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Design and test of precision mechanics for High Energy Resolution Monochromator at the HEPS

Lu Zhang, Hao Liang†,1, Wei Xu[1], Zekuan Liu, Yang Yang, Yunsheng Zhang

Institute of High Energy Physics, [100049] Beijing, China, [1]also at University of Chinese Academy of Sciences, School of Physics, [100049] Beijing, China

INTRODUCTION

The Nuclear Resonance Scattering (NRS) spectroscopy at High Energy Photon Source (HEPS) demands extremely high energy-resolving power better than 10^{-7}. The high resolution monochromator (HRM) shall maintain a high stability in terms of positioning, which could influence the energy precision as well as the beam stability at sample position, at fourth generation sources like HEPS. In the proposed monochromator configuration , the range for fine pitch adjustment mechanism is relatively small. There also lacks an integrated angular sensing measurement device, thus real time precise tracking of fine pitch position is not possible. By referring to the previous design from APS and PETRA III, we have designed a new compact HRM mechanism with an *in-situ* metrology framework. This newly designed flexure mechanism is promising in increasing the stroke while minimizing errors of measurement system through highly rigid metrology devices. The developed mechanism successfully balances requirements between large travel range and high stability. In this poster, we will present the concept, simulation and offline measurements of the new HRM.

MECHANICAL DESIGN

According to the optical design, the HRM comprises two pairs of pseudo channel-cut crystals, with each pair being secured and adjusted by a pose adjustment mechanism. Consequently, the HRM is equipped with two pose adjustment mechanisms for each pair of pseudo channel-cut crystals.

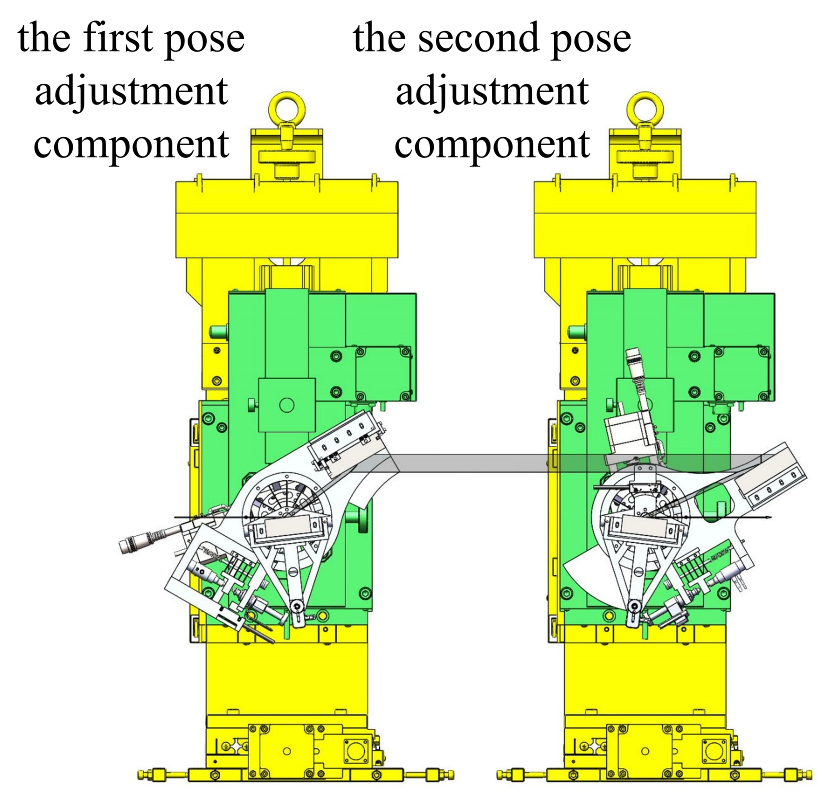

Figure 1: Mechanical design of the HRM.

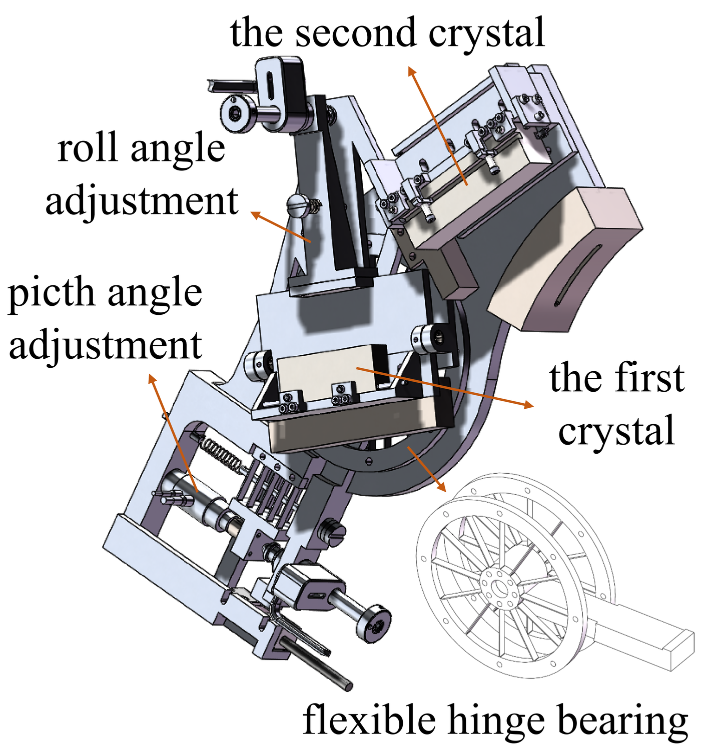

Figure 2: The first pose adjustment component.

FINITE ELEMENT ANALYSIS

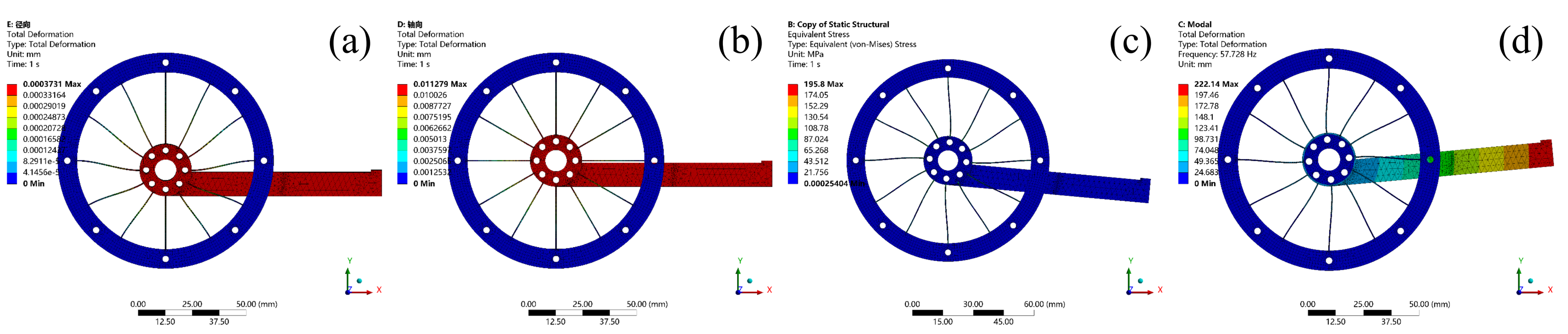

Figure 3: FEA of the flexible hinge bearing. (a) Radial stiffness:26802 N/mm, (b) axial stiffness:886 N/mm, (c) stress:196 MPa and (d) modal:58 Hz.

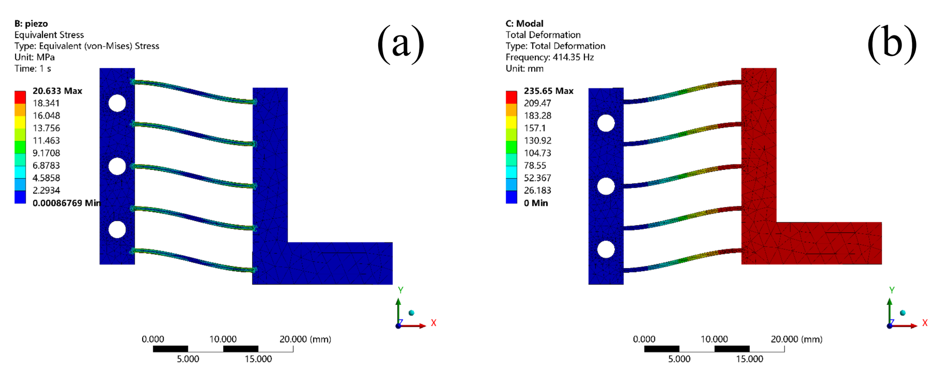

Figure 4: FEA of the flexible guide mechanism. (a) Stress:21 MPa and (b) modal:414 Hz.

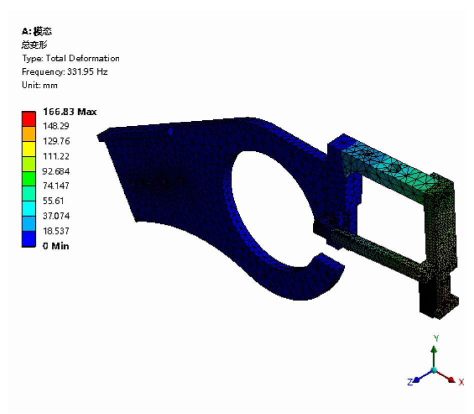

Figure 5: Modal FEA of the measurement structure:331 Hz.

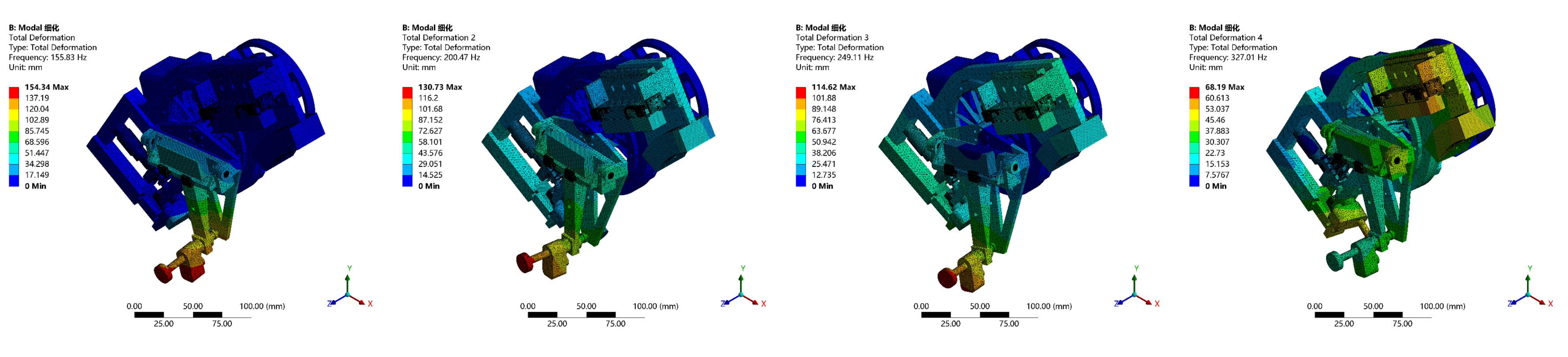

Figure 6: Modal FEA of the pose adjustment component: 155 Hz.

OFFLINE TEST

Preliminary testing of the precision pose adjustment mechanism has been conducted. The two sets of pose adjustment mechanisms have been individually affixed to KOHZU's three-axis motorized stages, KTG and KHI. The motor's base is bolted to a granite table via an adapter. The granite table is positioned on the ground support-ed by 4 wedge blocks.

Figure 7: Experimental device.

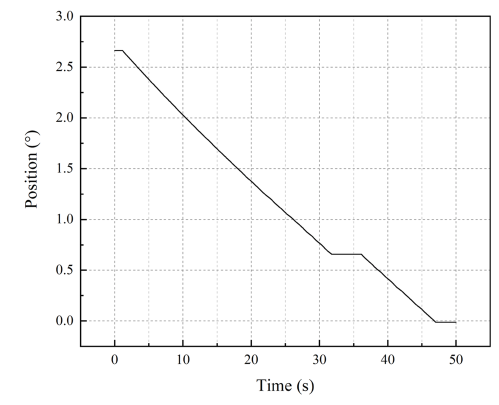

Figure 8: Stroke test of coarse pitch: ±1.3°.

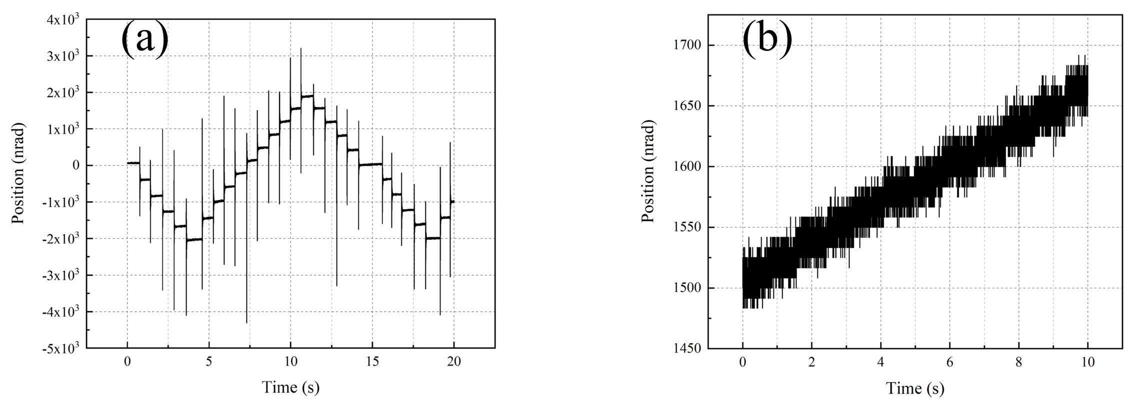

Figure 9: Resolution test. (a) Coarse adjustment resolution:250 nrad and (b) fine adjustment resolution:8.3 nrad.

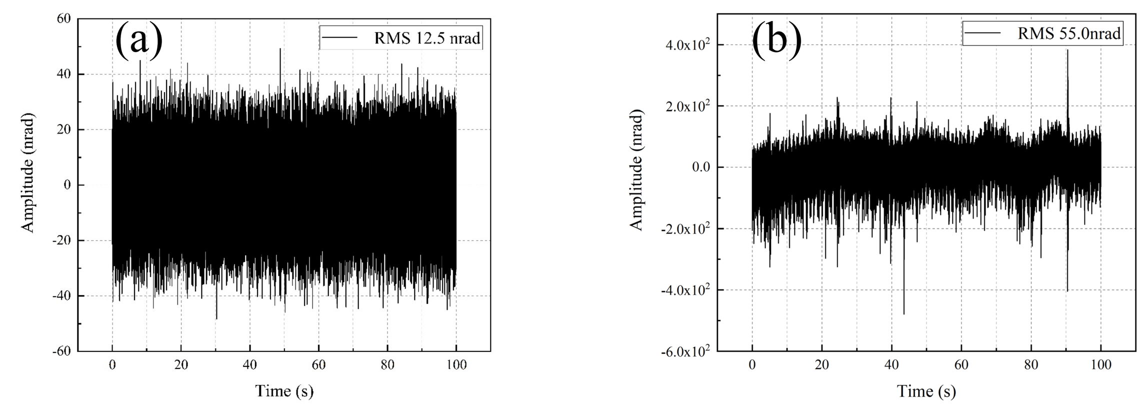

Figure 10: Stability test. (a) The stability between the first and second crystals:12.5 nrad RMS (0.5-500Hz) and (b) the stability between the first and second mechanisms:55.0 nrad RMS (0.5-500Hz).

CONCLUSION

The precision adjustment mechanism incorporated within the HRM has been designed to address the de-mands for large stroke and high accuracy. FEA results confirm the viability of this solution, and experimental testing validates the efficiency of the design. In the future, the designed HRM will be tested under conditions more similar to its final locations. The current results demonstrate that the newly developed HRM can offer dependable optical modulation capabilities for the high energy resolution beamline of HEPS.

ACKNOWLEDGEMENTS

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