Modal Testing for the Girders with Multi-Stage Adjustable Dampers in Taiwan Photon Source

C.-S. Lin, K.-H. Hsu, S.-Y. Perng, H.-S. Wang, P.-L. Sung, T.-C. Tseng, J.-R. Chen#, and D.-Y. Chiang*
National Synchrotron *Radiation Research Center, No 101, Hsin-Ann Road, Hsinchu 30076, Taiwan*
 # Department of Biomedical Engineering & Environmental Sciences, National Tsing-Hua University, Hsinchu, Taiwan
** Department of Aeronautics and Astronautics, National Cheng Kung University, Tainan, Taiwan*

Abstract

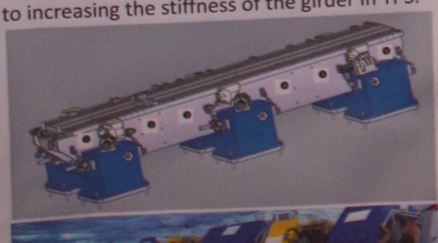
The stability of electron beam is a major concern for the operation of the Taiwan Photon Source (TPS). To overcome mechanical vibration of the accelerator components due to ground motion, the multi-stage adjustable dampers are introduced for passive vibration damping, and presently installed between the girders and the pedestals. Through adjusting the amount of hydraulic fluid which bypasses the damping passage between two hydraulic chambers, the desired damping coefficient of the shock absorbers can be achieved. Results of experimental modal analysis presented in this paper show that the multi-stage adjustable dampers in conjunction with wedge locking systems under the assembly of the girders reduced the level of girder vibration.

A schematic configuration of the hybrid damper

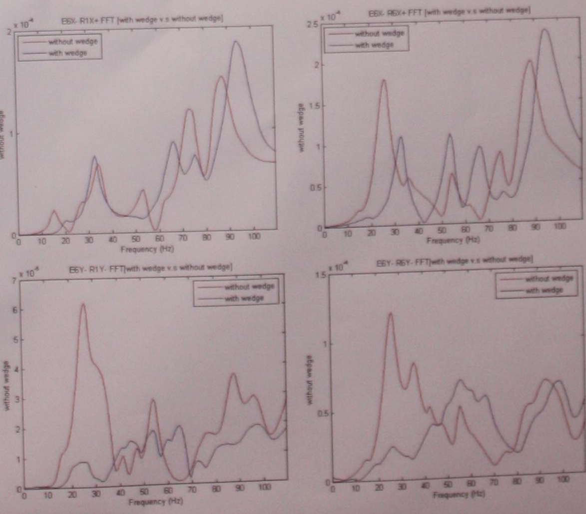
This damper is partitioned into three pressure chambers: the compression chamber, rebound chamber, and gas chamber. In the gas chamber, a compressible gas, such as nitrogen, is used as the springing medium; it is separated from the compression chamber by the floating piston. In both the compression and rebound chambers, a hydraulic fluid is used to convert pressure to force. This relationship allows the damping force of the adjusting member within a cylinder to be easily controlled in real time. During the compression stroke, the hydraulic fluid in the cylindrical housing flows from the compression chamber into the rebound chamber. For the rebound stroke, the pressure definitions become the opposite and the flow reverses. These flows passing through the piston assembly are related to the pressure differences in the pressure chambers. These pressure differences drive the flow from the compression chamber to the rebound chamber and generate the damping force. At low-speed conditions, the damping force is caused by the resistance of fluid that passes through some orifices. At high-velocity conditions, the fluid pressure is high enough to deform the shim stacks and the fluid can also pass through the space between the shims and piston orifices. Since the fluid is effectively incompressible, as the piston rod enters the rebound chamber, the sum of the volumes of the fluid and the rod in the rebound and compression chambers must increase. To accommodate the increased volume, the floating piston compresses the nitrogen gas in the gas chamber to decrease the gas volume by an amount equal to the volume of the inserted rod. In reality, the pressure in the compression chamber is a function of the piston acceleration, gas-chamber pressure, and piston displacement. Additionally, the effect of the acceleration is much smaller than the pressure in the gas chamber, which effectively shows that the gas pressure is a function of the floating-piston displacement, and affects the pressure in the compression chamber.

Modal Testing

To increase the natural frequencies and to reduce the level of girder vibration, we apply the multi-stage adjustable damping absorbers in conjunction with wedge locking under the assembly of the girders reduced the level of girder vibration, and modal testing can then be performed. A Instrumentation setup of modal testing for a magnet-girder system with the multi-stage adjustable dampers in conjunction with wedge locking systems. The measured acceleration responses of a girder system will be obtained from accelerometers. The corresponding frequency response function of acceleration data for each measured point. We clearly see that the locking systems in conjunction with adjustable damper under the assembly of the girders improve the natural frequencies of girders due to increasing the stiffness of the girder in TPS.



Typical frequency response function of a girder (G1) with/without a locking system subjected to impulse excitation



Conclusion

To improve the natural frequencies of magnet-girder system, in this paper, we introduce the locking systems in conjunction with adjustable damper under the assembly of the girders. It becomes effective to increase the natural frequency of a magnet-girder assembly by increasing the stiffness of the girder in TPS through installing wedge locking systems. Through the comparison of frequency response function of a girder (G1) between with and without locking systems subjected to impulse excitation, the results of modal testing show that the multi-stage adjustable dampers in conjunction with wedge locking systems under the assembly of the girders, in general, not only improve the natural frequencies of magnet-girder system, but also reduce the level of girder vibration.

Wedge locking system