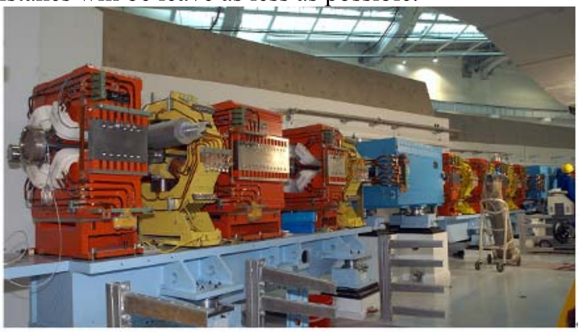

Figure 6: The sector machine in the tunnel.

DYNAMIC PERFORMANCES

The mechanical vibration of storage ring components is one of the critical issues to influence the beam orbit stability. The specification for the mechanical system in SSRF is that the first eigenfrequency should higher than 20Hz and the frequency response function should less than 30 in lateral direction and 10 in vertical direction, respectively. One of the efforts in the design of the support system is to decrease the amplification from floor to magnets through structure optimization. The first eigenfrequency for the girder-magnet assembly is about 30Hz after optimized in ANSYS. In order to confirm the dynamic performances, a serial of measurements were carried out on the girder-magnet assembly in the installed sector to characterize the system.

The tests are performed for the long girder in the sector. The length of the girder is 4m and the total weight is about 11T. The ambient excitation method is adopted in the test. Two sets of sensors (941B seismometers) are used for the test. One set is arranged on the floor while the other is located on the top of a quadrupole. The results are shown as figure 7 and figure 8. From figure 7 we can see that the first eigenfrequency in lateral direction for the girder-magnet assembly is 19.1Hz. The frequency response function is around 38 in the first eigenfrequency and there is no amplification in the low frequency range (less than 6Hz). There is no much response in vertical direction in figure 8. From the results we can see that the damping structure maybe necessary to suppress the vibration in the lateral direction. The damping pad as APS [2] and the damping link as ESRF [3] will be considered. Extensive testing for the structure will be carried out on the sector in next step.

CONCLUSION

Based on the first group of components, one standard sector for the SSRF storage ring has been installed according to the proposed procedure. The related utility system was also set in the tunnel. Most of the design for the sector was confirmed during the installation, but still some problems were found. Some necessary modifications for the overall design and for the components design have been made before the hardware mass production. The dynamic performance of the girder-magnet assembly was tested also. The damping structure maybe necessary to considered for the support system. From this work, the construction reliability for the ring is ensured. This sector will be used as a platform for the electrical test, control test and other test for the machine in the next several months.

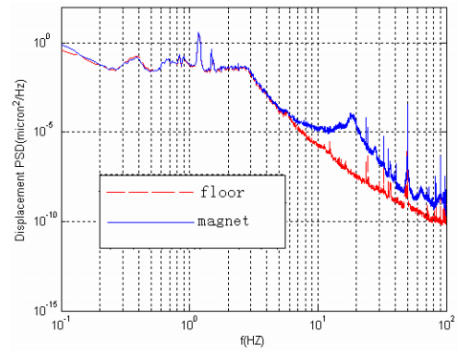

Figure 7: PSD curve for magnet to floor (Lateral direction).

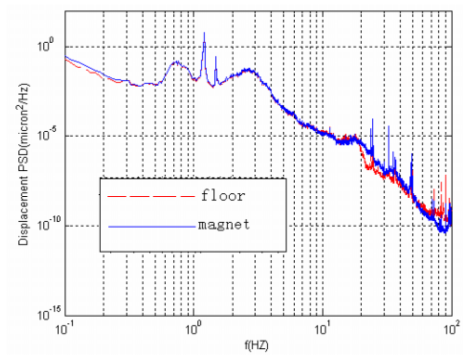

Figure 8: PSD curve for magnet to floor (Vertical direction).

ACKNOWLEDGEMENT

The authors would like to thank Mr. T. K. Chen, Mr. X. J. Cai and Mr. K. Qian in the Shanghai Installation Engineering Co. Ltd. for the discussion on the installation techniques. And also thank the colleges in SSRF for their assistance throughout the installation and the test.

REFERENCES

[1] Z.T. Zhao, "Construction of Shanghai Synchrotron Radiation Facility". These proceedings.

[2] C. Doose, S. Sharma; "Investigation of Passive Vibration Damping Methods for the Advanced Photon Source Storage Ring Girders", MEDSI02, APS, Chicago 2002, p 133-139.

[3] L. Zhang, "Vibration Damping Device Development for the ESRF Storage Ring Magnet-Girder Assembly", 22nd Advanced ICFA Beam Dynamics Workshop on Ground Motion in Future Accelerators, Stanford, November 2000.