

DEVELOPMENT OF 14 CM PERIOD MULTIPOLE WIGGLER AT PLS

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Abstract

Pohang Accelerator Laboratory (PAL) is developing a Multipole Wiggler (MPW14) to utilize high energy ($\sim 30\text{keV}$) synchrotron radiation at Pohang Light Source (PLS). The MPW14 is a hybrid type device achieving higher peak flux density. PLS MPW14 features period of 14cm, minimum gap of 14mm, 24 full field poles, maximum flux density of 2.02 Tesla, and the total magnetic structure length of 2056mm. The peak flux density is higher compared to the other wigglers of similar pole gap and period. The high peak flux density has been achieved by using advanced new magnetic materials and optimised magnetic geometry. The MPW14 will be used in hard x-ray region of 10 keV to 30 keV at 2.5 GeV electron energy. The total photon power is 8.10 kW and the peak power density is $3.13 \text{ kW}/\text{mrad}^2$ at 2.5GeV, 150mA. To facilitate the magnetic measurement and installation, C-type support structure is selected. In this article, all the developments efforts for the PLS MPW14 wiggler are described.

1 INTRODUCTION

Pohang Light Source is a 2.0–2.5GeV 3rd generation synchrotron light source [1]. The critical photon energy of the synchrotron radiation from bending magnet is about 5.48 keV at 2.5 GeV electron energy. To utilize higher photon energy, and more flux, PLS is developing a multipole wiggler that can generate high energy ($\sim 30\text{keV}$) synchrotron radiation for X-ray diffraction and protein crystallography studies. The on-axis critical energy should be greater than 8 keV and central beam line should be able to operate at 3 or 4 times critical photon energy. To achieve the requirements, conventional hybrid type wiggler which uses ferromagnetic poles and permanent magnet blocks is designed [2] and fabricated. The major parameters of the 14cm period multipole wiggler (MPW14) are summarized in Table 1. In this article all the developments efforts for the PLS MPW14 wiggler are

Table 1: Major parameters of the MPW14 based on 2.5GeV and 250mA

Parameters	Value
Period Length [cm]	14
Minimum Pole gap [mm]	14
Device length [m]	2.056
Number of full field poles	24
Peak Field [Tesla]	2.02
Max deflection parameter	26.4
Total Power [kW]	8.30
Peak Power density [kW/mrad^2]	3.13
Maximum ϵ_c at 2.5 GeV [keV]	8.40

described with some preliminary measurement results.

2 MPW14 DEVELOPMENTS

2.1 Physical Mechanical Design

The conventional out vacuum hybrid magnetic configuration consists of NdFeB magnetic blocks and Vanadium Permendur poles. The vertical vacuum chamber clearance is determined to be 10 mm from beam dynamics requirements. Allowing 1mm thick vacuum chamber thickness and 1mm clearance between magnetic structure and vacuum chamber, the minimum pole gap is determined to be 14mm. Vanadium Permendur ferromagnetic pole is used to achieve higher peak field. Also advanced magnetic materials having coercivity of 13.1 kOe, residual magnetic induction 13.6 kG are used to reflect recent advances in rare earth high performance magnetic materials.

The geometry of the pole and magnet blocks are optimised using 3D FEM Ansys code. The ratio of pole and magnetic block is varied while analysing the magnetic flux distribution at the mid plane of the wiggler at a given wiggler period length. The side, top overhang of the blocks are also varied and the effects of them on the peak flux density, flux distributions are evaluated to achieve maximum fan angle and the highest critical photon energy. The major parameters of the MPW14 is listed in Table1.

A C-shape support and drive structure is selected considering the ease of installation and magnetic measurements. Usually, there are undulators using C-shape support frame where the field level is low and magnetic loads are rather small compared to the wiggler. In our case, the length of the magnetic structure is about 2m and the expected magnetic load is about 14tons which is rather large when compared to the undulator case.

To apply the C-shape support/drive structure, detailed structural analysis using commercial FEM code is carried out. Using the symmetry of the problem, only one quarter of the problem is modelled. Backing beam of the MPW14 is constructed using aluminium (A7075). The support points are determined to minimize the deformations of the backing beam coming from the gravity and magnetic force load. The maximum deformation is estimated to be about 270 μm without compensation spring system. Compensation spring system is designed and implemented in the MPW14 to counteract the expected magnetic load of 14tons. According to FEM analysis, the deflection is minimal when 90% of the reaction forces are applied to the backing beam with minimal deformation of 22 μm . Combination of disk springs are used to follow the gap dependence of the magnetic load as far as

possible. The magnetic load and the reacting spring load is shown in Figure 1. In summary, C-shape support/drive structure is used in PLS MPW14 wiggler in spite of the heavy 14 tons of magnetic load.

2.2 Measurement System

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. 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 0.5 μm move. The absolute position of the Hall probe is measured by counting the pulses, and trigger clocks are generated at every 1.0 mm 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 the 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 analogue and digital part. The random noise of the measurement system is less than $\pm 1 \times 10^{-4}$ and the reproducibility of the field integral is about $\pm 10 \text{ Gcm}$.

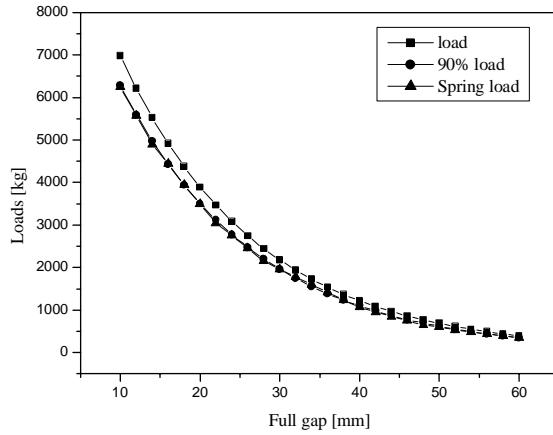


Figure 1. Magnetic load and reaction forces from the compensation spring systems.

3 MEASUREMENTS RESULTS

The measurement results showed good agreements with FEM analysis data. The measured peak field agreed with the calculated one within 1%. The calculated, normalized harmonic field with $n=3,5,7$ is 0.140 , -2.77×10^{-2} , -2.48×10^{-2} while the measured ones are 0.141 , -2.87×10^{-2} ,

-2.48×10^{-2} at the minimum gap of 14mm. For other wiggler gaps, the agreements were good as well. The random fluctuation of the peak fields were less than 0.2%

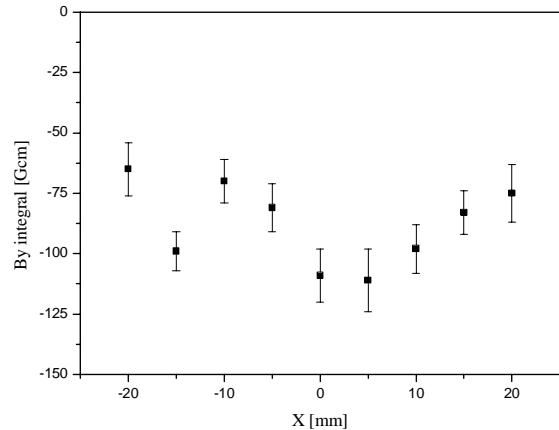


Figure 2. X-dependence of the measured field integral

The dependence of the residual field integral in the transverse direction was corrected using small multiple trim magnet which is similar to ALS undulator [3]. The final residual field integral is levelled to 50 Gcm for ± 20 mm and the results are shown in Figure 2.

The gap dependence of the field integral is also measured. The maximum occurred at the gap of 40 mm with 330 Gcm. This is exceeding the required specification of 100 Gcm and further optimisation will be carried out before the final installation in the PLS in Aug. 2002.

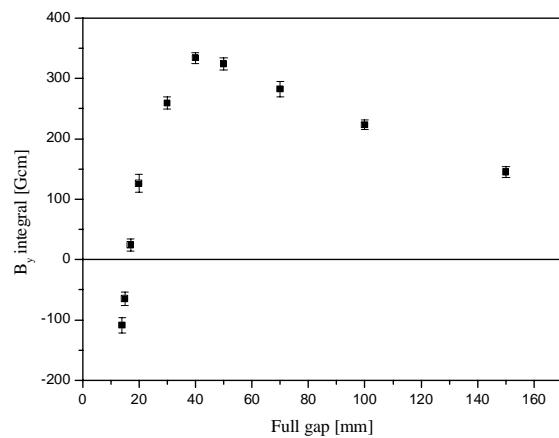


Figure 3. The gap dependence of the field integral.

4 CONCLUSIONS AND SUMMARY

PLS have been developing 14 cm period multipole wiggler for the high flux macromolecular crystallography beam line. It features 2.02 Tesla, 24 poles at minimum magnet gap of 14 mm with C-shape support structures. The preliminary measurements are verifying the design

calculations. The residual field integral is within the specification for transverse direction. But the gap dependence of the field integral is exceeding the requirements and need fine tuning for the installation. Also due to the strong transverse hall effect, the horizontal field integral measurements is non trivial. To calibrate the transverse hall effect, a flipping coil system is being developed.

5 ACKNOWLEDGEMENTS

The authors would like to thank POSCO, and the Ministry of Science and Technology (MOST) of Korea for their support

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