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Stress Concentration Evaluation of RV Capped CEDM Nozzle Threaded Joint and Omega seal in APR1400

Jung-Dae Son, Se-Hun Kim, Ji-Hyun Kim, Moon-Kil Park
DOOSAN Heavy Industries and Construction Co. LTD, Reactor Design Team 555 Gwigok-Dong Changwon, Gyeongnam 641-792, Korea, jungdae.son@doosan.com

1. Introduction

In operating nuclear reactors, spare reactor vessel capped Control Element Drive Mechanism (CEDM) nozzles are not connected to CEDM assembly and are maintained with the cover capped on.

This study presents a stress concentration analysis of RV capped CEDM joint threaded and omega seal in APR1400. It is important to evaluate a stress concentration factor which is to be used in fatigue analysis assuring its structural integrity. The stress concentration factor which had been applied to the fatigue analysis of CEDM Nozzle was based on the previous analysis and had not been evaluated accurately.

2. Methods and Results

The thermal and structural analyses were performed in this study. A thermal analysis as well as a structural analysis was introduced to obtain more accurate stress concentration factors for Thread joint part and Omega seal connection part of RV CEDM Nozzle and CEDM Nozzle cap.

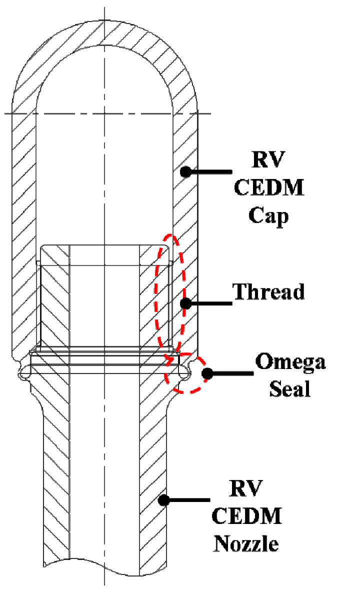

Figure 1. RV CEDM Nozzle and CEDM Nozzle Cap [1]

2.1 Model of FE Analysis

An RV Capped CEDM Nozzle consists of an RV CEDM Nozzle and a CEDM Nozzle Cap. The Nozzle and Cap are assembled by threaded connection. The shapes of two parts are shown in Figure 1.

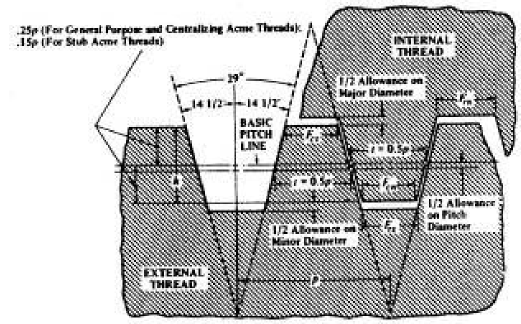

Figure 2. ACME screw thread form [2]

The general purpose ACME screw thread was used for the threaded joint in the RV Capped CEDM Nozzle. ACME screws are power fasteners with specialized threads. The advantage of ACME screw threads is that they are wider and stronger than those of standard screws. The shape of ACME screw thread is shown in Fig. 2.

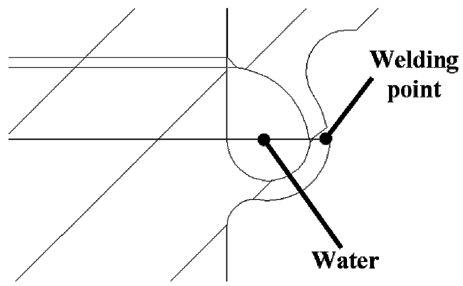

Figure 3. Omega seal

Figure 3. shows the configuration of Omega-seal connection. Function of the Omega-seal is sealing the pressure boundary of RV Capped CEDM Nozzle to prevent the primary coolant from leakage.

2.2 Boundary Condition

Boundary conditions were defined considering its jointing environment of each threaded joint and the Omega-Seal weld. Also, Design pressure was applied as a load of FE model. The design pressure (2500 psi) was applied to the model in contact with the primary coolant. RV Capped CEDM Nozzles undergo various thermal transients. Two representative transients, plant heat-up

(Figure 4.) and cool-down (Figure 5.), were considered. Boundary conditions were applied as below.

1) Internal pressure + Heat-up thermal load

2) Internal pressure + Cool-down thermal load

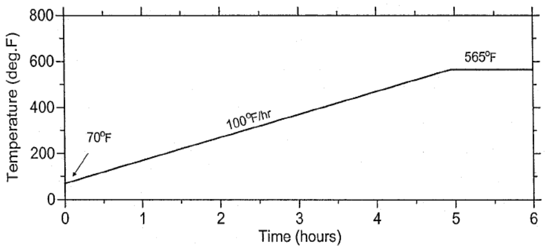

Figure 4. Temperature Variation during Heat-up

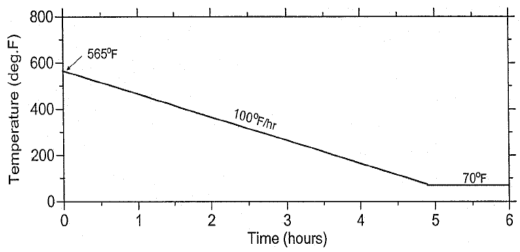

Figure 5. Temperature Variation during Cool-down

2.3 Analysis Results

To calculate stress concentration factor, the stress distribution in the threaded joint was evaluated for each transient. Using these stresses, the stress concentration factors for each joint of RV CEDM Nozzle and RV CEDM Nozzle Cap thread were calculated. Generally, the highest stress concentrations occur at the thread roots. Thus, the thread roots were considered as the main regions of interest. This is shown in Figure 6.

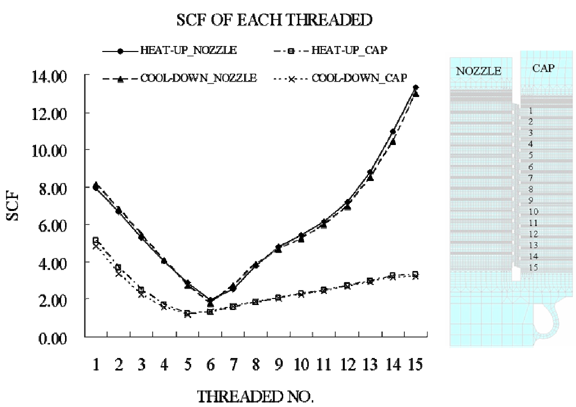

Figure 6. SCF Value distribution in each thread

Also, the SCF values of Omega-Seal region are produced by using these stresses. This is shown in Figure 7.

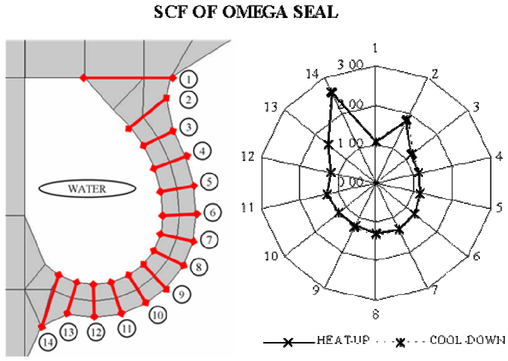

Figure 7. SCF Value distribution in Omega seal

3. Conclusion

In this study, stress concentration analysis of RV Capped CEDM Nozzle based on actual APR1400 dimensions was performed. Realistic operating conditions were also considered to evaluate SCF. The results can be concluded as follows.

1. Maximum SCF in RV Capped CEDM Nozzle threaded joint is 13.32 which occur at the 15th thread of RV CEDM Nozzle during plant Heat-up transient.

2. The SCF value greater than 2.0 is found at the 13th cut in the Omega-seal region. Maximum SCF in Omega seal is 2.61 which occur at the 13th cut of RV CEDM Nozzle during plant cool-down transient.

3. The results of this study are in accordance with ASME code requirements which prescribe that SCF not be less than 4.0 for threaded joint and be less than 5.0 for Omega-seal.

REFERENCES

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