Stress Analysis of Pool-wall pipe supports

J. M. Lee, B. S. Sim, K. N. Park, D. Y. Chi, S. K. Park, S. H. Ahn, C. Y. Lee, Y. J. Kim
HANARO Utilization Technology Division, 3-Pin Fuel Test Loop R&D Department, Korea Atomic Energy Research Institute, P. O. B 105, Yuseong, Daejeon, 305-353
jmlee@kaeri.re.kr

1. Introduction

This study describes the method and input data used for the finite element analysis of the Pool-Wall Pipe Supports of the KAERI fuel test loop. The assessment of the support frame to the design code, ASME Section III Sub-Section NF, is discussed

2. Model description

The extent of the inner model is shown in Fig. 1. It is composed of 2 1/2” main cooling pipe and 4" middle pipe, which is welded together. The weld region is explicitly modeled with its 5 mm radius.
The end part of 4” middle pipe is connected to the model of middle by the keyword of ∗tie in ABAQUS code. The loads acquired from the beam model are inadequate for the sold model, the main cooling pipe is truncated and the keyword of ∗coupling is used for the application of loads.

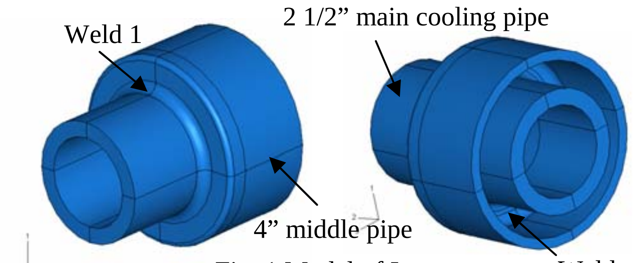

Fig. 1 Model of Inner

Four parts are modeled for the model of middle. The 4” middle pipe with 2086 mm length, 2 flanges and flow ring were modeled using solid elements and wedge element is used in weld part. The model is shown in Fig. 2. Contact with a no friction was defined between surface of flow ring and inner surface of support in ABAQUS code.

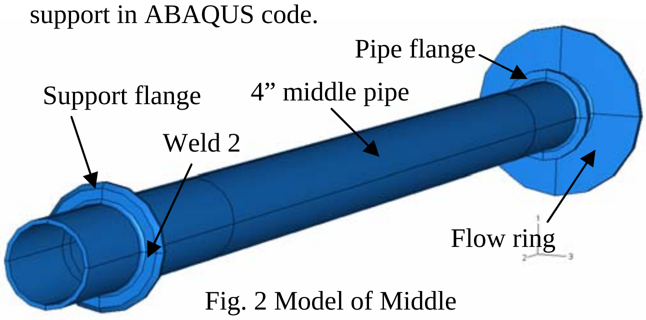

Fig. 2 Model of Middle

The Model of outer is a main support system for the 2 1/2” main cooling pipe. It is composed of two parts. The 6” penetration pipe with 1840 mm length is embedded in HANARO reactor concrete wall which has approximately 1526 mm thickness. The extrusion length of Penetration pipe to the pool side is approximately 114 mm and to the gallery side is approximately 200 mm. The 1 1/2” Penetration cooling water pipe is modeled for the boundary conditions of the model. The outer model is shown in Fig. 3.

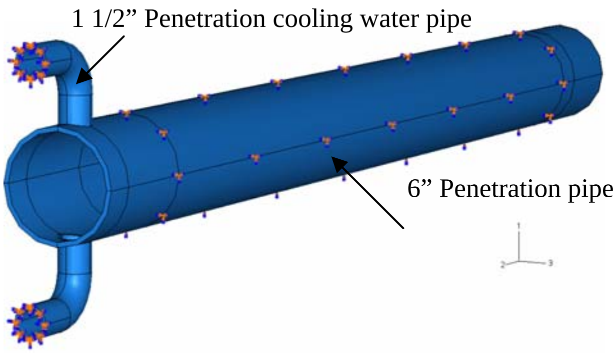

Fig. 3 Boundary conditions of outer assembly

The meshed model of pool-wall pipe supports was shown in Fig. 4. There were two elements types in the model. 8-node solid element (C3D8) was applied to the whole model except the weld region which applied 6-node wedge element (C3D6). A coarse mesh was used at the middle parts of 4” middle pipe and embedded part of 6” penetration pipe under the consideration of available computer resources and required time.

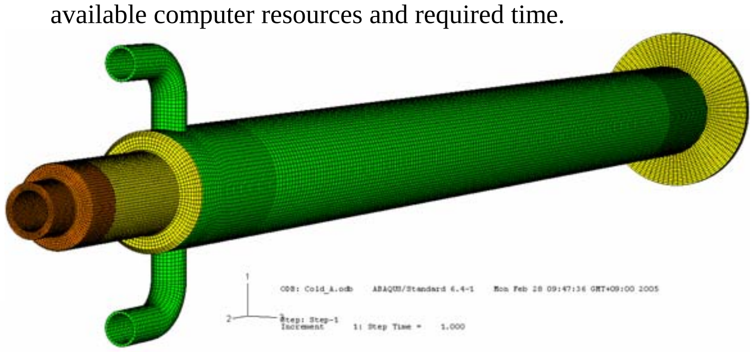
Fig. 4 Mesh of pool-wall pipe supports

3. Materials

Properties of the 316 stainless steel were defined and assumed as an isotropic material. Also the Young’s modulus and Possion’s ratio were constant for the model because its operating temperature will be $40^{\circ}C \sim 60^{\circ}C$. Material properties of density and thermal conductivity which were related to the self-weight and thermal expansion were not considered.
Table 1 Mechanical properties of the 316 stainless steel

Young's Modulus (E)	Possion's Ratio (υ)	Yield Strength (Sy)	Tensile Strength (Su)
190.44	0.271	146.9 MPa	469.5 MPa

4. Loads

ASME III NF requires design by analysis, with stresses in components satisfying acceptance criteria. In order to simplify the analysis here, two enveloping load cases are used for each leg:

- Case 1, where the loadings for all service levels up to C are included along with the Level D SSE event. The results of this load case will then be compared with the code allowable stresses for service Level A.
- Case 2, the loadings for the service Level D in-pool pipe break event envelope (including Level A). The results of this load case will then be compared with the service Level D allowable stresses defined in ASME III Appendix F.

5. Analysis

The supports considered are treated as "Plate- and Shell-Type" supports (NF-1212). This type can be analyzed elastically based on maximum shear stress theory in accordance with the rules of NF-3200. Elastic stress results for elements of Class 1 supports are shown as Table 2 and 3.

The stress intensity of Sm which defined at ASME III NF code is 137.9 MPa. ASME NF code requires the general primary membrane stress intensity Pm shell not exceed specified allowable stress of Sm and primary membrane plus primary bending stress intensity Pm+Pb shell not exceed specified allowable stress of k × Sm.

For the simplification of stress analysis of Case 1, the constant value of k is regarded as 1 for the conservative calculation, which is defined in Tables NF-3522(b)-1.

The yield strength 146.9 MPa is used to compare with the Case 2. In accordance with the ASME III Appendix F, the stress limit for the Case 2 is defined as 1.2 × Sy for the primary stress and 1.8 × Sy for the Primary plus secondary stress. Fig. 5 shows the Tresca stress.

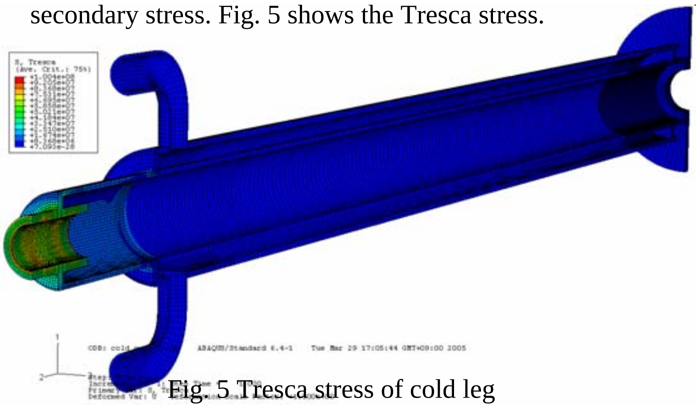

Fig. 5 Tresca stress of cold leg

Table 2 Stress results of Cold leg

		Primary	Primary+ Bending
Case 1	weld 1	5.26585e+07	5.41094e+07
	weld 2	1.27652e+07	2.26163e+07
Case 2	weld 1	6.73111e+07	7.12879e+07
	weld 2	7.80645e+07	1.42541e+08

Table 3 Stress results of Hot leg

		Primary	Primary+ Bending
Case 1	weld 1	2.34787e+07	2.98503e+07
	weld 2	1.91537e+06	3.14307e+06
Case 2	weld 1	4.02516e+06	2.27976e+07
	weld 2	1.18583e+07	1.42147e+08

6. Conclusion

Case 1, the maximum primary stress which calculated through the linearization is about 52.6 MPa. This is sufficiently lower than the allowable stress of 137.9 MPa. Also, the maximum primary plus bending stress is 54 MPa, which is lower than the 137.9 MPa.

Case 2, the results are compared with the 1.2 × Sy because this is conservative than the 1.8 × Sy. The maximum primary stress is 78 MPa and the maximum primary plus bending stress is 142 MPa. All these values are lower than the allowable stress 176 MPa.

As a result, it is regarded that Pool-wall pipe supports could maintain its structural integrity for the design loadings and service loadings.

REFERENCES

[1] ASME Boiler and Pressure Vessel Code, Section III NF, 2001

[2] In-Pool Parts for 3 Pin FTL 4" NB Penetration Pipes, HAN-FL-340-PB-R032, Issue P5, 2004.

[3] FTL Pool Penetration Stress Analysis Report, HAN-FL-E-074-RX-H005, Rev. A, 2004.

[4] Design Report for Supports (for IPS & Piping), HAN-FL-E-320-RT-R002, Rev. 0, 2005.