Fatigue Analysis of a Feedwater and Condensate System Nozzle of a Boiling Water Reactor

Comision

S. Pérez-Montejo[1, a], G. Soto-Mendoza[1, b], L. H. Hernández-Gómez[1, c], P. Ruiz-López[2, d], L. G. Carbajal-Figueroa[1, e], J. A. Beltrán-Fernández[1, f], G. M. Urriolagoitia-Calderón[1, g]

[1]Instituto Politécnico Nacional, ESIME Zacatenco, SEPI, Edificio 5, 3er Piso. Unidad "Adolfo López Mateos" Colonia Lindavista, 07738 Ciudad de México, México.

[2]Comisión Nacional de Seguridad Nuclear y Salvaguardias. Dr. José Ma. Barragán No. 779. Colonia Narvarte, Delegación Benito Juárez, C.P. 03020, Ciudad de México, México

[a]perez_ms01@hotmail.com, [b]gilberto.soto.m@esimez.mx, [c]luishector56@hotmail.com, [d]pruiz@cnsns.gob.mx, [e]laura_gcf@yahoo.com.mx, [f]jbeltranf@hotmail.com, [g]urrio332@hotmail.com

Antecedents

The feedwater and condensate recirculation (RFW) nozzles of a Boiling Water Reactor are passive components. It means that they are not replace during the whole life of the reactor. Therefore, they must maintain always their structural integrity. Those reactors have four RFW nozzles of 12 inches diameter. A severe failure of these nozzles causes a reduction of the power of the reactor or could generate a shutdown, which has not been programmed. In this way, security is compromised.

A RFW nozzle is subjected to thermo mechanical cyclic stresses. The temperature of the reactor is 270°c and 65°c outside of it. When this nozzle is in operation, water is injected at 36.6°c and a thermal shock takes places. The coefficient of convection is 265.75 W/ m^2°c. In a current design, a RFW nozzle has a single thermal sleeve. A stress concentration point is developed at the junction of nozzle with the thermal sleeve. Cracks are developed at this point, as a result of the cycle stresses that are generated during each injection of water. In order to reduce the stress gradient, a new design has been proposed, a nozzle with three thermal sleeves (Fig, 1). In this paper, an evaluation of its fatigue life is reported. The injection of water condition was evaluated, because it is considered as the most severe. A thermo mechanical analysis was carried on with ANSYS code, in accordance with ASME code **[1].**

Thermomechanical Stress Analysis of the RFW Nozzle

A transient thermo-mechanical analysis was carried on. It was determined the temperature and stress field that takes place during one cycle of water injection. Figure 2a shows the finite element mesh. It has 179,243 elements and 381,558 nodes. The boundary conditions are shown in figure 2b. Regarding the stress analysis, the safe end was fixed along the axial direction (Fig. 3a).

Analysis of Results

Peak stresses [70664 psi] were developed at joint between the thermal sleeves and the nozzle (Fig. 3c). With this data, the alternate stresses were determined. The fatigue life was determined with the table I-9.1 of the ASME code, Section III, Division I. For this case, 1059 cycles have to take place before failure. In accordance with the transient considered, 219 cycle were postulated. They will take place in 60 years. The Cumulate Usage Factor is 20.67% **[1-5].**

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Statement

The conclusions and opinions stated in this paper do not represent the position of the National Commission on Nuclear Safety and Safeguards, where the co-author P. Ruiz-López is working as an employee. Although special care has been taken to maintain the accuracy of the information and results, all the authors do not assume any responsibility on the consequences of its use. The use of particular mentions of countries, territories, companies, associations, products or methodologies does not imply any judgment or promotion by all the authors.

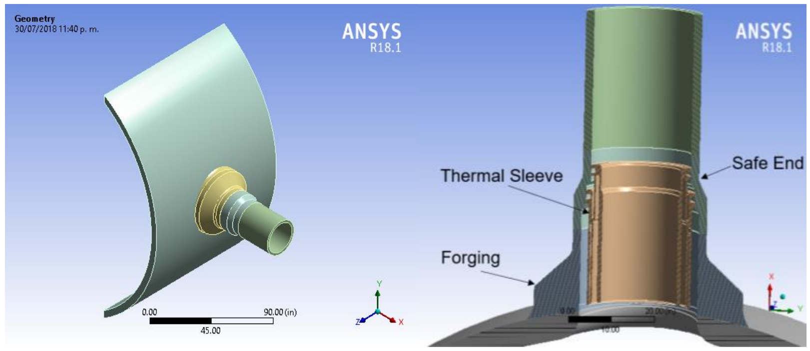

Figure 1. Geometric characteristics of RFW nozzle with three thermal sleeves.

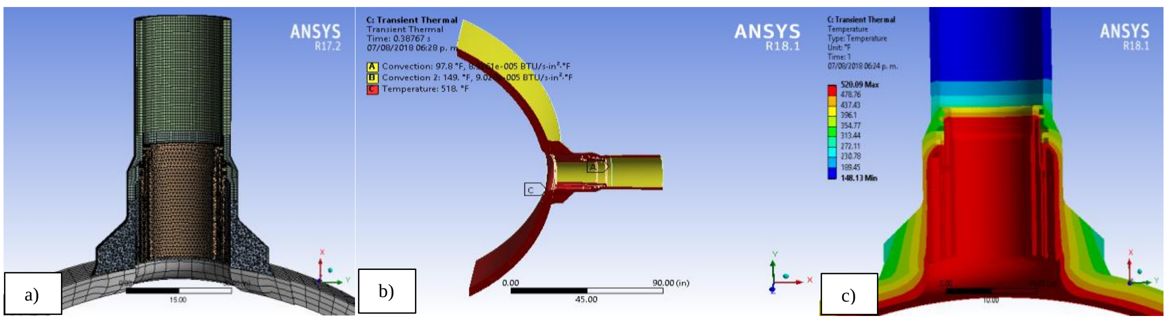

Figure 2. a) Finite element mesh, b) Boundary conditions, c) Transient temperature field.

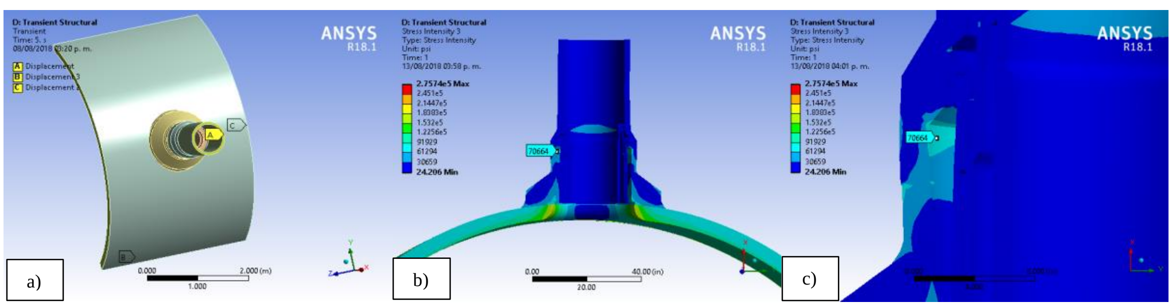

Figure 3. a) Boundary conditions for the stress analysis; b) Resultant stress field; c) Peak stresses.

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Key words: ASME, Cumulative usage factor, Transient stress, BWR reactor.