Design Concept for a Standard C-Frame Support Structure for Insertion Devices

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Introduction

A standard C-frame mechanical structure with highly reproducible gap motion and mechanical stability is necessary for the various insertion device. The factors considered for the C-frame design consequently include :

- Cost
- Rigidity
- Practicality
- Assembly
- Physical Limits
- ...

The eventual integrated device with magnet assemblies easily will readily achieve the requirements of enhanced stability and reproducibility of this light source. The purpose of this work is thus to provide a feasible main-frame body as a common base for arranging the magnet rows of ID.

Requirement, Limitation and Configuration

Table 1: Main Parameters of TPS Insertion Devices

Ee (GeV)		EPU10*	EPU7	EPU4.6	IU2.8	CU1.8
3						
Photon energy / keV	HP	0.014-4	0.055-5.7	0.3-8.7	0.81-14.25	1.35-22.2
	VP	0.02-4	0.09-5.7	0.58-8.7		
Current / A		0.4	0.4	0.4	0.4	0.4
λ / cm		10	7	4.6	2.8	1.8
N_{period}		88	64	97	160	250
By / T		1.14	1	0.76	0.9	1.34
Bx / T		0.99	0.77	0.49		
Ky_{max}		10.65	6.54	3.27	2.35	2.25
Kx_{max}		9.25	5.03	2.11	0	0
L / m		8.8	4.48	4.462	4.48	4.5
Gap / mm		15	15	15	7	5
F_{mag} / kN		179.5	60.3	32.97	33.69	39.04
Peak Power density / $kWmr^{-2}$		35.23	22.48	25.89	50.58	117.66
Total power / kW		26.06	10.21	5.87	8.27	18.41
Type		Pure	Pure	Pure	Hybrid	Hybrid

* *The ID of special types are not be discussed in this paper.*

Table 2: Engineering Dimensions of an ID in a Short Straight Section

Profile	Dimension or Mass
From ground to electron-beam trajectory	1350 mm
Overall vertical height	2800 mm
Overall longitudinal length	4500 mm
Segmentation length	2200 mm
Overall transversal width	1300 mm
Transverse width to right side of beam*	800 mm
Transverse width to left side of beam*	500 mm
Overhang crane capacity	12 ton

* *View from upstream to downstream.*

Table 3: Engineering Requirements and Specifications (under worst conditions)

Item	Quantity
Min. / Max. Gap / mm	4.5-100
Magnetic force / kN	60
Allowed girder deformation / μm	≤ ± 3
Change gap accuracy / μm	≤ 3
Taper control / μm	≤ ± 3
Temperature stability / ℃	± 0.35

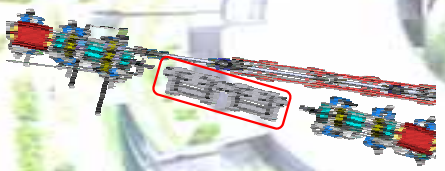


Figure 1 shows the TPS lattice design and space limitations of the configuration. An ID planed to be placed in a red circle rectangular area will not allowed interfere with the front end or beam line; the geometric profile of an ID is hence determined by the boundary conditions set by the lattice distribution, overhanging crane capacity and buildings.

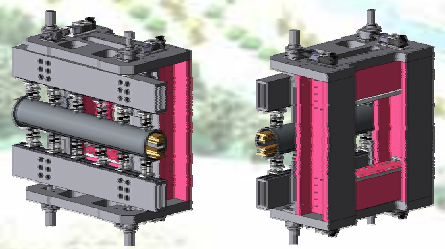
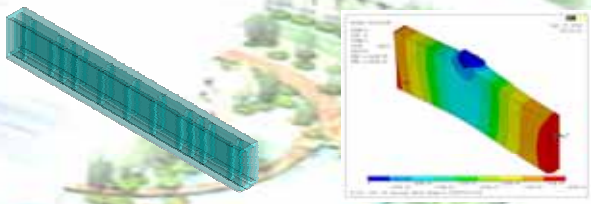


Figure 2 presents a 3D view of the Support and Transmission System (STS) without the retraction and transport systems adopted in a 2.2 m IU2.8 segmentation that consists of almost standard components, with only a few parts need for machining and welding.

FEM Simulation

Girder Analysis

To attain a robust girder, girders of various cross sections assembled from standard parts such as an H-section beam, I-section beam and channel etc. will be taken into account. A girder integrated with an H-section beam, enhanced ribs and side plates will be adopted as shown in Fig.4(a). According to Fig.4 (b) the maximum deflection of the upper girder in the worst situation is about 4 μm, but also resulting in a flatness variance of the surface of the girder that is connected with the beam in vacuum only 3 μm deviation, consistent with the specification.



(a) Conceptual design *(b) FEA Result of the upper girder*

Figure 4. Girder outside the vacuum

STS Analysis

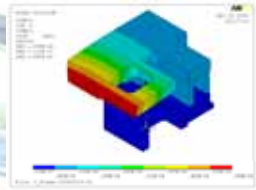


Figure 5 explains the maximum deformation under a maximum force 6 tons is approximately 0.06 mm, but the deformation of the vertical column used to constrain transverse motion of the girder outside the vacuum with linear guides appears to minimize displacement to an order of micrometer to meet the high precision required. Based on this design concept, the error of gap position will be compensated from the encoder recorded with closed-loop control.

Conclusion

- The conceptual design of a STS and girder that has been investigated is proved feasible, and therefore it readily applicable for similar ID equipment.
- But another support and an altered device for gap motion consisting of a ball screw with travel nuts slightly modifying the present design might be a solution for the STS.
- For a high-performance machine base, supported structure systems of other kinds will be simulated continuously.

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