LATEST PROGRESS OF MAGNET GIRDER PROTOTYPES FOR HEPS-TF

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Abstract

The magnet girder technology is one of the key technologies which should be overcome in the stage of HEPS-TF (Test Facility of High Energy Photon Source). The girder should be beam-based aligned, and must has high adjusting precision and high stability as well. For these issues, two girder systems are designed and developed. This paper will describe the latest progress of the girder prototypes, including structure design updates, control system progress, and processing and assembling of Girder I prototype.

INTRODUCTION

HEPS is one proposed high energy photon source with extremely high spectral luminance after built up. The girder technology is one of the key technologies in the stage of HEPS-TF. The design aim of the alignment accuracy between girders is within 50 μm, and the adjusting resolution is within 3μm. The design aim of the natural frequency is above 30 Hz.

Cam mover mechanisms are used as the basic design, because of the flexibility and accuracy in adjusting, which can save manpower and time [1-2]. There are two types of girder prototypes needed to be developed, for the straight multiplet and FODO section respectively, which are shown in Fig. 1. The Girder I is for straight multiplet with the length of 3300mm and having 6 axes. While Girder II is for FODO section with the length of 4300 mm and having 8 axes. The overall designs were described in previous work [3].

Now the structure design of girder prototypes are finished. Girder I is now being assembled and tested. The design of Girder II has been finished, the processing will begin after design requirements achievement of Girder I and some detail updates from the experience of Girder I.

STRUCTURE OPTIMIZATION OF GIRDER II

To minimize the deformation and improve the stability of the girder system, topology optimization was first used in girder design area. The optimization of Girder II is very similar to that of Girder I [3]. Take the volume as the constraint, the aims are structure supple degree and natural frequency separately. The reserved elements are shown is Fig. 2.

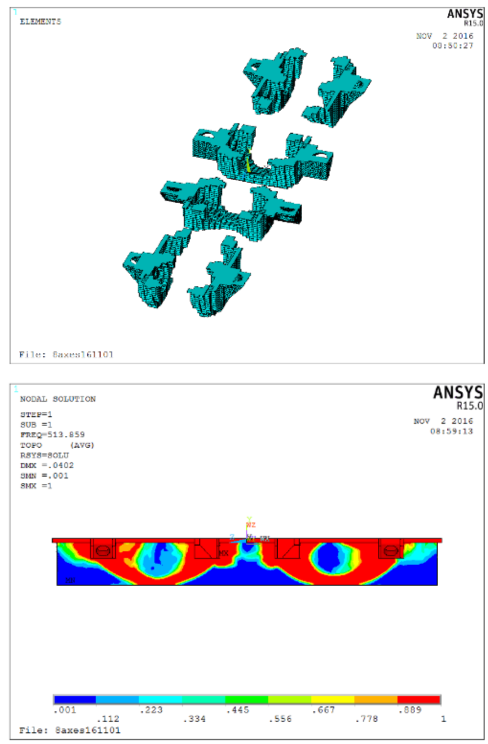

Figure 2: Topology optimization of 8-axes Girder body. U: structural optimization; D: modal optimization.

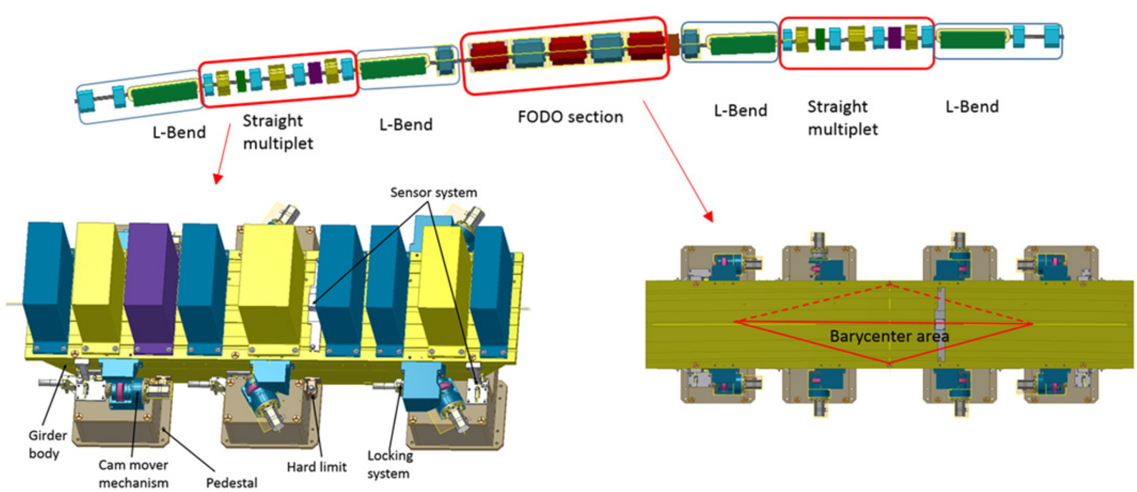

Figure 1: Overall designs of girder prototypes for HEPS-TF.

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The primary target is to minimize the deformation of the girder, so the structure design mainly uses the result of structure supple degree optimization. Simple structure and good manufacturability are also considerations. The final design of the girder body of Girder II is shown in Fig. 3. For comparison, the integral analyses are done, assuming all the contacts are rigid. The results are not realistic because the calculation assuming, but they can show the tendency, which are listed in Table 1. The detailed data needs further analyses and tests.

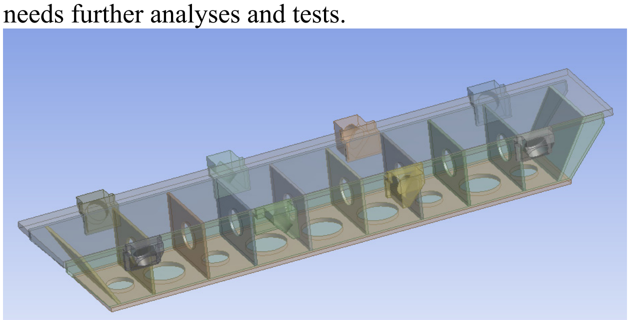

Figure 3: Structure of the girder body of Girder II.

Table 1: Optimization Comparison of the 8-axes Girder System

	Girder system before optimization	Girder system after optimization
Deformation of top plate (μm)	15.2	7.6
Natural frequency (Hz)	65.9	68.9

PROGRESS OF THE CONTROL SYSTEM

The control system of the girders for HEPS-TF will uses the Beckhoff controller and EtherCAT. Figure 4 shows the control scheme of girder I. There are one inclination sensor and eight absolute length gauges, which are used for the detection of girder translation and rotation. The 6-axes cam mover mechanism needs 6 stepping motors, and

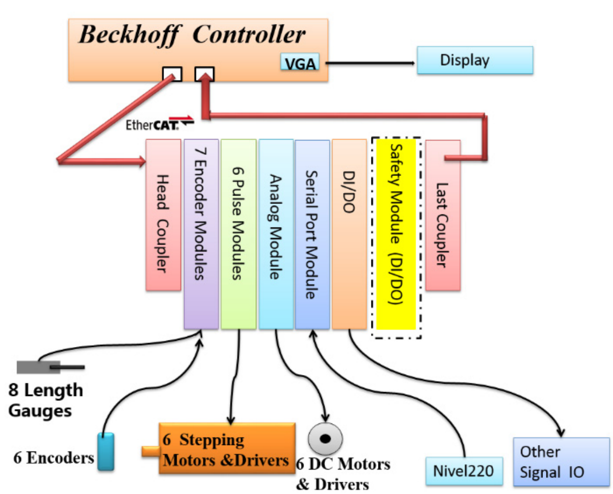

Figure 4: Control scheme of girder I.

also 6 encoders to detect the rotations of the shafts. The 6 DC motors are used for locking systems. Besides, there are some basic I/O signals. For Girder II, the control scheme is almost the same, except that the 6 stepping motors are replaced by 8 servo motors.

The adjusting algorithm of the girder location is developed in Simulink, for its convenience in matrix calculation and friendly interface. The flow diagram is shown in Fig. 5. The rotation of girder body will be adjusted first because it has certain coupling effect on translation calculation. The sensors reads the state of girder body, if adjusting needed, the algorithm will calculate the angle of each motor, then the motors are driven by Bechhoff controller. After one step of adjustment, the sensors will read the status of girder body again, the location of girder body is adjusted step by step.

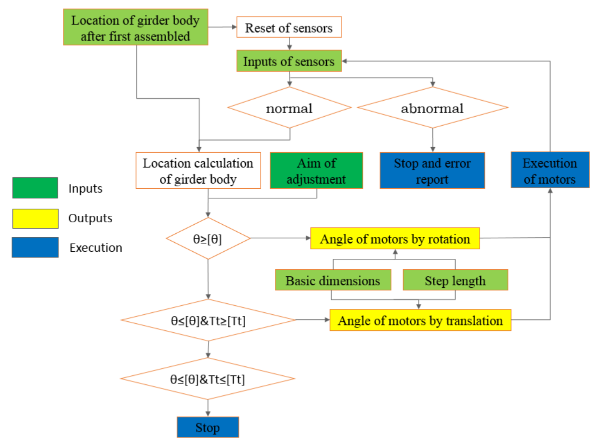

Figure 5: Flow diagram of the girder adjusting algorithm.

PROCESSING AND ASSEMBLING OF GIRDER I

The processing of Girder I has been finished. And it is now under detection and assembling, which are shown in Figure 6-9. The girder body and pedestals are welding parts, sufficient stress relieving was done before finish machining. The cam mechanisms have been mounted to pedestals, which composes the supports of girder body and magnets. The ball transfer units have been mounted to girder body, the ball transfer units will be contacted with the cams. Other parts, including the locking system which will be placed between pedestals and girder body to increase natural frequency, the hard limits which are designed for safety, and processing parts of sensor systems are all sub-assembled. Detailed detections are being done now before the integral assembling, especially for the location calibration and performance tests of each subassembly. Until now, the detections of each component have been done. The location calibration of the cam-pedestal, the ball transfer unit-girder body are almost finished. The performance tests of cam mechanisms and locking systems are being debugged.

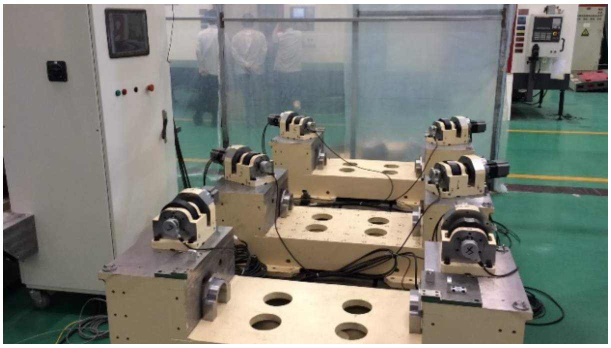
Figure 6: Pedestals and cam mechanisms.


Figure 7: Girder body and ball transfer units.


Figure 8: Calibration and test of the cam and ball transfer unit.

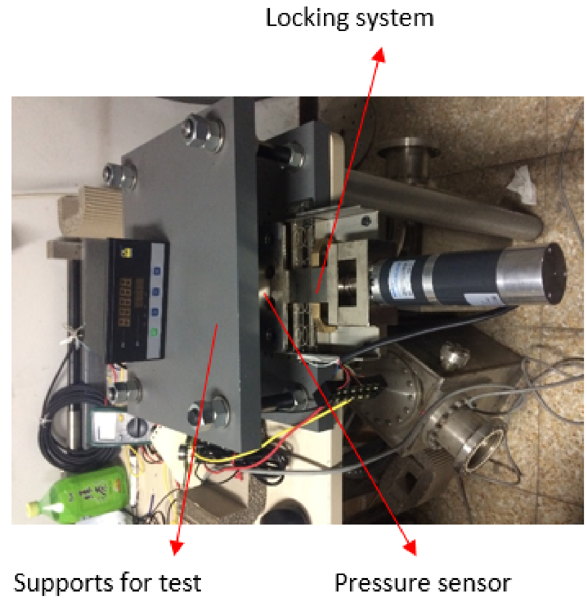

Figure 9: Test assembly of locking system.

CONCLUSION

The girder technology is extremely important to HEPS-TF. The two types of prototypes are being developed. This paper described the latest progress of the two prototypes. The further study will focus on the assembly and test of Girder I, and the improvement of Girder II based on the experiences from Girder I. Besides, the vibration and stability of the girder system should be given seriously consideration.

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