Transactions of the Korean Nuclear Society Autumn Meeting
Jeju, Korea, May 18-19, 2017

Stress analysis of IHX Facility in SFR

Hae-Seob Choi *,Woo-Shik Kim, Min-suk Kong, Dong-Jin Euh
Korea Atomic Energy Research Institute,
111 Daedeok-daero 989 beon-gil, Yuseong-gu, Daejeon, 305-353, Korea
**Corresponding author: hschoi@kaeri.re.kr*

1. Introduction

Sodium-cooled Fast Reactor (SFR) is a promising conceptual design for the commercial nuclear power plant. The SFR is a pool type reactor which consists of a reactor coolant system (RCS) and a heat transport system. The RCS in SFR is composed of a reactor core, a upper internal structure (UIS), two mechanical pumps and four intermediate heat exchangers (IHX).

The intermediate heat exchangers which are located at the boundary of the hot and cold pools (classification of Redan), strongly influence the heat transportation from the primary side to the secondary side through the piping line situated at the internal flow path. Therefore, investigation of IHX is of importance for the design of the SFR concept.

The IHX performances were tested in Intermediate Heat Exchanger test Loop for PGSFR Safety (IHELPS) experimental facility of KAERI. However, instead of sodium, water was selected as the working fluid. The purpose

The IHX facility has several duct. And duct is a rectangular shape. For shape preservation, it should be neither transformed nor damaged in an actual test. Therefore, SolidWorks Simulation based structural analysis was conducted for securing the integrity of IHX facility.

2. Methods and Results

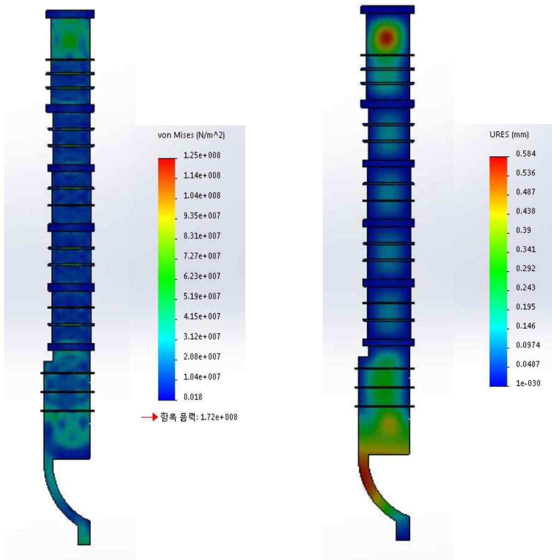
The IHX in the IHELPS experimental facility is designed as a scale-down model of the prototype IHX in SFR followed the scale-down rules in size and volume. SolidWorks Simulation was applied to create a 3D geometric input that can be imported into the SHXSA code to calculate the stress information.

The scale-down IHX has the shape of rectangular duct with 548 mm×210 mm in size and 5.9m in height. The design pressure is 0.65 MPa and the design temperature is 60ºC. The IHX performance tests were conducted under static and dynamic state conditions.

2.1 Stress analysis in static state

According to the ASME VIII Div.1, it is impossible to apply the ASME code to analyze stress information in the rectangular IHX of the present test because the code is only applicable for the cylinder type. Therefore, the stress analysis in this study were done by using a different CFD code (SolidWorks Simulation).

The static test was conducted without recirculation of inlet flow into the heat exchanger. The pressure is gradually increased to the design value to evaluate stress on inner duct. Under the static experimental conditions, the allowable displacement of the duct inside IHX should be within 1 mm criterion. Fig. 1 shows the calculation results of the stress information and square duct displacement under the static state conditions



(a) Stress analysis (b) displacement analysis

Fig. 1 Stress analysis & Displacement

The stress analysis in Fig.1(a) meet the acceptable criterion for the stress at the design pressure 0.65 MPa. Fig. 1(b) shows the result of duct displacement analysis within the range of 0.04~0.58 mm, which is still within the 1mm duct displacement criterion. The largest duct displacement of 0.58 mm occurred at the highest elevation in the heat exchangers. In order to reduce the duct displacement as much as possible, it is scheduled to install a reinforced rib onto the top part of the IHX.

2.2 Stress analysis in dynamic state

In the dynamic state conditions, the working fluid water is recirculated into the IHX with a maximum flow rate of 51.99 kg/s and the water temperature is 30°C. The real pressure from the fluid flow on the inner duct that cannot be determined in the static state conditions, is then able to obtain in the dynamic state.

At the maximum flow rate conditions, the force acting on the duct wall can be evaluated as shown in Fig. 2. The force magnitude has a maximum of 87N.

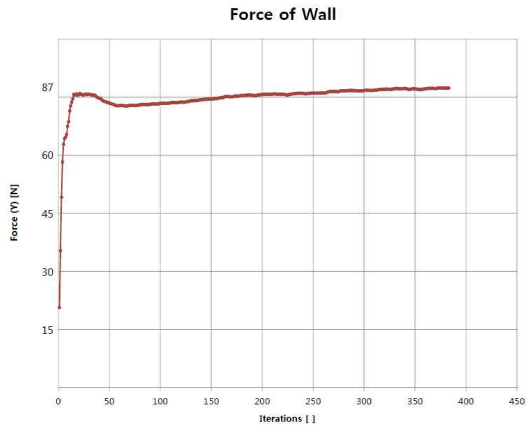


Fig. 2 Stress imposed on square duct

The duct displacement analysis is therefore deduced from the force analysis. The duct displacement results are shown in Fig. 3.

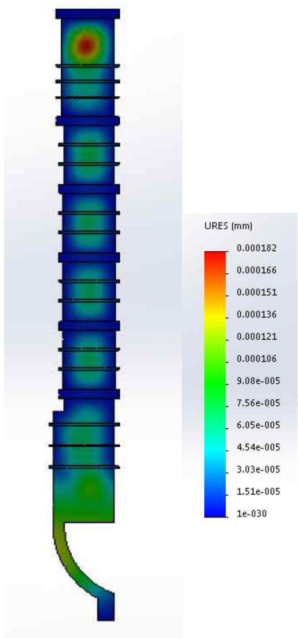


Fig 3. The duct displacement at the maximum flow

The maximum duct displacement in the IHX under the maximum flow conditions is obtained with very small value of 0.000182mm. As a conclusion, the IHX performance test showed great preservation of inner duct integrity under all static and dynamic conditions.

3. Conclusions

The performance of intermediate heat exchanger were tested in IHELPS experimental facility. The characteristics of the prototype IXH in the SFR design concept were preserved in IHELPS experiments followed the scale-down rules.

By using the SolidWorks Simulation program, the stress on inner duct of IHX were analyzed. The analytical results showed satisfactory performance of the scale-downed IHX in comparison of ASME VIII Div.1 criterion. The CFD calculation results showed that the integrity of the IHX were preserved under static and dynamic state conditions. To strengthen the inner square duct of IHX, reinforced ribs are scheduled to install into the top part of the IHX.

Acknowledgements

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP).
(NO.2012M2A8A2025638)

REFERENCES

[1] W.S.KIM, D.J,EUh, Design Report for Flow Characteristics Test Facility of the SFR IHX
[2] Tubular Exchanger Manufacturers Association (TEMA), Ninth Edition, p 1-2, 2007.
[3] The American Society of Mechanical Engineering, Measurement of fluid flow in pipes using orifice, nozzle, and venture, ASME MFC-3M-2004, 2004.