MAGNETIC FIELD OPTIMIZATION

The HXN XU was procured as-turn-key device by Hitachi Metals America (America) and installed into the storage ring in August 2014 in a short straight section. This device has a period length of 20 mm and a maximum effective field of 1.8 kG at 0.2 mm pole gap. The magnetic module consists of a half-period unit with two NdFeB magnets of high intrinsic coercivity and one Permenial alloy pole piece. Figure 3 shows the HXN comparison of the 1D magnetic measurement facility (ID-MFM) for the magnetic characteristics and tuning.

MULTIPLE ERRORS COMPENSATION

After improving the phase error distribution, the next and final step of magnetic optimization was performed to compensate the remaining non-uniformity and the total first integral of the device, primarily to minimize the quadrupole components. The first magnetic optimization was achieved by a rearrangement of the NdFeB magnets called "Magic Fingers" inserted into special fingers arrangement is a practical method to decrease greatly the multipole errors. The five individual error values after the magic fingers tuning are shown in Fig. 8. Even though the vertical dipole is out of the optimization range, the steering coils located upstream and downstream of the device can really correct it.

Magnetic Field Optimization of an In-Vacuum Undulator at NSLS-II

MECHANICAL ADJUSTMENTS

In July 2018 a catastrophic failure of the HXN XU resulted in a complete opening of the horizontal drive shaft that was a common synchronous drive of all vertical axes. The fractured shaft of the second gearset at the position circled in red in situation view of Fig. 2 and shown clearly at the top of Fig. 3, separated the supplied upstream and downstream magnetic girders (both out of vacuum structure and the in-vacuum cooling girders) showing them to move independently. The uncontrolled independent movement of those girds led immediately to structural secondary failures. Firstly, the leg of the gear drive synchronization corrupted the once precise relative parallelism of each magnet pair. Ring extraction, with realignment and magnetic field optimization, in the O-MFM was inviable. Secondly, a shear of the copper water lines integral to the in-vacuum cooling girders breached the XU vacuum chamber. Thankful, its huge rectangular size could not keep the containment but rather acted to relieve the rising internal pressure (plied onto the tunnel floor). Forensic inspection and survey of the horizontal drive train uncovered gross malalignments at the junction of intersecting shafts and distortion even within shaft segments. Subsequently, data from accelerometers that had been attached to the shipping container revealed the HXN XU had experienced higher than expected accelerations, particularly along its long axis. Field element analyses of the XU subject to such sensor-recorded loads shows deflected shapes of the structural frame and drive shaft that closely resemble post-motor surveys data as shown in Fig. 4. Furthermore, an in situ survey performed at the users’ end-XU identified similar misalignment errors that are, in fact, of even greater magnitude at certain points in the drive train. Various measures were proposed by committee to address this serious concern (e.g., structural reinforcement with “Bridge Drive”, water detection system, passive pressure shut of valves, etc. The HXN XU was relocated immediately over a long weekend and transported to the ID magnetic measurement facility. Detector site guidegirder were ordered, set just for the failed unit, but for all four vertical axes. Upon receipt, careful bench assembly of O-MFM measurement indicated to varying degrees, a poor alignment between the horizontal input shaft and vertical output shaft on all new units. Yielding to operations team, these new girders were manufactured while taking careful measure to “lounging out” those misalignments with existing flexible couplers, especially at critical high stress-points to minimize possible further fatigue.