A Unique Multianvil 6–6 Assembly for a Cubic-Type Multianvil Apparatus

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Keywords: 6–6, multianvil, cubic-type

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Using a multianvil apparatus has been one of the methods to generate high pressures in material and Earth sciences. Here, we focus on a cubic-type apparatus consisting of six cubic type anvils in the [100] axis direction. Such an apparatus has been installed in not only laboratories but also synchrotron x-ray and neutron beam facilities worldwide to carry out in situ experiments. The principle of generating high pressure is simple; the external load exerted on the main ram is transmitted to the anvils, which push a sample embedded in a cubic pressure-transmitting medium. Here, we call such a traditional method one-stage compression.

Innovation in the compression method occurred around 2010; many apparatuses have begun to adopt a two-stage compression method [1,2]. The six small anvils assembled with an anvil guide, which we call a *frame*, are compressed by the outer set of anvils. While the latter first-stage anvils are usually equipped with the apparatus, the second-stage assembly (SSA), which contains a sample, is readily removable. The portability of the SSA facilitates replacing the anvils by those with a different truncation edge length (TEL), depending on a pressure range desired, thus reducing the loss of beamtime when a user uses sets of anvils with different TELs in a given period of beamtime.

However, when compression is performed using a set of inner anvils of only the same TEL, a two-stage compression does not necessarily bring about the reduction of lost time; it rather increases loss time much unless more than one SSA is available. An SSA is composed of a set of inner anvils, stuck together by Teflon™ chips of special size, which is held in a metal frame wrapped up by a Kapton® tape to ensure electric insulation. A set of chips with an appropriate height, such as pieces of balsa sheets with a specific thickness, must be stuck on the corners of the frame to center exactly the SSA (see Fig. 1). (Purchasing these specific parts, in addition to a set of inner anvils, is burdens on the user side.) A situation, in which preparing the SSA cannot proceed in parallel to the experiment, results in serious loss of efficiency of the whole experiment.

Our project has started to address these issues and set the following goal: A user alone can set up the SSA and start-up compression within 15 min.

To this end, we paid attention to the roles of a frame supporting a set of inner anvils: (i) It must support the inner anvils so that the object to be measured is exactly located on the beam path. (ii) It must be electrically insulated for electric current to flow through a heater enclosing the sample (container).

The condition (ii) is satisfied if we use insulators as a frame at the outset. We first replaced a metal frame by a plastic one (but with high processing accuracy to satisfy condition (i)). (Some users have already used plastic frames.) To meet the condition (i), we devised a *special tool* with which the inner anvils are set in such a way that their centers of the faces become equally distant from the body center of the frame. Using this device, it usually takes within 4 min to assemble the inner anvils with the required precision. The anvils are finally clamped with six small screws to the frame. Such works as shielding a frame with Kapton® tape, adjusting the position of a frame with balsa pieces, and joining the anvils with Teflon™ chips are now no longer required (Fig. 1).

We confirmed that the new SSA caused no troubles in real experiments performed up to 10 GPa and 1000 K.

Figure 1. The SSA mounted in the first-stage anvils of MAX-80 installed in BL NE5C, KEK-AR. The conventional assembly (left) requires more than 1 hour, whereas the new assembly (right) allows a single user to finish setting within 10 min.

We are planning to demonstrate the setup process of the SSA using the device at the conference.

Acknowledgments: This work, supported by the Ehime Industrial Promotion Foundation and Institute for Collaborative Relations, Ehime University, was performed under the approval of the Photon Factory Program Advisory Committee (Proposal No. 2018G583). Preparations for the experiments were carried out using the facility at the Geodynamics Research Center, Ehime University.

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