DEVELOPMENT OF U10 UNDULATOR AT THE PLS

H. S. Suh, H. G. Lee, K. H. Park, Y. G. Jung, D. E. Kim and C. W. Chung
Pohang Accelerator Laboratory, POSTECH, KOREA

Abstract

A 10 cm period Undulator (U10) was installed at Pohang Light Source (PLS) in Korea on August 2001. U10 is designed for micro-spot high resolution photo-electron spectroscopy studies of materials in the soft X-ray region. The shape of poles and magnetic blocks of U10 are wedged to increase the effective field strength. Field distributions obtained by Hall-probe measurements were analyzed in terms of trajectory, phase errors, and brightness. In this paper, we present efforts for mechanical analysis and field measurements of U10.

1. INTRODUCTION

The Pohang Light Source (PLS) is designed to provide intense, bright synchrotron radiation from VUV to hard X-rays. Two insertion devices (U7 and EPU6) have been already installed in the electron storage ring, and the U10 was installed on August 2001, and a multipole wiggler will be installed on July 2002.

The wedged-pole hybrid undulator has 34 poles (including end poles), 10 cm period and 1.53 T effective field at 16 mm gap, which is optimized for radiation between 6 and 1000 eV at 2.5 GeV electron energy. Quimby and Pindroh proposed a wedged-pole hybrid configuration [1]. The magnetic saturation of pole is avoided by increasing the thickness of the ferromagnetic pole for high field region. In addition, widening the pole tips reduces the harmonic content of the field.

The deformations of support structure from the magnetic load and gravity are analyzed to optimize the deflection of the backing beam. Magnetic field measurements have been carried out using Hall probe system and the results are analyzed to decide the rotor magnets and multiple trim magnet configurations.

2. DESIGN OF U10 UNDULATOR

Permanent magnets (Neomax-44h, Br = 13300 Gauss, Hc = 12600 Oe) and ferromagnetic poles (Vanadium Permendur) have a cross section of wedge type to increase the effective magnetic field of U10. 3D simulations using OPERA of VECTOR FIELDS have been completed to study the optimal magnetic geometry. In the final analysis, maximum magnetic field is 1.49 Tesla with effective field of 1.53 Tesla. But in the case of hexahedron magnet blocks, maximum magnetic field is 1.51 Tesla with effective field of 1.44 Tesla. We estimate about 10% increase manufacturing expenses and challenges in bonding and aligning blocks. The rotor magnets are used to compensate for the first integral and correct the electron trajectory. Multiple trim magnets are used to decrease the transverse multipole contents and correct the field integrals. The main parameters of U10 undulator are listed in Table 1, and the end magnet structure is shown in Fig. 1.

Table 1. Main parameters of U10 undulator

Period length	10 cm
Number of full field poles	28
Device length	1.67 m
Max. field	1.49 Tesla
Effective field	1.53 Tesla
Min. pole gap	16 mm
Max. K	14.3
Photon energy range	6 ～ 1000 eV

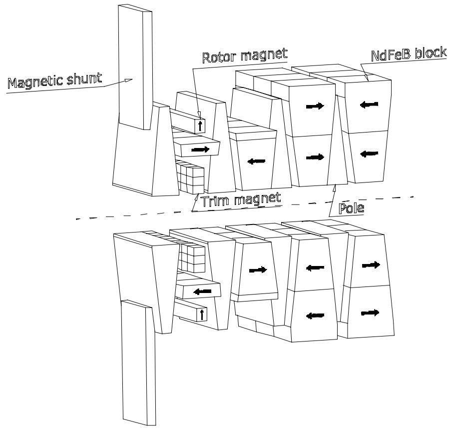

Figure 1. End magnet of U10

3. SUPPORT STRUCTURE AND DRIVE SYSTEM

3.1 Mechanical structure of U10 undulator

The U10 undulator consists of magnetic structure, support structure, drive system and control system. Drive system adjusts magnetic structure to control the pole gap, which includes the L type frame supporting the magnetic structure. The L type frame structure is designed to allow easy installation of the vacuum chamber. The undulator shown in Fig. 2 is designed with very rigid moment of inertia to result in minimum deflection. The compensation spring system are implemented to reduce the system friction, which gives better positional response from the drive system, and to reduce the structural compression and holding torque required at any magnetic gap. The drive system provides the gap adjustment mechanism to control the magnetic structure from 14 to 210 mm gap. The drive system includes two independent drive system groups in a standard structure. Each drive system is composed of step motor, gear reducer and absolute rotary encoder. Two encoders attached on both ends of a ball screw determine the position accuracy. The gap reproducibility of the drive system is less than 7 μm.

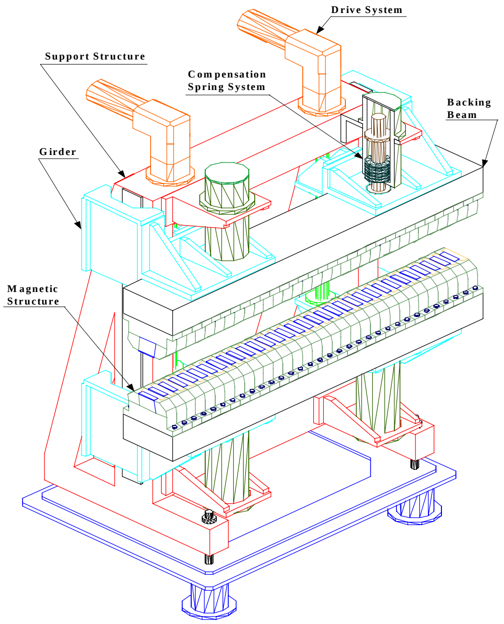

Figure 2. U10 undulator drawing

3.2 Deformation of backing beam

The structural deformation of the backing beam depends on the pole gap. The backing beam is made of aluminum A6061-T6 and the girder is made of nonmagnetic stainless steel 316L. The backing beam is designed to support the maximum magnetic load of 10 metric tons at the minimum gap. The deformation of backing beam have been analyzed at no load, maximum magnetic load and maximum magnetic load with reaction force. The minimum deformation at no load is about 6 μm and the maximum deformation is about 216 μm in the vertical direction, and then, gradually increasing reaction forces are applied to get optimum reaction force configuration. The maximum deformation is about 20 μm in the vertical direction with optimized compensation springs as shown in Fig.3. The compensation spring system consists of several stacks of Belleville washers.

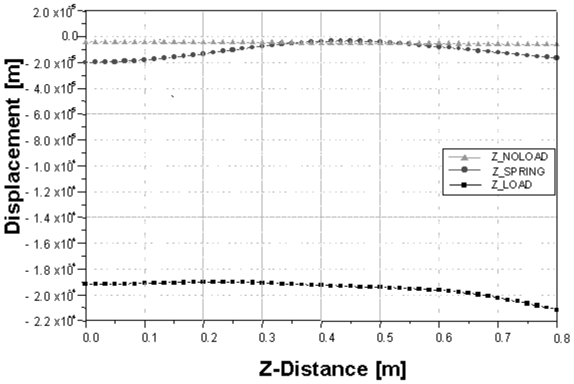

Figure 3. Displacement along Z-direction of backing beam

4. MAGNETIC FIELD MEASUREMENTS AND ANALYSIS

The integrated multipole components of the undulator should be small to be transparent to the stored electron beams. The integrated dipole components of the U10 are specified to be less than 100Gcm for normal and 500Gcm for skew components. To satisfy the requirements, the reproducibility of the measurement system should be better than 10Gcm. The field measurement in PLS has been carried out through Hall probe scan systems. The scan system consists of a linear motion system LMS (Linear Motion System), DVMs (Digital Voltmeters), gauss meters, and computer as shown in Fig. 4. Hall probes assembly is carried along the longitudinal direction by LMS. While Hall probe is moving, the linear scale attached to LMS generates pulses for every 0.5μm move. The absolute position of the Hall probe is measured by counting the pulses, and trigger clocks are generated at every 0.6mm movement for DVMs by the counter. The counter has a filter function to eliminate chattering included pulses, which could generate error during count. Chattering was more severely generated during an acceleration or deceleration than a constant speed motion. Noise of the scan system is minimized by using two isolating grounds, the one for signal part and the other one for LMS part that is major noise source. Two different power lines 120V and 220V are applied to the measurement system to prevent the interference of the power lines. The trigger clocks for DVMs is isolated by photo couplers to reduce interference between analog and digital part. The random noise of the measurement system is less than ±0.6 Gauss.

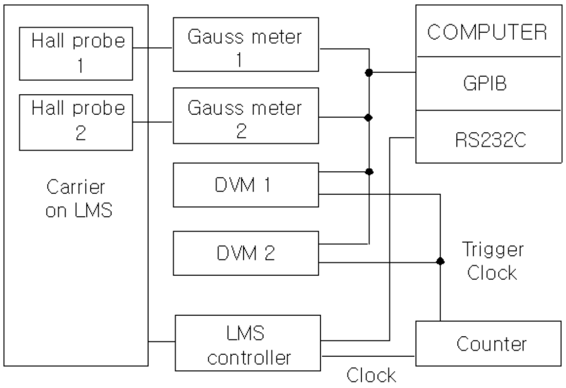

Figure 4. Diagram of measurement system

Fast measurement are required to minimize signal drift due to temperature variation during the scan. The on-line PROM calibration table cannot be used for the measurement because the conversion rate of the gauss meter is about 10Hz, which is too slow considering the required 100 readings/sec. An off-line calibration table to overcome the drawback has been constructed to convert analog output voltage of the gauss meter to magnetic field. The off-line table is separated into the even and odd part to tune the calibration table for precise field integral measurement [2].

Total 3400 data points were measured in a scan, and the data points of voltage were converted to the magnetic fields. The *rms* fluctuations of the peak fields excluding the transient entrance/exit part are 0.2 %. The variations of integrated magnetic fields with gap are shown in Fig 5. It can be seen that it is within 100Gcm requirements. Integrated field profile B_y along the transverse axis was adjusted using the multiple trim magnets at up and down stream sides and the normal component of B_y was compensated by the rotor magnets. Also, the *rms* optical phase errors are estimated to be about 4.5° at 16mm magnet gap.

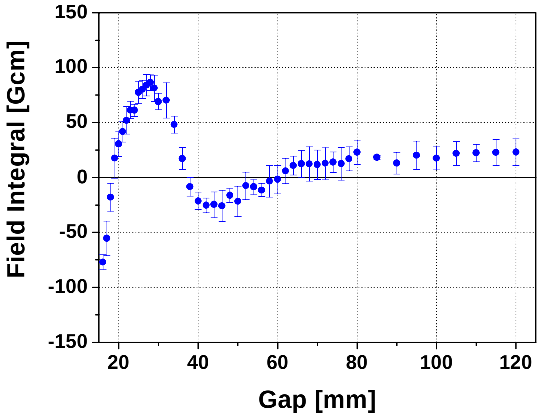

Figure 5. The variations of the field integral vs magnet gap

5. SUMMARY

The wedged-pole hybrid U10 undulator has a 6 % increased effective magnetic field compared with conventional hybrid undulator. The maximum deflections of backing beams are estimated to be about 20 µm with the compensation springs under load of 10 metric tons. And the field integrals are measured to be less than ±100 Gcm in the whole gap range.

ACKNOWLEDGEMENTS

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