Stress Concentration Factor in Fatigue Analysis of the DVI Nozzle using Finite Element Analysis

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1. Introduction

If the environmental fatigue requirements are applied to the primary components of the nuclear power plant, to which the present ASME Code fatigue curves are applied, some locations with high level cumulative fatigue usage factors(CUFs) are anticipated not to meet the Code criteria. Therefore it is needed to investigate the fatigue analysis procedure of these locations to identify the conservative elements in the procedure and to assure the integrity and the margin through fatigue analysis with detailed models. In this paper, the conservatism of stress concentration factor is investigated using finite element analysis results for DVI nozzle in reactor vessel of the Shin-kori unit 3, 4.

2. Analysis Methodology

In this section, general fatigue analysis procedure and finite element analysis of DVI nozzle is represented.

2.1 Fatigue Analysis Procedure

Figure 1 shows general fatigue analysis procedure in ASME code[1]. Generally, if stress concentration occurs by geometry of the fatigue evaluation section, stress concentration factor is considered in the calculation of alternating stress intensity(Salt).

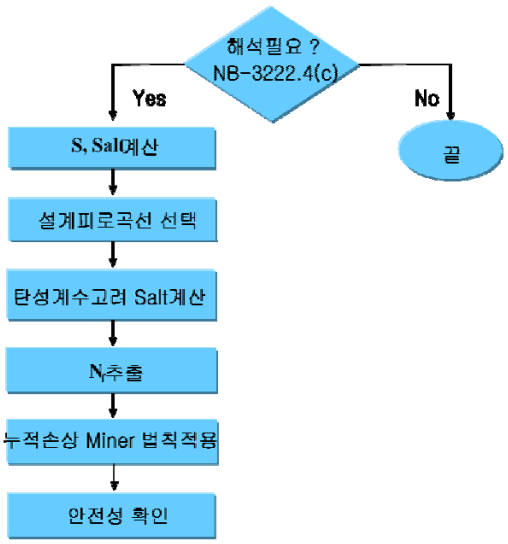

Figure 1 Fatigue Analysis Procedure

2.2 Finite Element Analysis

Figure 2 shows DVI nozzle of reactor vessel in the Shin-kori unit 3,4, and Figure 3 shows finite element model for fatigue evaluation.

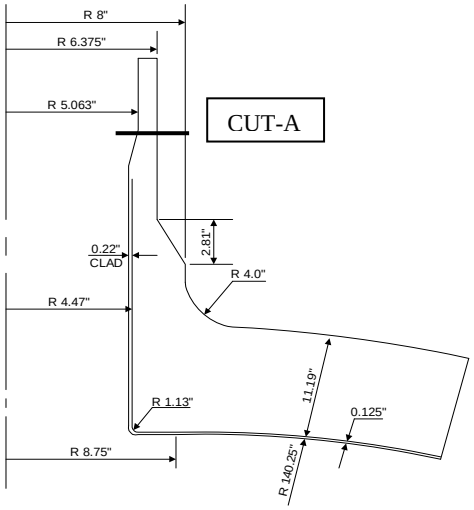

Figure 2 Geometry of Reactor Vessel DVI Nozzle

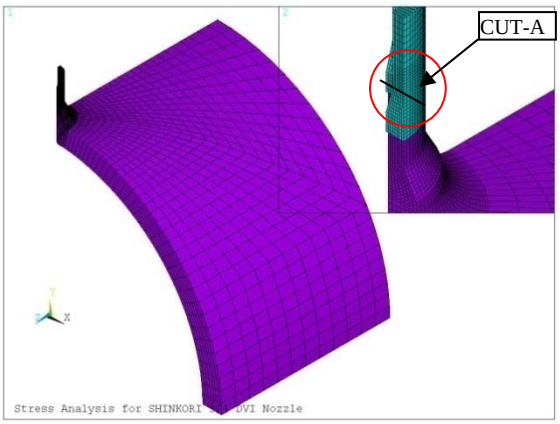

Figure 3 Finite Element Model of RV DVI Nozzle

As shown in Figures 2 and 3, stress concentration occurs at CUT-A by geometrical discontinuity. Therefore, stress concentration factor is considered in stress analysis and fatigue analysis.

In this paper, fatigue evaluation is performed with various finite element mesh sizes shown in Figure 4. Table 1 summarizes the number of elements contained in the part shown in Figure 4.

Design transient and occurrence number are obtained from group 1 and group 12 in reference [3]

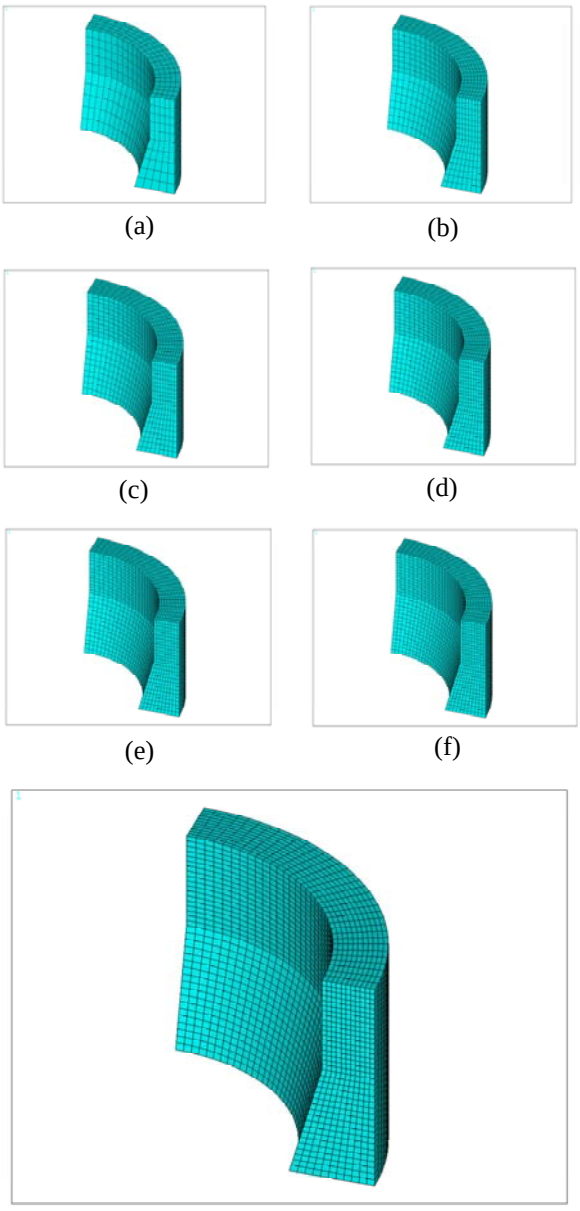

Figure 4 Finite Element Mesh

Table 1 No. of Elements for analysis case

Case	No. of Elements
a	1100
b	3200
c	4860
d	6960
e	9548
f	11968
g	13464

2.3 Stress Concentration Factor

The stress concentration factor is theoretically calculated using equation (6.22) in reference [2]. The calculated stress concentration factor of CUT-A, inside surface, in Figure 2 is 1.25.

3. Fatigue Analysis results

Figure 5 shows fatigue analysis results for various finite element mesh represented in Figure 4. The Cumulate Usage Factor increases as more fine mesh is used but it converges to 0.4. When a stress concentration factor of 1.25 is applied to case (b) model, cumulate usage factor is calculated to be 0.51. This result is more conservative then convergence value 0.4 of finer mesh analysis results.

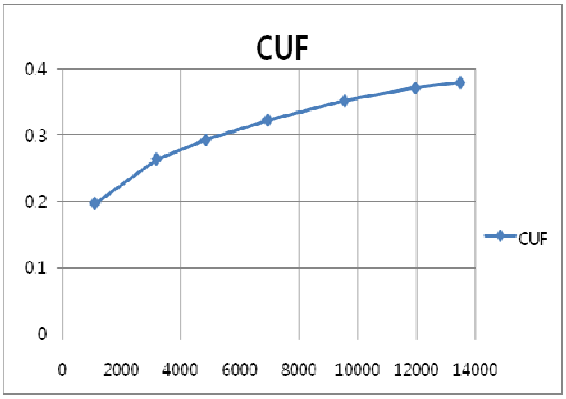

Figure 5 Fatigue Analysis Results

4. Conclusions

In the fatigue analysis using the finite element analysis, the stress concentration factor corrects the effect of stress concentration due to geometry but yields over-conservative result when applied to a finite element model with relatively finer mesh.

REFERENCES

[1] ASME Boiler and Pressure Vessel Code, Section III, Rules for Construction of Nuclear Power Plant Component, 1998 Edition.

[2] Stress Concentration Design Factors, R.E. Peterson; John Wiley & Sons Inc., 1974.

[3] Design Specification for Reactor Vessel Assembly for Shin-Kori units 3, 4, Rev. 04, KOPEC.