# An experimental setup for thermal oscillation near the dryout front in the single semi-circular channel

Jin Su Kwon[a], Sung Gil Shin[a], Jeong Ik Lee[a,*], Sang Ji Kim[b]

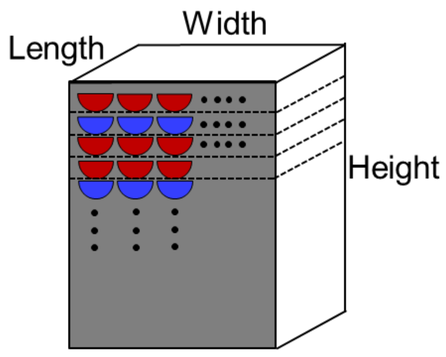
[a]*Department of Nuclear and Quantum Engineering, Korea Advanced Institute of Science and Technology, 373-1 Guseong-dong Yuseong-gu,Daejeon 305-701, Republic of Korea*

[b]*Korea Atomic Energy Research Institute 150 Dukjin-dong, Yuseong-gu, Daejon 305-353, Republic of Korea*

**Corresponding author: jeongiklee@kaist.ac.kr*

## Introduction

▣ Printed circuit steam generators (PCSG), is a kind of compact heat exchangers, have been studied as a potential candidate for the steam generator in SMR (Small Modular Reactor)

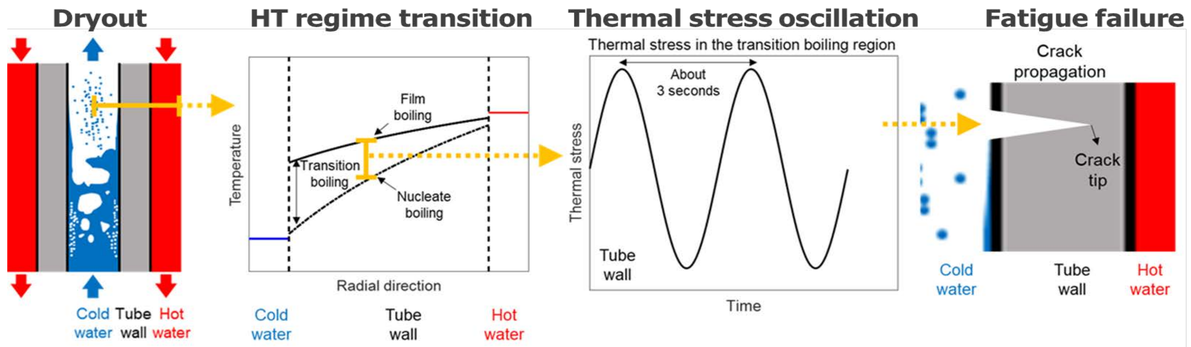



◢ Configurations of PCHE

▣ To produce superheated steam, the dryout occurs inside the PCSG since it is used as an once-through type steam generator.

▣ Dryout front oscillates regardless of changes in mass flow rate. The movement of dryout front induces a transition in boiling regions between nucleate boiling and mist evaporation region, which leads to a significant wall temperature oscillation.

▣ The purpose of this study is to design an experimental facility in order to investigate the major parameters of thermal oscillation induced by dryout.




◢ Mechanism of thermal fatigue induced by dryout oscillation

## Setup for the thermal oscillation experiments

### 1. Test section

▣ The test section is fabricated by stacking two plates and welding the joint.

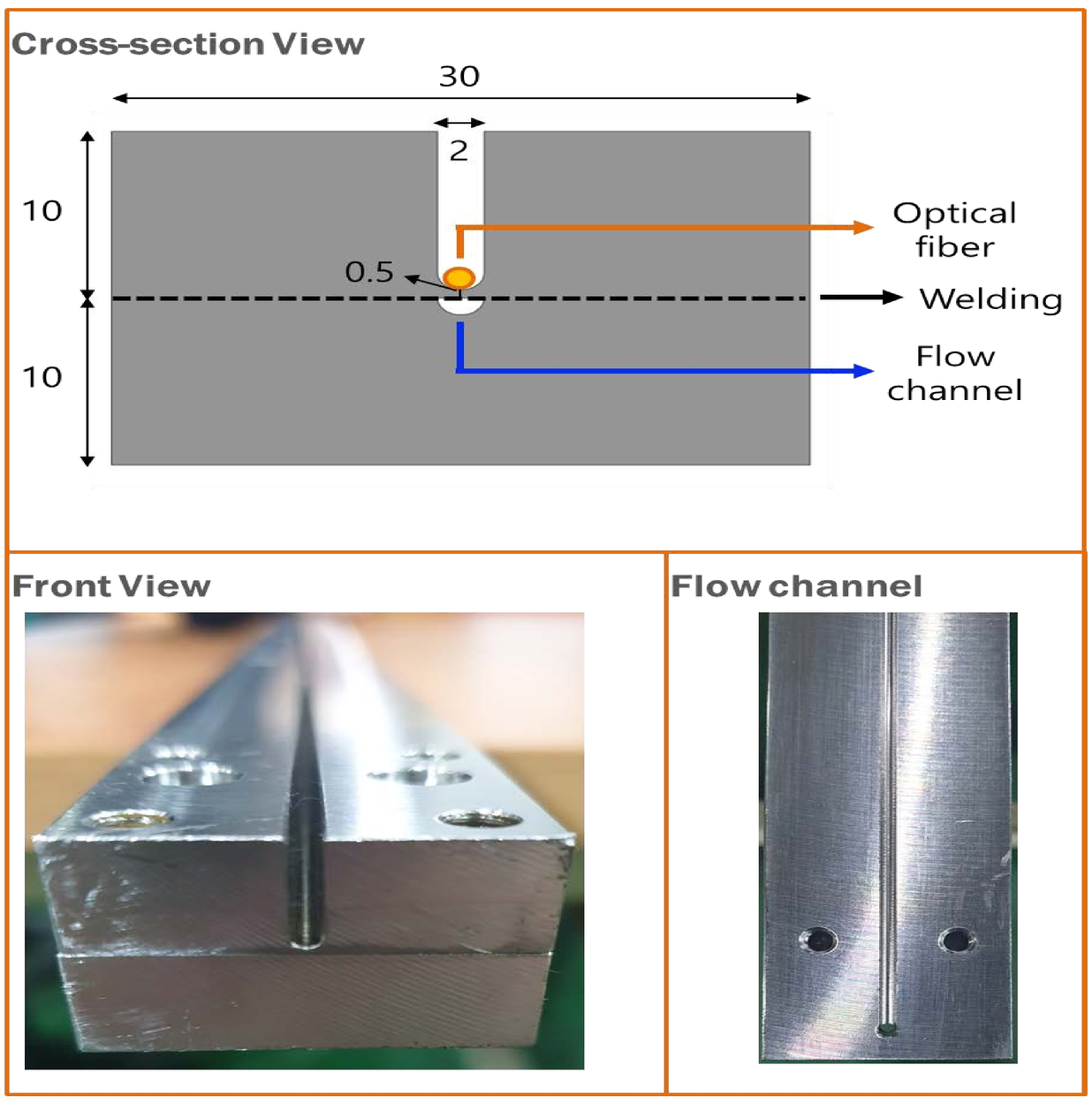
▣ Bolting between two plates was performed first to prevent the structural deformation during welding process.

▣ Another purpose of bolting is to give well defined geometry to the semi-circular flow channel by adhering two plates completely.

▣ There is a 2 mm-wide groove with a depth of 9.5 mm in the middle of the upper plate. This is the space where the temperature sensors including the optical fiber and thermocouple are positioned.

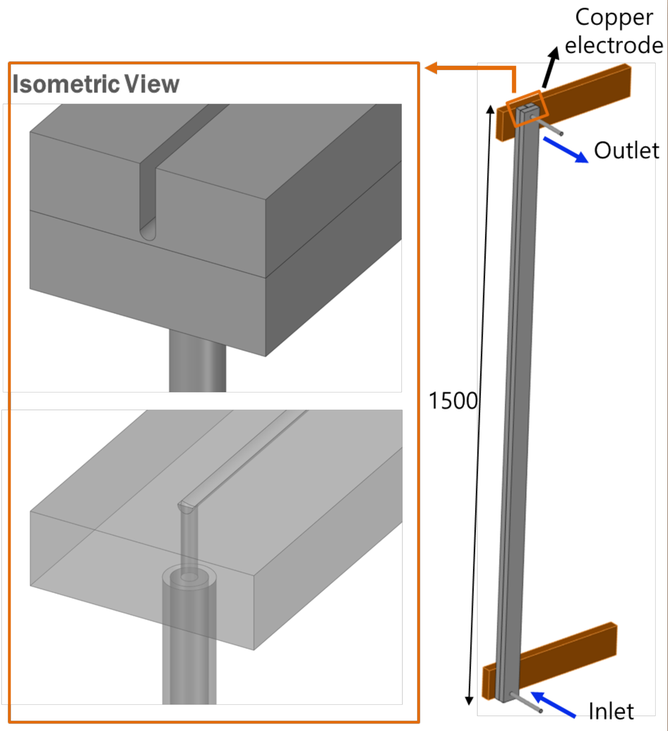
▣ An optical fiber sensor with the diameter of 0.16 mm is located at the deepest place of the groove to measure the wall temperature directly.

◢ Cross section of the test section




▣ The width and length are determined as 30 and 20 mm, respectively, considering many factors such as the heat loss, material buckling, and electrical resistance adequate for rectifier conditions held in the laboratory. The height is set to 1500 mm to reduce the wall temperature when dryout takes place.

▣ The test section has single semi-circular channel with the diameter of 2 mm to focus on the thermal oscillation behavior for the thermal-hydraulic parameters without multi-channel effects.




◢ Isometric view of the test section

▣ The inlet and outlet of the flow channel, which is welded with outer diameter 0.25-inch tubes, is located in a perpendicular direction to the flow path.

▣ To generate the superheated steam in the flow channel, the rectifier transfers direct current to the test section through copper electrodes, which is placed on top and bottom of the test section by bolts and on the other side of the inlet and outlet.

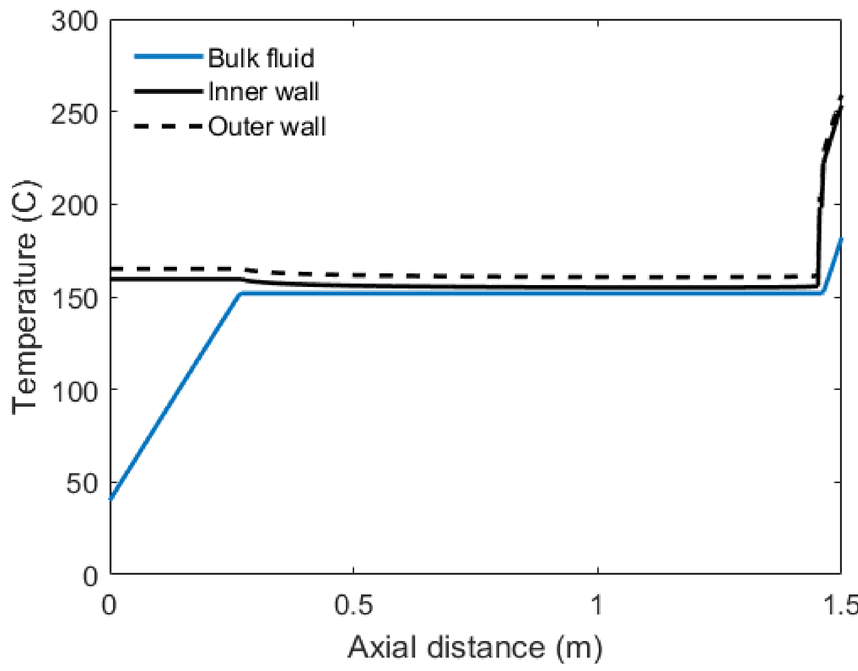
### 2. Test section analysis

▣ A preliminary thermal-hydraulic analysis of the test section is conducted to check the test section design with one-dimensional analysis.

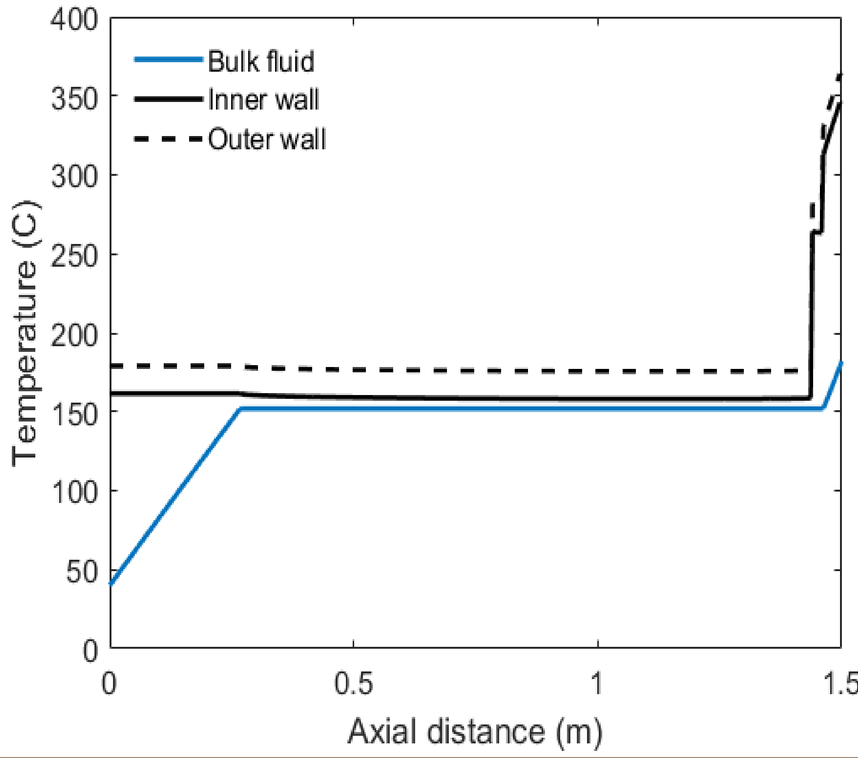
▣ The heat transfer rate in the control volume is determined by the electrical resistance heating.

▣ In the initial stage, the constant electrical resistance and current are assumed for every control volume, and then, an FDM analysis is conducted sequentially from the inlet to the outlet.

▣ The dryout can be recognized from the wall temperature distribution (near 1.4 m from the inlet). Since the heat transfer regime changes from nucleate boiling to dispersed flow film boiling after the dryout, the wall temperature rapidly increases.




◢ Temperature distribution versus the axial distance (2 mm of semi-circular diameter)




◢ Temperature distribution versus the axial distance (4 mm of semi-circular diameter)