

# Fabrication of small mock-ups using TIG welding for the KO HCCR TBM

Jae Sung Yoon<sup>1)\*</sup>, Suk-Kwon Kim<sup>1)</sup>, Seong Dae Park<sup>1)</sup>, Dong Won Lee<sup>1)</sup>, Yi Hyun Park<sup>2)</sup>  
 Korea Atomic Energy Research Institute, Daejeon, Republic of Korea : [jsyoon2@kaeri.re.kr](mailto:jsyoon2@kaeri.re.kr)  
<sup>2)</sup> Korea Institute of Fusion Energy, Daejeon, Republic of Korea

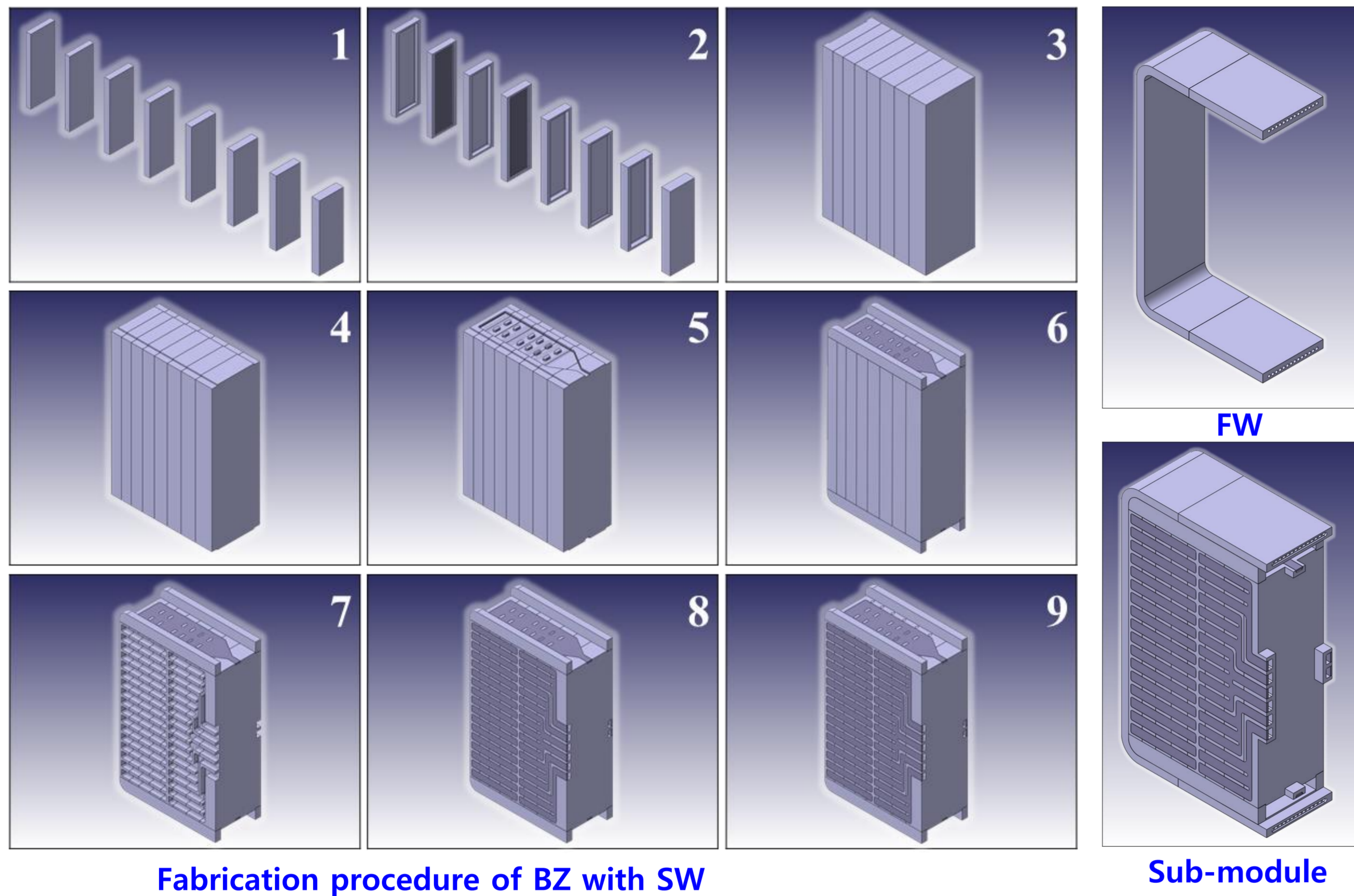
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**ABSTRACT:** Korea has developed a helium cooled ceramic reflector test blanket module (TBM) for fusion reactors. An advanced reduced activation alloy has been developed as a structural material and various joining methods such as E-beam welding, TIG (tungsten inert gas) welding, laser welding, and hot isostatic pressing have been applied to establish its fabrication method and procedure. Based on the current design of the TBM and breeding blanket, TIG welding was selected as the main joining method, and the U-shaped first wall (FW) was adopted. For welding of the breeding blanket, a special joining technique without a permanent backing strip while simultaneously keeping a full penetration welding in accordance with the design rules of class N2RX of RCC-MRx is required for the pressure vessel. For the U-shaped FW, distortion of the drilled cooling hole during the bending should be limited. To investigate these issues, three small mock-ups were fabricated in this study. The joints and bending parts were observed visually after cutting, and the hydrostatic pressure test was performed for regions with less thickness. The results show that the proposed fabrication methods are applicable in the fabrication procedure development for the breeding blanket.

## Fabrication procedure of the HCCR TBM sub-module

### Fabrication procedure of the HCCR TBM sub-module

- The HCCR TBM sub-module is composed of
  - FW including 13 cooling channels with a 10 mm holes width intervals of 18mm;
  - BZ, which is a seven-layer breeding zone;
  - SW fabricated complex cooling path.
- The main fabrication sequence of the BZ and SW is machining each part and then welding the parts using TIG and E-beam welding
- The sub-module fabrication procedure is finally completed after assembling the FW and BZ-SW parts using E-beam welding.



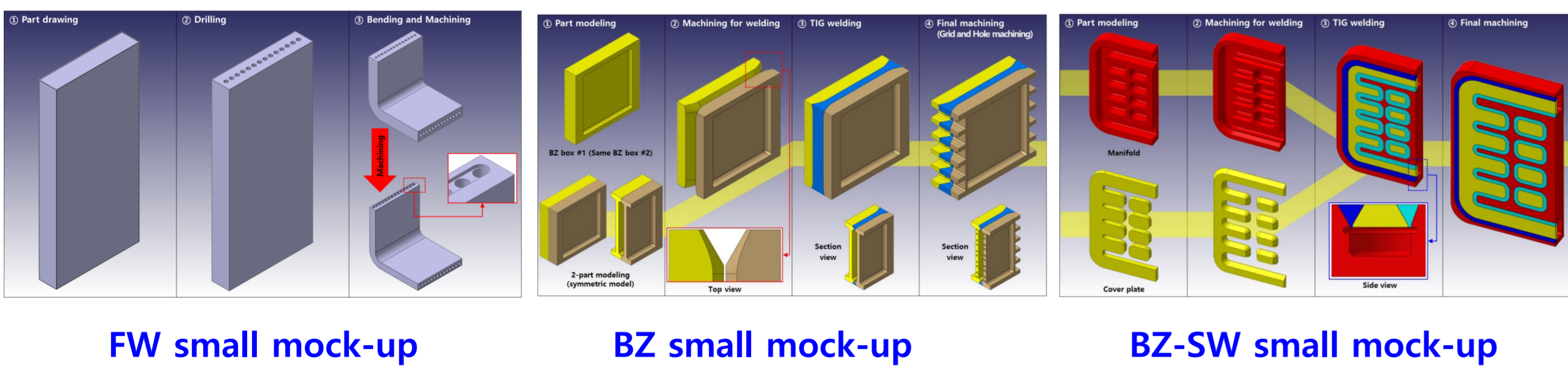
Fabrication procedure of BZ with SW

Sub-module

## Design of the small mock-ups

### Design of the small mock-ups

- Three small mock-ups were designed and fabricated to verify the fabricating procedure and method of the HCCR TBM sub-module
- The small mock-ups is parts of the scaled-down sub-module
  - FW small mock-up is a part of the scaled-down FW of a front plate with 7 cooling channels of 10 mm holes
  - BZ small mock-up is composed of two parts of the BZ components to verify the welding procedure
  - BZ-SW small mock-up is composed of two parts of the BZ, SW of 27 mm thickness, and SW cover of 6 mm thickness



FW small mock-up

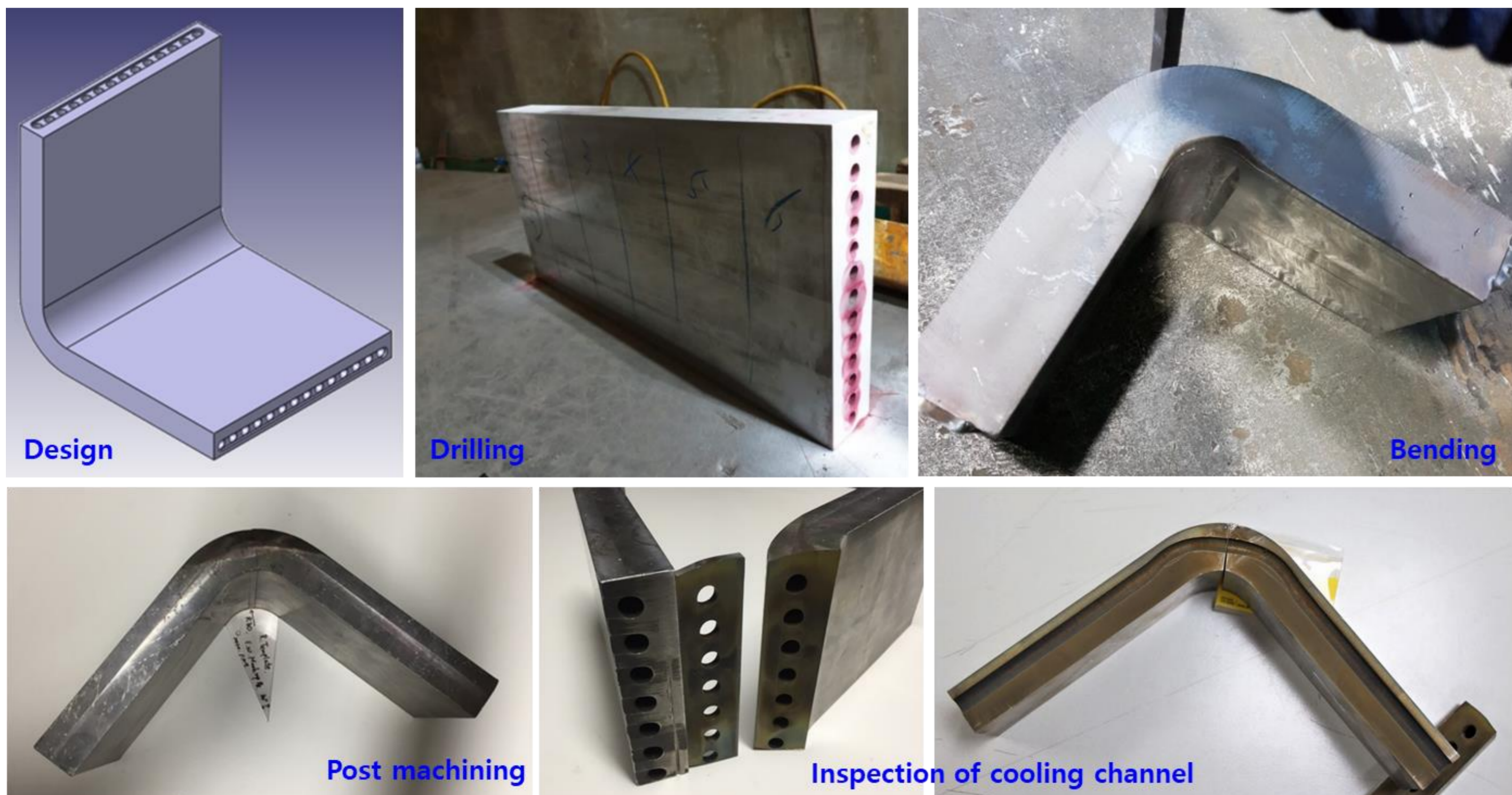
BZ small mock-up

BZ-SW small mock-up

## Fabrication of the small mock-ups

### Fabrication of FW small mock-up

- The manufacturing procedure of the FW small mock-up is as follows:
  - Component machining → Drilling → NDT testing → Bending → Post-machining → Inspection of cooling channels deformation after bending.



Design

Drilling

Bending

Post machining

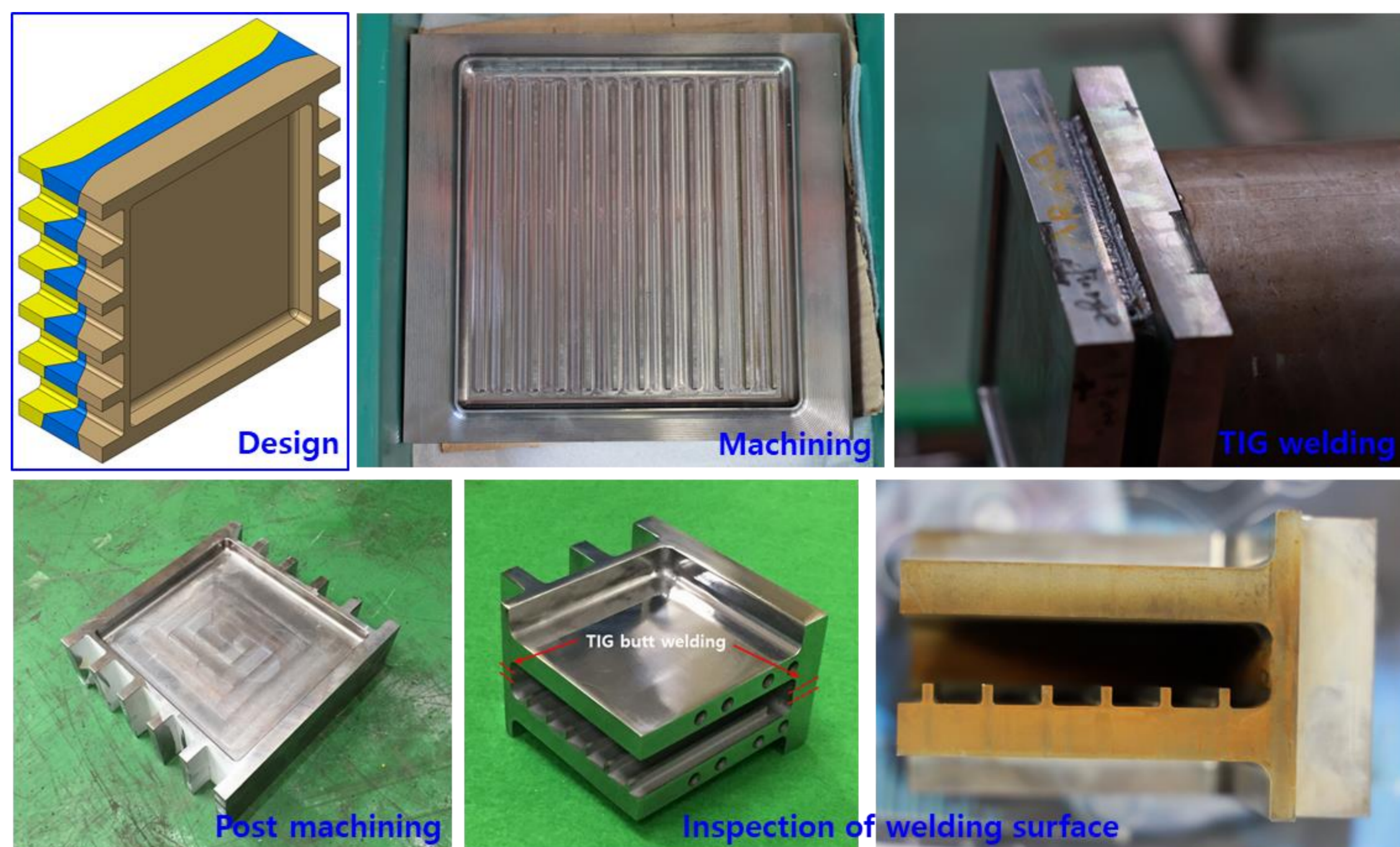
Inspection of cooling channel

FW small mock-up

## Fabrication of the small mock-ups

### Fabrication of BZ small mock-up

- The manufacturing procedure of the BZ small mock-up is as follows:
  - Component machining → Welding → Post-machining → NDT testing using radiography test (RT), and ultrasonic testing (UT).



Design

Machining

TIG welding

Post machining

Inspection of welding surface

BZ small mock-up

### Fabrication of BZ-SW small mock-up

- The manufacturing procedure of the BZ-SW mock-up is as follows:
  - Component machining → Welding → Post-machining → NDT testing using radiography test (RT), and ultrasonic testing (UT).



Design

Machining

TIG welding

Post machining

Inspection of welding surface

BZ-SW small mock-up

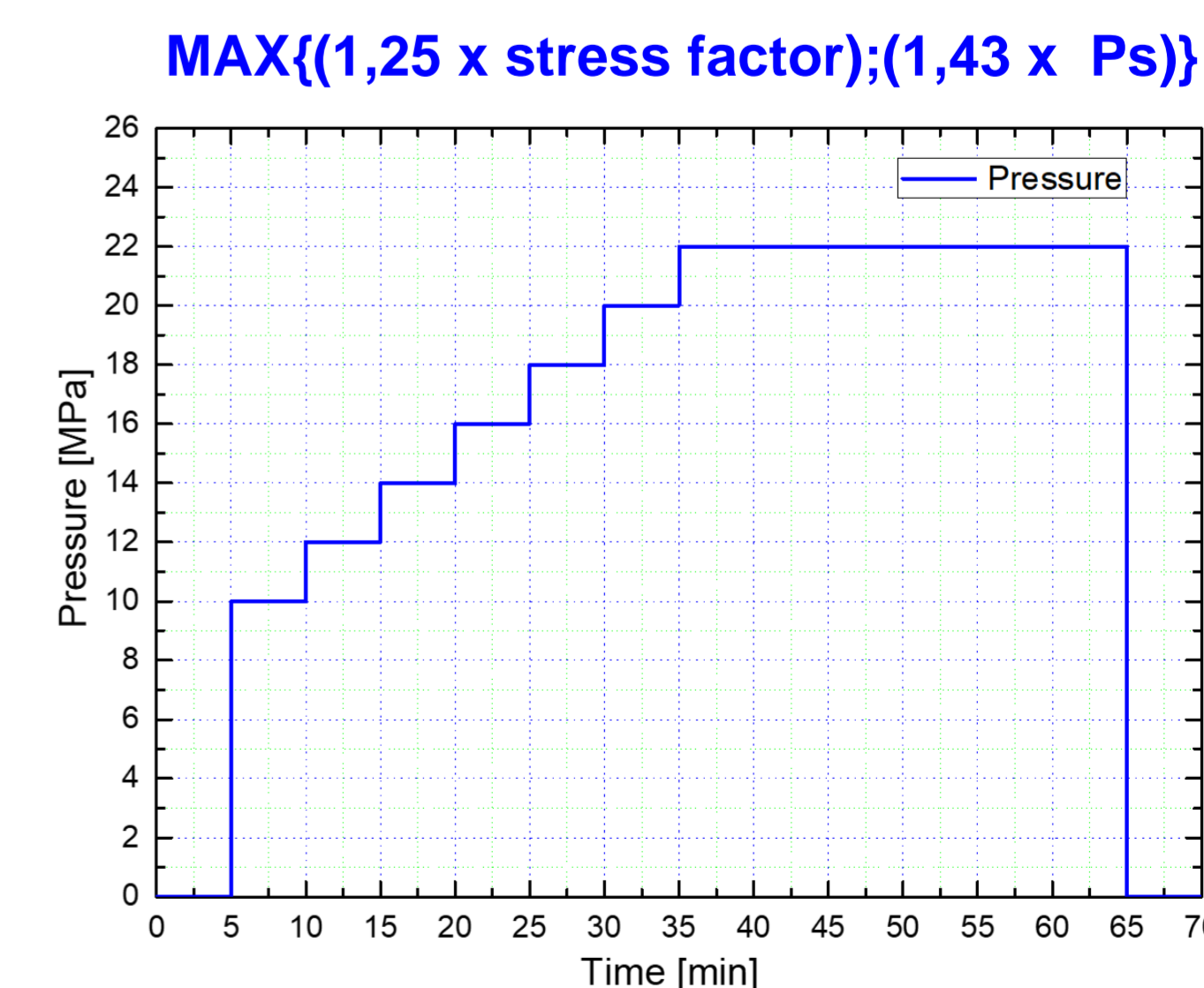
## Qualification tests for the small mock-ups

### NDT test

- Penetration, Ultrasonic and Radiography tests were carried out to investigate joint integrity for the three small mock-ups

### Helium leak test and water pressure test for the BZ-SW small mock-up

- Helium leak test was performed up to  $1.0 \times 10^{-7}$  Pa
- Water pressure test was carried out up to 22 MPa



Water pressure test for mock-up of BZ-SW small mock-up

**Conclusions:** For developing the fabrication methods and procedure of the breeding blanket, the currently adopted TIG welding and U-shaped FW were confirmed through the fabrication and test of small mock-ups. From the FW mock-up, U-shaped fabrication with drilled cooling holes can be considered acceptable after checking their distortion after bending. From the BZ mock-up, the full penetration welding with TIG can be applicable even without a backing strip. From the BZ-SW mock-up, the pressure endurable welding can be possible even with narrow and relatively thin cover welding. From the small mock-ups fabrication and test results, the fabrication methods of the submodule will be updated.

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