WIGGLERS AT DANFYSIK

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Abstract

In the past 2 years, a number of insertion devices have been designed, assembled and tested at Danfysik. They are used for a variety of applications at free electron lasers and synchrotron radiation facilities. In this paper, we highlight 3 different wiggler projects: A 2.0 T wiggler for Astrid-II in Århus, Denmark, a fixed-gap electromagnetic wiggler for Helmholtz Center Dresden-Rossendorf, and 6 identical damping wigglers for NSLS-2 at Brookhaven National Laboratory (BNL). For the Astrid-2 facility in Aarhus, Denmark, we have designed and built a 6 period wiggler, with a peak field of 2.0 T. The magnetic design and performance is presented and discussed. As part of the ELBE THz facility, at Helmholtz Center Dresden-Rossendorf, we have designed and built a fixed-gap electromagnetic wiggler, with 300 mm period length, and a peak field of 0.39 T. We present the design and magnetic results. For the NSLS-2 project at BNL, damping wigglers are an integral part of the design, both as a means of reducing the emittance, but also as a source of intense radiation sources for users. We present the mechanical and magnetic design, as well as magnetic results obtained for the wigglers.

INTRODUCTION

Danfysik[1] has the ability to deliver all types of insertion devices, including in-vacuum devices, out of vacuum devices, and Apple-II type devices[2,3]. In this short paper, we describe the last 3 wigglers which we have produced, which in their design and application differ greatly.

MAGNETIC DESIGN AND RESULTS

HZDR DRESDEN

Danfysik received the order to design and build a 300 mm period, fixed-gap, electromagnetic wiggler. This wiggler will serve as a source of narrow-band THz radiation in the 100 μm to 10 mm range[4]. It will be operated with electron beams of 15 to 40 MeV, with beam currents up to 1.6 mA.

Magnetic Design

The wiggler was modeled both in RADIA[5] and in Vectorfields OPERA. RADIA was used to get the end termination correct, whereas Vectorfields OPERA was used to double-check the iron losses to make sure we had sufficient current. The field in the pole was approaching 1.9 T, so we felt quite confident that a minimum K_{RMS} of 7.5 could be reached. To achieve the specified double focusing action, we designed a small groove into all of the poles, except the thin end poles. In this way, we achieved a field increase of 0.2 % at 20 mm.

Due to the harsh demands for electron trajectory straightness, the wiggler is powered by 5 independent power supplies, such that the two end poles can be controlled independently, at the entrance and exit, while the central poles are on a common supply. The magnet power supplies are all built by Danfysik, and are summarized in Table 2.

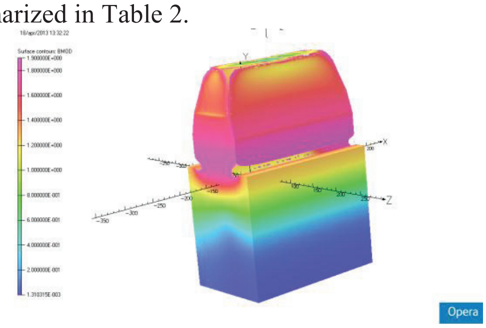

Figure 1: Modelling of a central pole using Vectorfields OPERA. The field is shown up to 1.9 T.

Table 1: Electromagnet Wiggler Specifications

Period Length	300 mm
Number of full-size periods	8
# poles, including end poles	16+2
K_{RMS}	7.76
Peak field	0.38 T
Minimum clear gap	102 mm
Field flatness	+0.2 %

Table 2: Summary of Magnet Power Supplies

MPS type	Quantity	Stability	Max. Current
Central poles	1	10 ppm	625 A
Large end poles	2	10 ppm	235 A
Small end poles	2	10 ppm	200 A

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Magnetic Results

At 625 A, we achieved a K_{RMS} value of 7.76, which is above the specified 7.5. We also found an RMS phase error of 1.23°. The electron straightness was found to be excellent, as is seen from Figure 2 and Figure 3

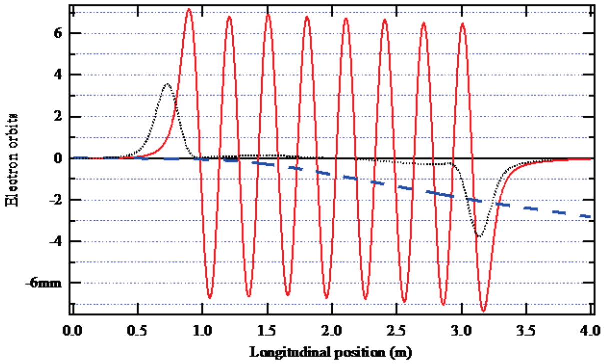

Figure 2: Simulated electron trajectory based on Hall measurements, for K_{RMS}=7.76. Electron energy is set to 40 MeV.

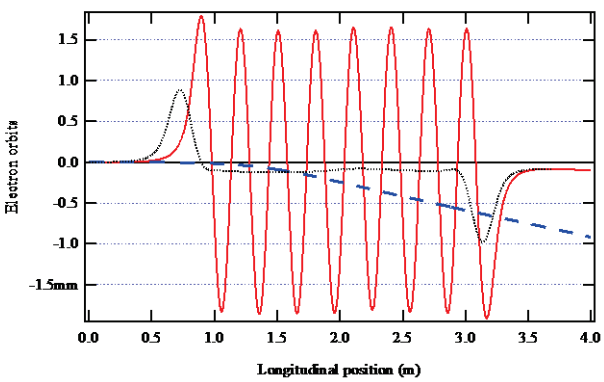

Figure 3: Simulated electron trajectory based on Hall measurements, for K_{RMS}=2. Electron energy is set to 40 MeV.

As is clear from Figure 2 and Figure 3, there is a small horizontal field, which is generating a vertical kick of the electron, shown as the dashed curve. This will be corrected using a short horizontal steering coil.

2.0 T WIGGLER FOR ASTRID-2

Danfysik received the order to design and build a 116 mm multipole wiggler(MPW) for ASTRID 2 in Århus, Denmark[6]. ASTRID 2 is a 580 MeV energy ring, with a horizontal emittance of 12 nm, which can produce synchrotron radiation from a few eV to the 1 keV range. The MPW is designed to maximize the flux of photons in the region of 500 eV to 1500 eV, with a small horizontal angle.

Magnetic Design

The magnetic design was carried out using RADIA and Vectorfields OPERA. RADIA was used to determine the central design and the sections, and Vectorfields OPERA was used to study demagnetization in the magnet blocks. The chamfer on the magnet block, toward the magnet gap was optimized in order to reduce the risk of demagnetization during operation.

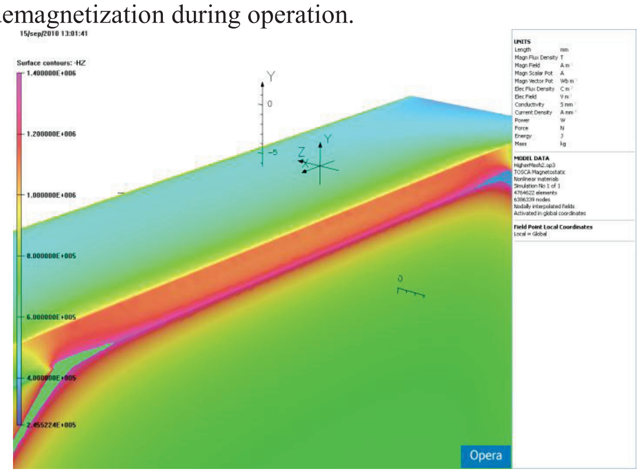

Figure 4: Magnetic field, shown near the magnetic gap, shown up to 1400 kA/m.

Furthermore, to minimize the horizontal angle where the flux of photons is propagating, the pole was optimized such that the peak field quickly decayed from 2.0 T to below 1.0 T.

Magnetic Results

We were able to shim the device satisfactorily to the specifications with little interaction effects versus gap.

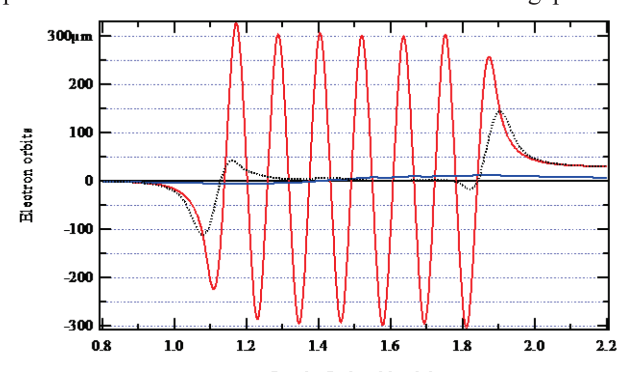

Figure 5: Simulated electron trajectory based on Hall measurements. Electron energy is set to 580 MeV.

A peak field of 2.01 T was achieved at 12 mm gap, and a K-value of 21.76. The electron orbit after shimming is seen in Figure 5.

In Figure 6, we show the finished wiggler, after shimming and installation of the window-frame corrector magnets.

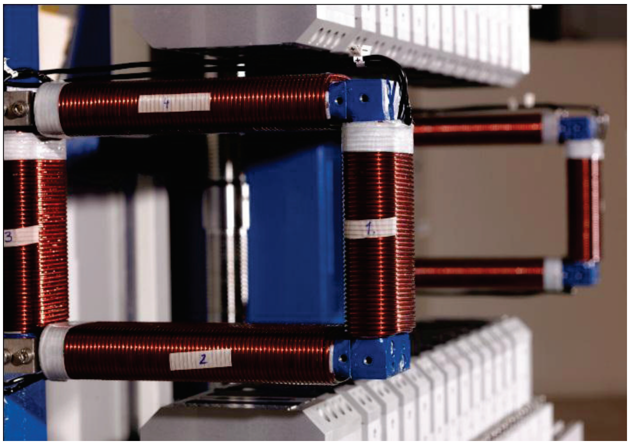

Figure 6: Finished ISA wiggler, with installed window-frame correctors.

1.8 T DAMPING WIGGLERS FOR NSLS-II

At NSLS-II, the third-generation light source being built at Brookhaven National Laboratories, damping wigglers are used to reduce the emittance of 2 nm, by a factor of 2[7]. The wigglers will also serve as intense radiation sources. As the wigglers are working at a fixed gap, they are incorporated into the lattice. Danfysik received the order to build 6 damping wigglers.

The period length is 100 mm, and each device is 3.4 m meters long. The pole width is 90 mm, thus calling for very large glued magnet blocks.

Magnetic Design

The magnetic design is carried out using RADIA and Vectorfields OPERA. The end section was optimized using RADIA to give minimal vertical interaction when changing the gap.

The sorting strategy is based on measuring the main magnet blocks with a stretch-wire system, and subsequently building a sorting list based on the integral values obtained. The wigglers were assembled off-line, away from the measuring bench. After mounting, the device is moved into the shimming area, where it is shimmed on the basis of local Hall probe measurements, see Figure 8. The results are shown, for 15 mm gap, in Figure 7 and Figure 9.

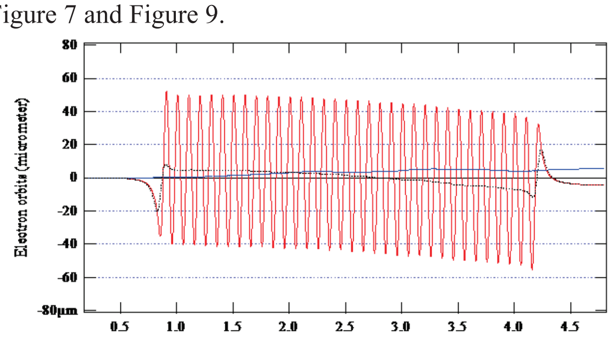

Figure 7: Simulated electron trajectory based on Hall measurements. Electron energy is set to 3GeV.

Figure 8: Damping wiggler for NSLS-II being shimmed.

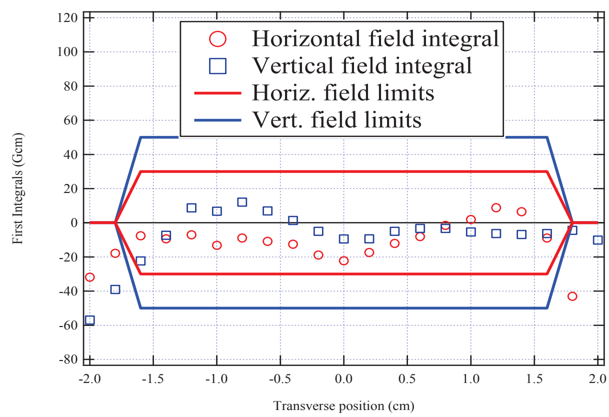

Figure 9: First integral measurements, including specification limits, for First Article wiggler.

CONCLUSION

We have presented 3 different wigglers, recently produced by Danfysik. A high level of magnetic performance was found for all 3, owing to careful design, measurement, and shimming.

REFERENCES

[1] http://www.danfysik.com
[2] F. Bødker, M.N. Pedersen, C.W. Ostenfeld, E. Juul, E.B. Christensen, T.L. Svendsen, H. Bach. EPAC06.
[3] C.W. Ostenfeld, F. Bødker, M.N. Pedersen, E.B. Christensen, M. Bøttcher, H. Bach PAC07.
[4] http://www.hzdr.de
[5] http://www.esrf.eu
[6] http://www.isa.au.dk/facilities/astrid2/astrid2.asp
[7] http://www.bnl.gov/ps/nsls2/about-NSLS-II.asp

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