

DEVELOPMENT OF CUSTOM HIGH PRECISION MOTION SYSTEM TO MANIPULATE A 7 TON PRESS

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Abstract

In this paper ADC will discuss the design and test results for a custom high precision motion system to manipulate a 7 ton press (fabricated by Rockland Research Corporation). The system was installed at Beamline X17B2 NSLS for High Pressure Mineral Physics research. The beamline contains 0.391 mm of graphite filters, .500 mm silicon filter, and 2.0 mm of beryllium windows. The experimental apparatus consists of a large volume (~1 cu mm) multi-anvil press in either cubic or octahedral mode, providing pressures up to 29 GPa and temperatures up to 2000 K.

OVERVIEW

The Multi-Anvil Cell X-ray (X17 MAC) facility at the National Synchrotron Light Source (NSLS) is one of the leading dedicated high-pressure beamlines in the world. The X17 MAC facility is best known for the development of high pressure and high temperature experimental deformation/rheological techniques and in situ ultrasonic interferometry experiments at extreme conditions [1]. The X17 MAC facility is located on a superconducting wiggler beam line (X17B2) and contains two Multi-Anvil presses; a 1000-ton press with various compressional modules (BAM11) that utilizes white X-Ray beam [2], and a side station with a 200-ton modified Paris-Edinburgh style press that utilizes monochromatic X-Ray beam (B2SS).

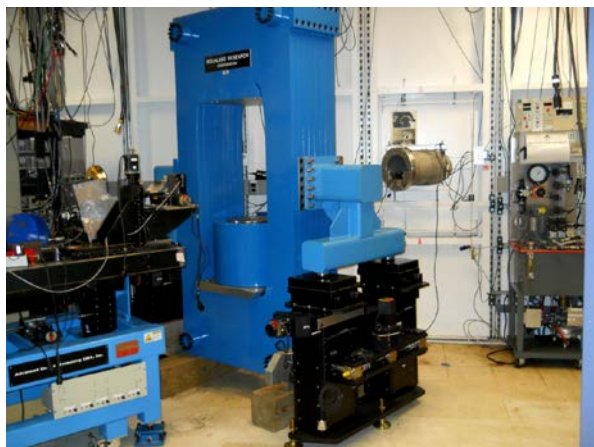


Figure 1: Press and Manipulator

MOTION SYSTEM DESIGN

The complete press and manipulator can be seen in Figure 1 to the left. The press frame has 8 plates 17" wide bolted together with each plate having 32 - 3/4" holes tapped on the side. Additional holes were provided near the elevation of the sample for attaching angle brackets for ADC's motion system supports. The design uses 2 jacks on each side, designed as close together as possible on the right side looking downstream, decreasing the footprint on that side.

Standard ADC jacks are driven by stepper motors using bipolar standard 2 phase motors from Lin Engineering. Stony Brook preferred to use Vexta 5 phase motors, which were easily applied to the ADC jacks. Rotation is achieved by combination of slides. The table below, Table 1, shows the range of motion.

Vertical	+/- 1" to follow sample movement from the press
Beam direction	+/- 1" or less, for alignment
Transverse to the beam	+/- 1" or less, for alignment.
Motion Repeatability	1 micron

Table 1: Range of motion

Initial levelling of pairs of jacks using common drive is done with Harmonic Phase Adjuster using a Harmonic Drive to coordinate the jacks together and level the pitch. The ADC design provided an easy means to place samples and equipment in and out of the press.

The press had intermediate hole patterns on the sides at the approximate elevation of the sample for best control of the experiment and also to minimize potential shock transmission to ADC supporting components. The dimension from the floor to the bottom of the press was up to 8" (54" beam height). It was preferred to keep the press close to the floor for safety as can be seen in Figure 2 on the following page.

Instead of a plate mounted to the floor, Stony Brook decided to use levelling feet. Shock absorbing 3/4" rubber was installed between the press and ADC motion system equipment. ADC Engineers worked closely with

Rockland Research Corporation to exchange information/drawing making sure a turnkey system is delivered to the customer. Figure 3, to the right, shows a 3D model of the system and the beam line.



Figure 2: Press Manipulator and Sample Loader

LINEAR STAGES

The system uses three of ADC's ultra-high precision, high load capacity linear stages. All linear axes have a Renishaw RELM linear encoder with $\pm 1 \mu\text{m}$ accuracy and $.1 \mu\text{m}$ resolution. All axes have limit switches. Several tooling holes are provided for survey targets consisting of a $\frac{1}{4}$ -20 threaded hole and a $\frac{1}{4}$ " reamed hole. A list of axis specifications is shown below in Table 2.

	X-Axis	Y-Axis	Z-Axis
Travel Range	25 mm	25 mm	25 mm
Position Resolution	$0.5\mu\text{m}$	$0.5\mu\text{m}$	$0.5\mu\text{m}$
Absolute Position Accuracy	$\pm 5\mu\text{m}$	$\pm 5\mu\text{m}$	$\pm 5\mu\text{m}$
Relative Position Accuracy	$\pm 1\mu\text{m}$	$\pm 1\mu\text{m}$	$\pm 1\mu\text{m}$

Table 2: X-Y-Z Motion Specifications

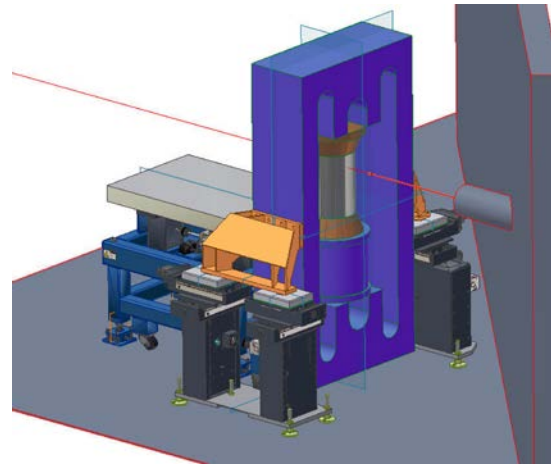


Figure 3: Model of press manipulator and beam line

FEA ANALYSIS

ADC uses Finite Element Analysis (FEA) to predict the deflections of complex and critical structures. For example, a detailed FEA was conducted looking at deflections of the weldment assemblies connecting the manipulation system to the press. Solid models generated using Autodesk Inventor, were imported into ANSYS, greatly simplifying the interactive design process. Many aspects of the design, such as material selection, geometry, and welding size, were optimized using FEA. Below, Figure 4, is a typical example of what you would expect to see.

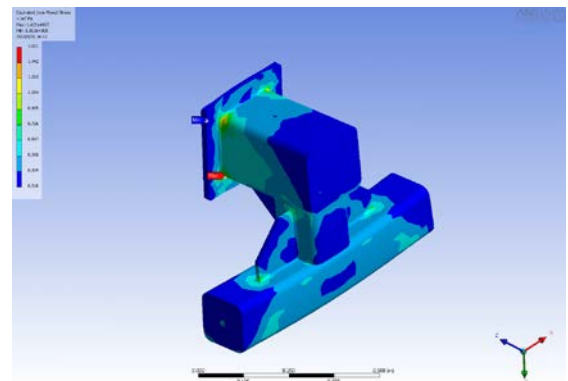


Figure 4: FEA; deflections of the weldment assemblies

REFERENCES

- [1] Karato, Shun-ichiro (2011) Water distribution across the mantle transition zone and its implications for the global material cycle. Earth Planet. Sci. Lett, 301, 413-423.
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