DAMPING LINKS TO ATTENUATE VIBRATIONS OF MAGNET GIRDER ASSEMBLIES

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Installation of damping links to reduce quadrupole magnet vibrations was completed at the ESRF during the March 2001 shutdown. The results from measurement clearly show attenuation of vibration of the quadrupole magnets, and significant improvement of electron beam and X-ray beam stability.

In the ESRF storage ring, there are three types of magnet girder assemblies (MGA) involving quadrupole magnets: G10, G20, G30. The G10 and G30 MGAs each contain five magnets, whereas the G20 MGA is longer and consists of seven magnets. The fundamental resonant frequency of these magnet girder assemblies is in the frequency range of 6.5 to 9 Hz, with a lateral rocking motion. This resonant rocking motion of the MGAs induces the electron beam motion with a dominant frequency of 6.8 Hz mainly in the lateral direction. The rms displacement in the frequency range of 4 to 12 Hz is typically 0.2 µm for quadrupoles, and 12 µm for the electron beam at high-ß section. The electron beam motion influences the position stability of the X-ray beam, the intensity stability of the X-ray beam after a monochromator, especially for a horizontally diffracting monochromator. Intensity variation of the X-ray beam with a peak frequency around 7 Hz has been observed in some beamlines, for instance, ID14, ID24 and ID26. In order to improve electron beam and X-ray beam stability, it is necessary to attenuate the vibrations of the magnet girder assembly in the storage ring.

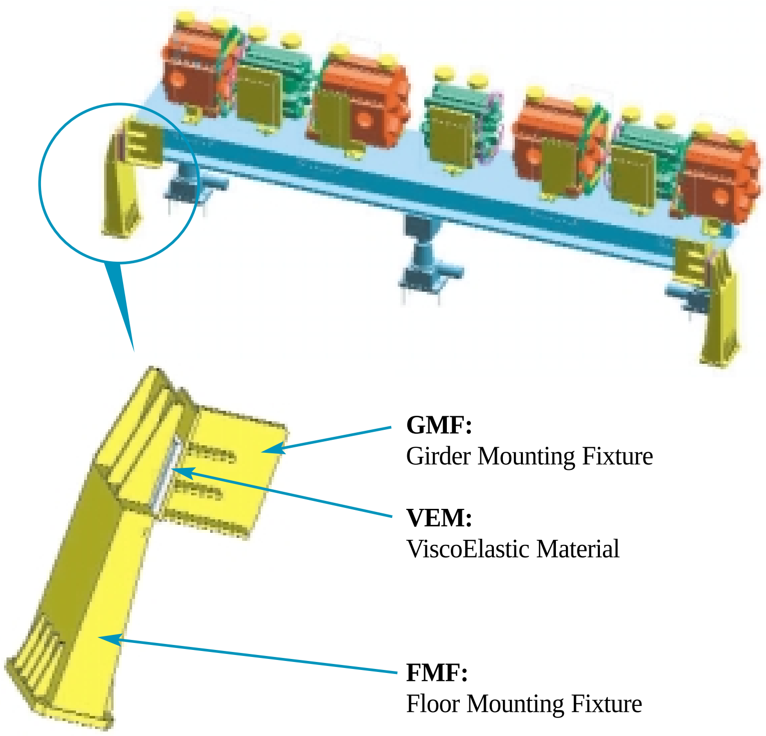

Fig. 1: Damping link and location on a storage ring girder.

A damping device, the so-called 'damping link', has been developed to attenuate the vibrations of the magnet girder assembly. It consists of three parts (Figure 1):

- a sandwich structure with aluminum plates and ViscoElastic Material (VEM): Al + VEM + Al
- a girder mounting fixture (GMF) which allows the sandwich structure to be linked to the girder
- a floor mounting fixture (FMF) which allows the sandwich structure to be linked to the floor

The idea is to use the sandwich structure with VEM to absorb the dynamic strain energy of the MGA. The damping links are installed on the two extremities of the girder and floor as shown in Figure 1. The mounting fixtures (GMF, FMF) should both accommodate the environment in the tunnel and be stiff enough to transmit maximal dynamic strain energy of the MGA to the VEM layer which then dissipates this energy. Mechanical properties of the VEM are key parameters for the successful design of damping link.

Significant efforts were necessary for the installation. The available space was very limited such that cooling pipes and some electrical tracks had to be moved. The installation of damping links at all locations in the ESRF storage ring was

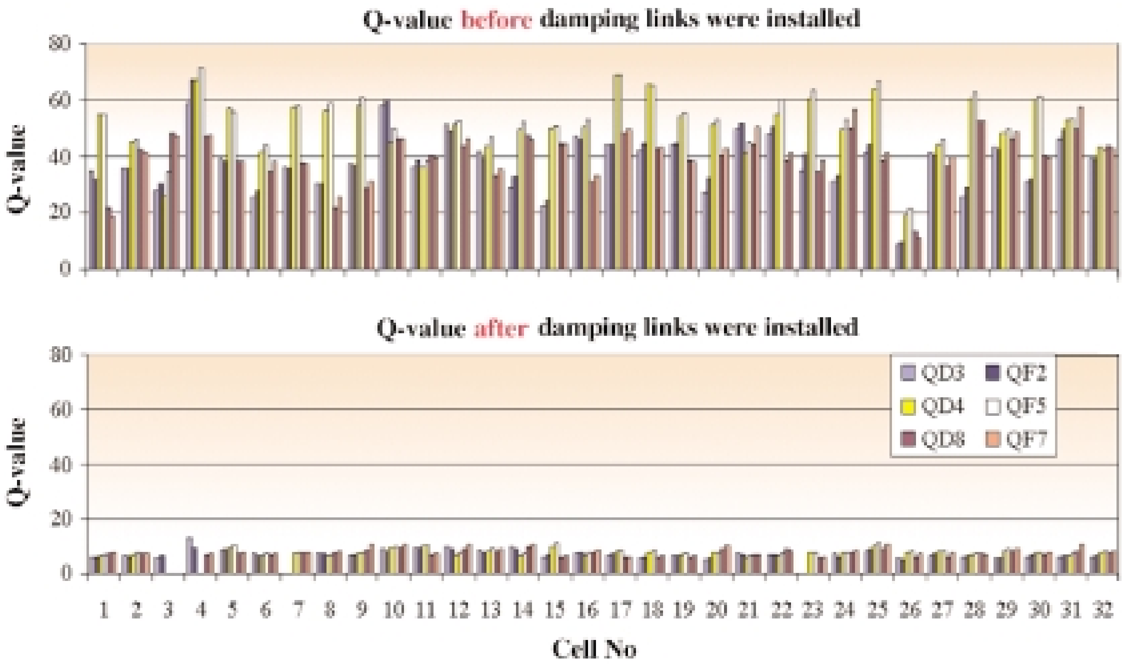

Fig. 2: Q-value of quadrupoles before and after the installation of the damping links in the storage ring.

completed during the March 2001 shutdown.

Vibration tests have been performed on quadrupoles before and after damping link installation. Results in terms of Q-value (peak value in the transfer function at fundamental resonant frequency) of quadrupoles are shown in Figure 2. Note that there are 32 cells in the storage ring, and 3 MGAs with quadrupoles per cell. Results are given here for 2 quadrupoles per MGA: QF2 and QD3 for G10, QD4 and QF5 for G20, QF7 and QD8 for G30. The Q-value of the quadrupoles was about 50 before installation of the damping links, and was reduced to about 10 after installation of the damping links.

In cell 26, damping plates (another damping device) were installed between the jacks and the floor in 1997. The jacks were bolted to the floor. The damping plates were partially shunted by the bolts, but there are still some damping effects. This explains why the Q-values before installation of the damping links in cell 26 were significantly smaller than in other cells.

Electron beam motion has been measured before and after the installation of the damping links in the storage ring. As the installation work was done during four machine shutdowns (Summer 2000, October 2000, Winter 2000/2001, and March 2001), measurements were also made in the case where only part of storage ring was equipped with damping links. Power Spectral Density (PSD) of the horizontal displacement of the electron beam is shown in Figure 3 for four cases. Before the installation of the damping links, there was a huge peak at 6.8 Hz in the horizontal displacement PSD. When half of the storage ring was equipped with damping links, limited damping effects on the electron beam could be observed. When the storage ring was totally equipped with damping links, the peak at 6.8 Hz in the PSD was shifted to about 9 Hz and dramatically reduced by a factor greater than 40. The RMS displacement in the frequency range of 4 to 12 Hz was reduced from a typical value of 12 µm to 3 µm for the electron beam, and from 0.2 µm to 0.05 µm for the quadrupoles. In the results shown in Figure 3, there is a wide peak around 30 Hz. The damping links have no effects on this wide peak. This is because the wide peak around 30 Hz in the PSD of the electron beam is due to the lateral rocking motion of the

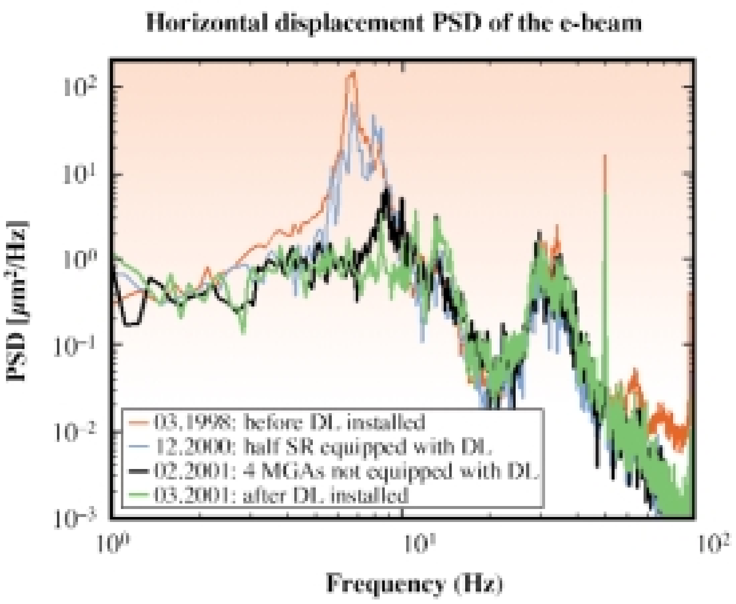

Fig. 3: Horizontal displacement PSD of the electron beam before, during and after the installation of the damping links in the storage ring.

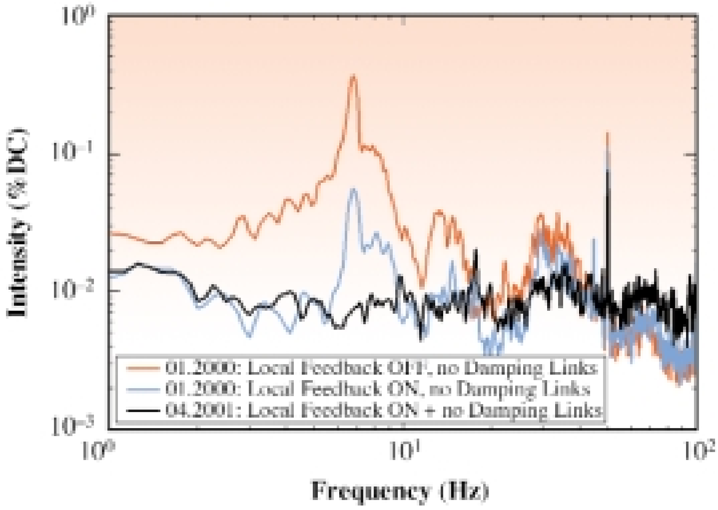

Fig. 4: Spectra of the X-ray beam intensity variation measured with the ID14-EH1 beamline.

quadrupoles QF2 and QF7 relative to the girder. As the girder does not move for this vibration mode at 30 Hz, the damping links are therefore not effective for the vibration of the quadrupoles around 30 Hz, as well as for the motion of the electron beam around 30 Hz. Some countermeasures to reduce the vibrations of quadrupoles QF2 and QF7 have been studied by finite element simulation, and could be very effective.

The significant enhancement of the electron beam stability was also observed on the X-ray beam. Figure 4 shows the spectra of the X-ray beam intensity variation measured at the ID14-EH1 beamline in January 2000 and in April 2001. Damping links for the machine girders were installed between these two dates. The spectra are expressed in percentage of the DC value. The variation of intensity should be as small as possible, so that the spectral value should be significantly smaller than unit 1. The peak at 6.8 Hz in the X-ray bean intensity spectra is removed in totality after damping links have been installed in the storage ring. Note that the local feedback on the electron beam significantly reduced the intensity variation around the peak frequency 6.8 Hz, but the peak is still visible.

In conclusion, the damping links have been successfully developed and implemented in the ESRF storage ring. Vibrations of the magnet girder assemblies were effectively attenuated. Electron beam and X-ray beam stability were significantly improved. ■

References

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