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Fatigue Analysis of a Steam Generator Module Feedwater Header in the SMART

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1. Introduction

Recently, efforts have been devoted worldwide to expand the peaceful utilization of the nuclear energy other than electricity generation. Therefore, small/ medium size multi-purpose advanced reactor draws keen attention in consideration of its adaptive nature, simplicity of reactor design, and passive safety approach. It is expected that the demand for small/medium size reactor will arise for various applications such as small capacity power production, heat generation, and energy source for seawater desalination in the near future [1].

SMART (System-integrated Modular Advanced ReacTor) of 330MWt is on the process of design [2]. The SMART has a unique design concept such as the integrated reactor vessel assembly system and the passive residual heat removal system. For the safety review of the SMART, identifying the structural integrity in the early design stage is necessary because it helps to prevent the unexpected cost increase and delay of the SMART licensing schedule. Moreover, the reliable structural integrity evaluation for the SMART is very important for ensuring public acceptance of the SMART.

In this study, as a part of tasks to construct regulatory verification system for the structural integrity assessment of principal components in the SMART reactor assembly, the fatigue analysis of a SG (Steam Generator) MFH (Module Feedwater Header) in the SMART was performed considering plant specific design characteristics.

2. Stress and Fatigue Analysis

2.1 Target Subcomponent

The MFH of SG was selected as a target subcomponent because of the high temperature difference between inner and outer surfaces, and the complicated configuration with notches which can generates stress concentration. Fig. 1 shows configuration of the SG MFH. Material properties were determined by using ASME B&PV Code, Sec.II [3]. The finite element model used for temperature/stress analysis consisted of two dimensional quadratic tetra elements.

Representative transients were derived via transient grouping so that conservative results could be induced. Temperature and pressure variations for the representative transients were determined in the viewpoint of conservatism. Fig. 2 depicts temperature and pressure variations of fluid group 5, which is reactor coolant after heat transfer to the secondary side of steam generator, for the representative transient T2D(3) and as an example of the enveloping results.

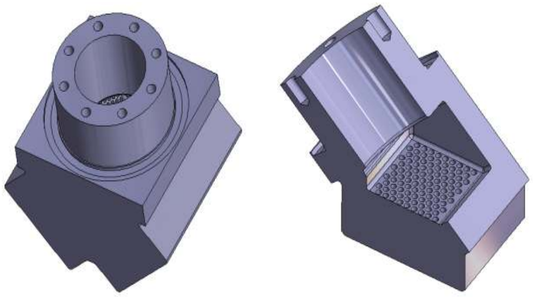
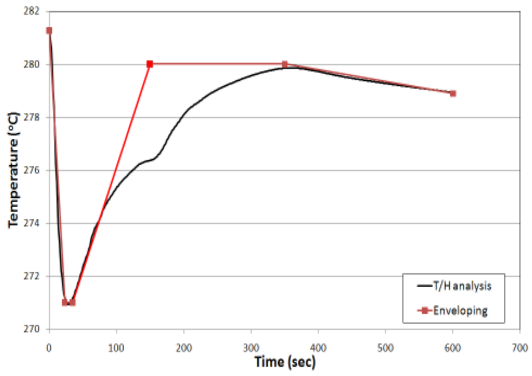
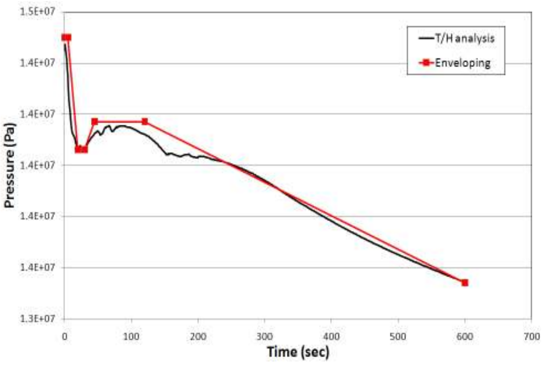


Fig. 1. Configuration of SG MFH (1/4 model).



(a) temperature



(b) pressure

Fig. 2. Temperature and pressure variations of fluid group 5 for the representative transient T2D(3).

2.2 Temperature and Stress Analysis

Heat conduction based temperature and elastic stress FEA (finite element analyses) were performed by using the commercial FEA program, Solidworks [4]. Fig. 3 depicts stress intensity distributions at steady state during normal operation. As depicted in the figure, high stresses occur at some notches.

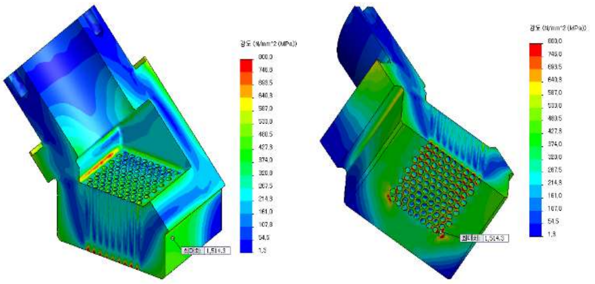


Fig. 3. Stress intensity distributions at steady state during normal operation.

2.3 Fatigue Analysis

CUFs (Cumulative Usage Factors) were calculated at some stress concentration locations by using the fatigue assessment procedure presented in ASME B&PV Code, Sec.III, Subsec.NB-3200 [5]. Fig. 4 shows CUF calculation locations of the SG MFH. Fig. 5 depicts variation of principal stress difference with time at the location 7.

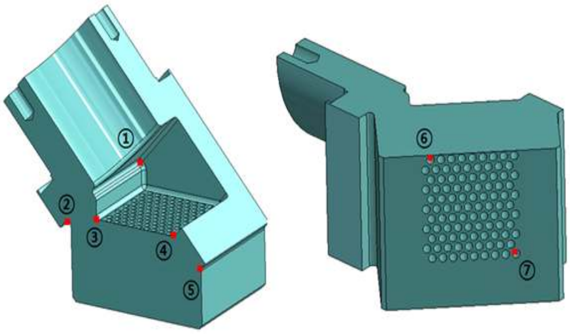


Fig. 4. CUF calculation locations of the SG MFH.

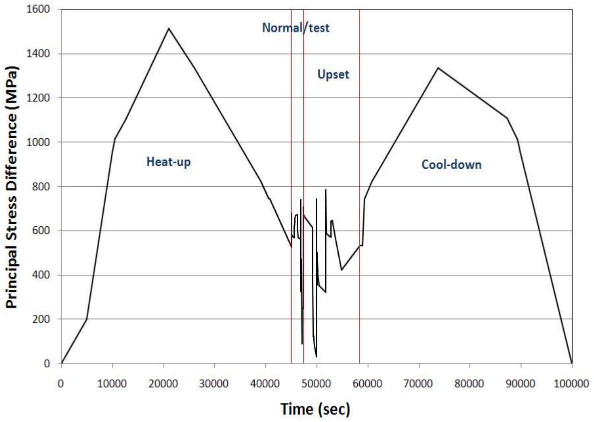


Fig. 5. Variation of principal stress difference with time at the location 7.

Table 1 presents the CUFs calculated for some stress concentration locations. From the table, the CUF values don' t exceed 1 during design lifetime.

Table 1. CUFs at some stress concentration locations.

CUF calculation point	CUF
1	0.0002
2	0.0136
3	0.0168
4	0.0031
5	0.0043
6	0.4481
7	0.5746

3. Conclusions

The following conclusions are found via the fatigue assessment of the SG MFH in the SMART:

- High stresses occur at some notches of the SG MFH,
- In the viewpoint of fatigue, structural integrity is ensured for the SG MFH during design life time.

REFERENCES

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