Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 24-25, 2013

Preliminary Stress Analysis of an IHX Tube Support Plate in Prototype SFR

Sung-Kyun Kim [a*], Gyeong-Hoi Koo [a]
[a]*Korea Atomic Energy Research Institute, Dukjin-Dong, Yuseong-Gu, Daejeon, South Korea*
[*]*Corresponding author: sungkyun@kaeri.re.kr*

1. Introduction

Tube support plates (TSPs) of the intermediate heat exchanger (IHX) in Prototype GenIV Sodium Cooled Fast Reactor (PGSFR) act to horizontally support IHX tubes against hydraulic loadings and they have numerous flow holes where a primary sodium flows downward and secondary sodium flows upward. Due to its many penetrations, its geometric shape is quite complex and structurally its integrity is quite weaker than other parts.

In this study, we investigated the structural integrity of the conceptually designed IHX tube support plate. In addition, TSP's supporting concepts were proposed to increase its structural integrity, and confirmed its integrity by using a finite element analysis.

2. Methods and Results

In this section, the geometric shape and boundary conditions of the IHX tube support plate to calculate its stress distribution are described. Also the stress analysis results in the static condition for the current design and modified designs are presented.

2.1 General assumptions

In order to perform the stress analysis for the tube support plate, following assumptions have been made.

- All hydraulic loadings applied to a tube support plate are assumed to the design pressure which is provided from KAERI fluid team.
- It is assumed that the temperature of the tube support plate is the same as the temperature of primary sodium.

2.2 Loading conditions

- According to the previous assumptions, IHX shell side design pressure 0.5 MPa is applied to the top surface of tube support plate.
- For applying its self-weight, the gravity 9.8 m/s^2 is applied to Y-direction (see Fig.2).

2.3 Boundary conditions

The tube support plates are aligned vertically and horizontally by using a laser sensor and then as shown in Fig. 1, 12 wedges are inserted into space between the tube support plates and the IHX cylinder, then finally all wedges are welded. A support flange is installed under the tube support plate to support its vertical load. Therefore a fixed condition is applied at the outer rim area of tube support plate.

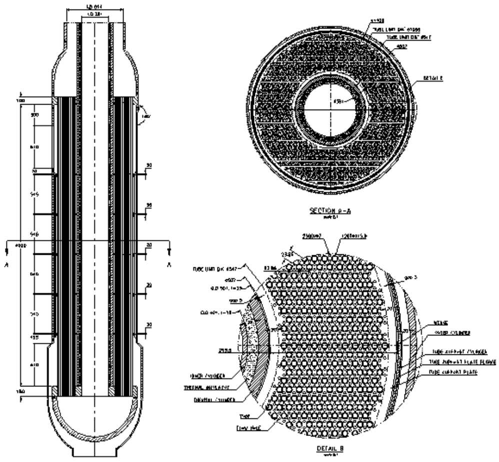

Fig. 1. IHX tube support plate 2D drawings

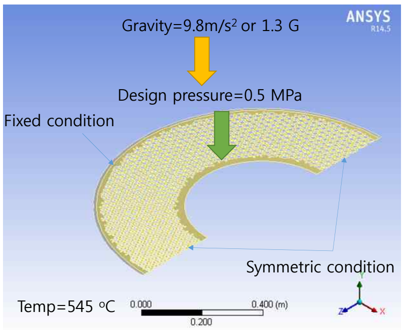

Fig. 2. Boundary condition for tube support plate

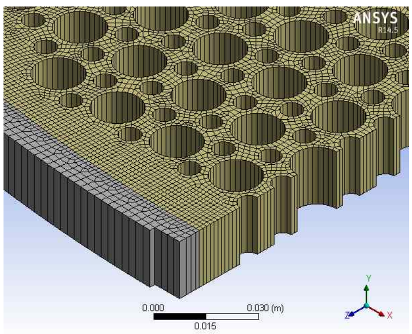

Fig. 3. Half symmetric FEM model

2.4 Stress Analysis Results

The stress analysis has been performed based on the above boundary conditions and loading conditions. Fig. 4 shows the stress distribution of tube support plate. As shown in the figure, the maximum stress is about 860 MPa which exceeds its stress design limit (120 MPa).

In order to reduce the maximum stress we came up with two alternatives shown in Fig 5 and Fig 6: 1) applying another support flange inner rim area, 2) applying tierods.

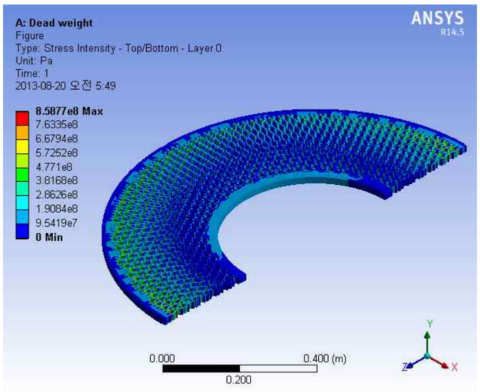

Fig. 4. Stress distributions in the normal condition

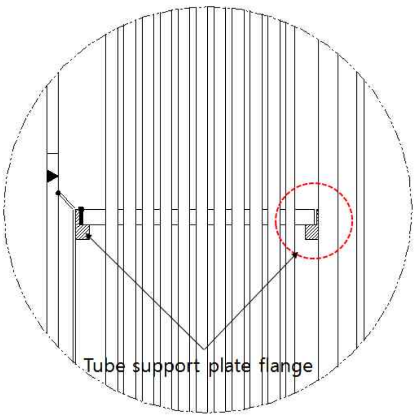

Fig. 5. Drawing of the conceptual tube support plate using support flanges

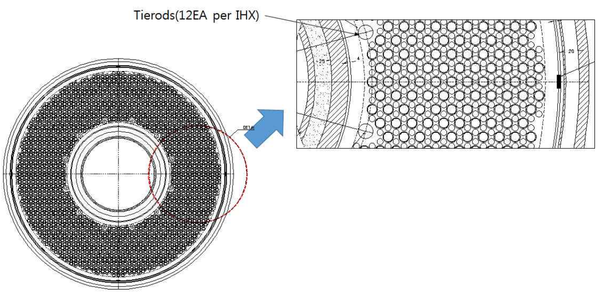

Fig. 6. Drawing of the conceptual tube support plate using tie rods

Fig. 7 and Fig. 8 show the stress distributions of tube support plate for both cases. As shown in these figures, the both maximum stresses are within the stress design limit (120 MPa).

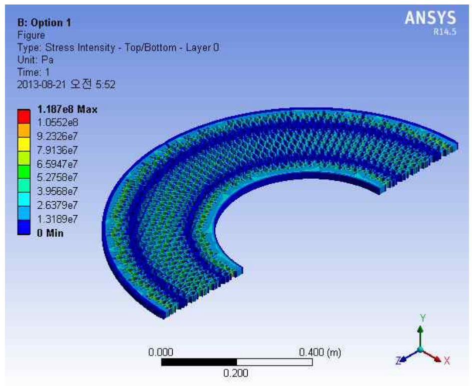

Fig. 7. Stress distributions (another support flange case)

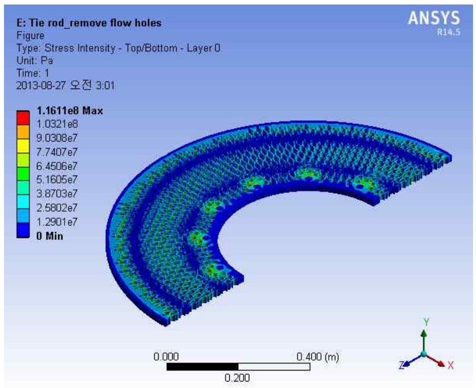

Fig. 8. Stress distribution (tierod fixed case)

3. Conclusions

In this paper, the structural integrity about the conceptual design of IHX tube support plate was reviewed and the design should be changed because of its high stress concentration at the outer rim area.

For reducing its maximum stress, two alternatives were proposed and reviewed for the structural integrity point of view. In both proposing support designs, the maximum stress decreases up to the stress design limit.

REFERENCES

[1] Conceptual Design Report of SFR Demonstration Reactor of 600 MWe Capacity, KAERI/TR-4598/2012, 2012.

[2] C.G. Park and J.B. Kim, Design Study of an IHX Support Structure for a Pool-Type Sodium-Cooled Fast Reactor, Nuclear Engineering and Technology, Vol. 41, pp. 1323-1332, 2009.

[3] C.G. Park, J.B. Kim and J.H. Lee, Design Improvement of the IHX Co-axial Structure using ANSYS, 2007 17th KOREA ANSYS User's Conference, pp. 46-51, 2007.

[4] ANSYS Inc. Manual, 2012.