MECHANICAL DESIGN OF SHIFT DRIVING SYSTEM FOR DEPU AT SSRF

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Abstract

Double elliptically polarized undulator (DEPU) for a soft X-ray beamline for ARPES and PEEM is being built at SSRF. In DEPU, two EPUs with different period lengths have the roughly same magnet array lengths and share a common H style frame. The shift driving systems for polarization adjustment, which are set on top of the backing beams for the constraint of space, are sophisticated designed to assure position stability under longitudinal magnet force change. Finite-element analyses are also performed to guarantee the rigidity of the systems. The system performance is tested under full operation range and the results are described in this paper.

INTRODUCTION

A soft X-ray beamline for ARPES and PEEM is being built at SSRF. The source will be a pair of EPUs covering the energy ranges from 20 to 200eV and from 200 to 2000eV of arbitrary polarized light with the first and third harmonics [1]. Table 1 lists the main parameters and specifications of the DEPU. In DEPU, Two EPUs have the different period lengths but the roughly same magnet array lengths and share a common support system with H-type due to the constraint of space. The whole structure is seated on a base with linear guides, which enables transverse movement for selecting the working EPU. Particular attention has been paid to the shift driving systems of mechanical design for DEPU to assure position stability under great longitudinal magnet force change.

Table 1: Main Parameters of DEPU

	EPU58	EPU148
Period length(mm)	58	148
Number of periods	84	32
Beam length (mm)	4968	4884
Gap range (mm)	16.5-120	22-130
Shift range (mm)	±29	±74

SHIFT DRIVING SYSTEMS IN DEPU

Just as shown in Fig.1, DEPU consists of H-style frame, EPU58 (a high energy EPU), EPU148(a low energy EPU), a mobile base and adjustable feet. Two EPUs parallel with each other and each EPU is driving by separate drive and control systems. There are totally 13 drive systems in DEPU: upper/lower beam in EPU148/ EPU58 is operated by two drive systems (totally eight); each mobile beam is operated by a drive system (totally four); the mobile base is operated by a drive system. Each drive system is composed of a servo motor, a worm gearbox, a ball screw, a linear guide, electrical and mechanical limiters. Eight drive systems for upper/lower backing beams are installed on transversely connecting girders of support frame while four systems for mobile beams are fastened to the backing beams. Each mobile beam is driven by a servomotor to change relative longitudinal position for the polarization of magnetic field. [2]

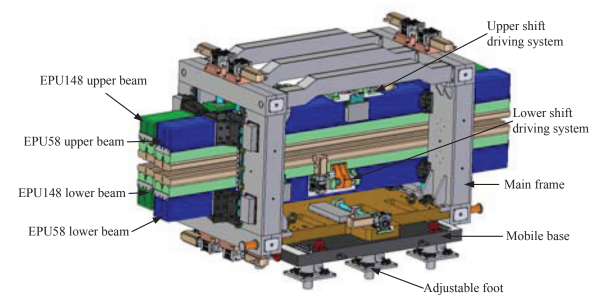

Figure 1: Global mechanical structure of DEPU.

The distance of upper backing beam between EPU58 and EPU148 is only 100mm. Shift driving system is installed on top of upper backing beam, rather than on the side of backing beam which is the position of lower shift driving system, in order to drive upper mobile beam which moves longitudinally along fixed beam, just as shown in Fig. 2. Maximum longitudinal load of EPU58 is 1.9T while that of EPU148 is 0.6T. The challenge is the mechanical design of upper shift driving system, especially that of high energy EPU, EPU58.

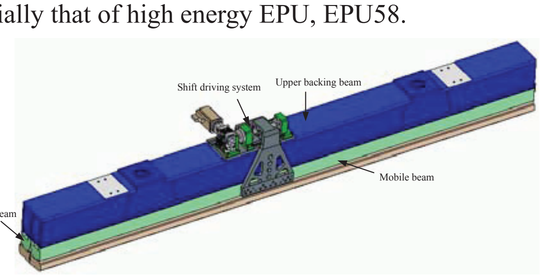

Figure 2: Shift driving system on top of backing beam in DEPU.

Similar to shift driving system for lower beam, the original mechanical design of shift driving system for upper beam is shown in Fig. 3(a). The arm length of upper shift driving system is 500mm while that in lower shift driving system is 200mm. Since maximum longitudinal load of EPU58 is 1.9T， the mechanical design of arm which links ball screw and mobile beam is sophisticated designed to assure position stability under such longitudinal magnet force change.

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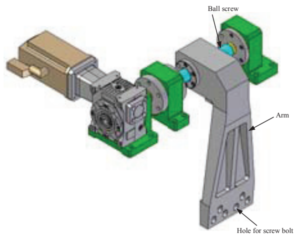
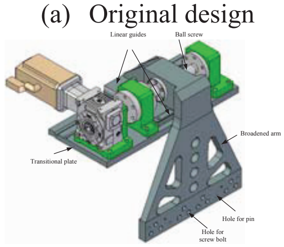


(a) Original design



(b) Broadened arm design

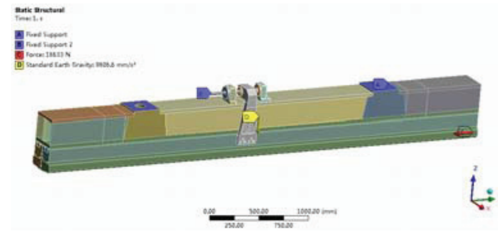
Figure 3: Mechanical design of shift driving system for upper beam.

Figure 3(b) is the broadened arm design based on Fig. 3(a). The arm which links ball screw and the mobile beam in upper shift driving system is twice as wide as that of lower shift driving system. Holes are carefully made in the triangular region of the steel arm in order to reduce the weight while remaining the strength of arm. At the same time, aside from 12 M12 screw bolts which attach the steel arm to the aluminum mobile beam, 6 Φ10 pins are added to fasten the linkage between arm and mobile beam. In order to protect ball screw and assure smooth movement of the driving system, two linear guides are added paralleling ball screw. The whole shift driving system is seated on a transitional plate so that the whole system is made detachable for ease of installation on the top of upper steel backing beam.

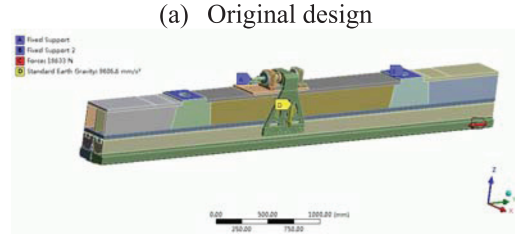
SIMULATIONS AND TEST RESULTS

Finite element analyses of these two schemes are carried to compare the mechanical stability of these two schemes of shift driving system. Figure 4 shows computational model of shift driving system in EPU58 when the mobile beam suffers maximum longitudinal load 1.9t. The magnet load is applied as surface force. Contact surfaces are used in the finite element to simulate linear guides.

Figure 5 shows longitudinal displacement of shift driving system in the two schemes. It can be seen that the maximum displacement of broadened arm is much smaller than that in original design and such mechanical design guarantees position stability under longitudinal magnet force change. Therefore, the final shift driving system for upper beam is manufactured according to broadened arm scheme. The picture of finished driving system is shown in Fig. 6. The assembled shift driving system for upper beam in DEPU is shown in Fig. 7.

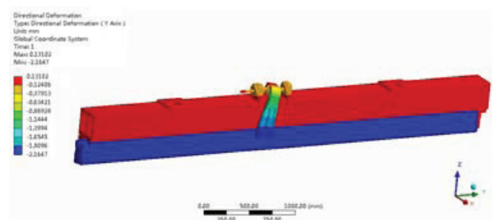


(a) Original design

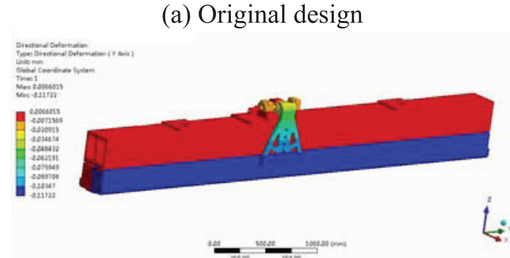


(b) Broadened arm design

Figure 4: Computational model.



(a) Original design



(b) Broadened arm design

Figure 5: Computational results (mm).

Figure 6: Manufactured shift driving system.

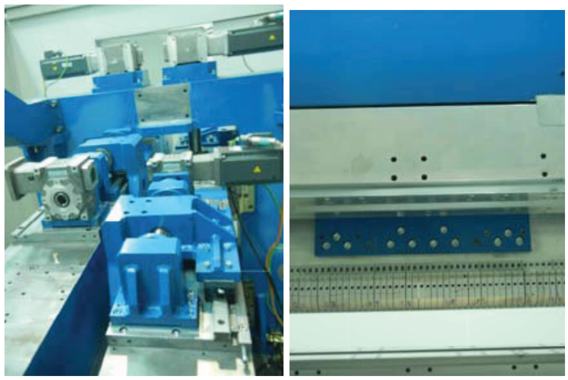


Figure 7: Assembled shift driving system.

After assembling shift driving system with upper beam in DEPU, 5 dial indicators are set to test the rigidity of such driving system. Figure 8 shows gauges for longitudinal displacement of shift driving system。Dial indicator1 tests the movement of mobile beam. Dial indicators 2 and 3 test the movements of arm which links the mobile beam and ball screw. Dial indicators 4 and 5 test the movements of transitional plate.

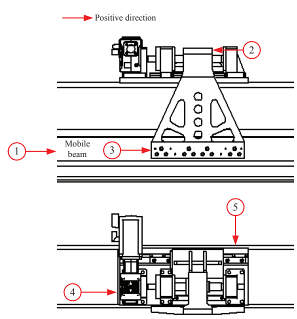


Figure 8: Gauges for longitudinal displacement of shift driving system.

Table 2 shows test results of readings for these 5 dial indicators. It can be seen that the broadened arm holds the mobile beam strongly and the mobile beam moves smoothly by the shift driving system.

CONCLUSIONS

The shift driving systems for polarization adjustment of DEPU, which are set on top of the backing beams for the constraint of space, are sophisticated designed to assure position stability under great longitudinal magnet force change. Two schemes of shift driving systems including arm, broadened arm companied with linear guides and transitional plate have been investigated in finite-element analyses. By changing the arm in the initial design with broadened arm, longitudinal displacement change of shift driving system under maximum longitudinal magnet force has diminished. In the mean time, tests for longitudinal displacement of actual shift driving system also show that the mechanical design of shift driving systems for are reliable and stable. DEPU was installed in cell 9 at SSRF on Feb. 2, 2013 and it works well now.

Table 2: Test Results

Distance	1	1	1	1	2	2
Gauge1	1	1	1	1	2	2
Gauge2	1.04	1.04	1.02	1.03	2.05	2.03
Gauge3	0	0	0	0	0.01	0.012
Gauge4	0	0	0	0	0	0
Gauge5	0	0	0	0	0	0
Distance	2	2	3	2	2	1
Gauge1	2	2	3	2	2	1
Gauge2	2.035	2.02	3.025	2.015	2.005	1
Gauge3	0.012	0.012	0.012	0.012	0.012	0.012
Gauge4	0	0	0	0	0	0
Gauge5	0	0	3	2	2	1
Distance	1	1	1	2	2	2
Gauge1	1	1	1	2	2	2
Gauge2	1.01	1.005	1.005	1.95	1.96	1.95
Gauge3	0.012	0.011	0.011	0.011	0.011	0.003
Gauge4	0	0	0	0	0	0
Gauge5	0	0	0	0	0	0
Distance	-2	-2	-2	2	2	2
Gauge1	-2	-2	-2	2	2	2
Gauge2	-1.96	-1.96	-2	1.99	1.955	1.96
Gauge3	0	-0.005	0	0.01	0.007	0.002
Gauge4	0	0	0	0	0	0
Gauge5	0	0	0	0	0	0

REFERENCES

[1] R. Reininger, "Optical design of the Dreamline at SSRF", August 9, 2009.
[2] SSRF, DEPU Conceptual Design Report, February, 2011.

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