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The analysis of temperature distribution for surveillance Capsule in reactor vessel of YGN unit 1

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1. Introduction

Generally, Hardening and irradiated brominating phenomena are occurred in the reactor vessel under operation conditions by atomic cavities and creation of impurity atoms which are led by high fast neutron flux. To assure the mechanical integrity of pressure vessel until the end of power plant life after monitoring the sample specimens on the vessel inside, a series of tests is performed over the retrieved surveillance capsule to examine the changes according to the plant operation in accordance with regulations.

Monitoring surveillance capsules attached to neutron shield wall of outer core are consists of impact sample, tensile sample and temperature monitor (Fig. 1).

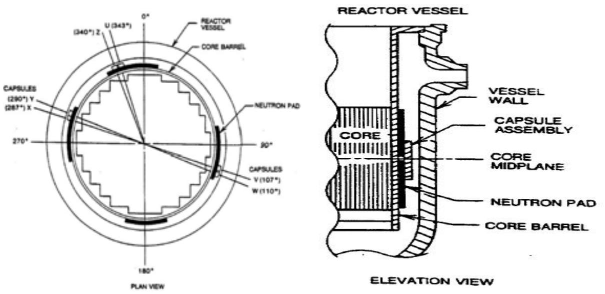

Fig. 1 Install position of surveillance capsule in YGN unit 1

The temperature monitor samples are examined to confirm the operation conditions whether the capsule would be in the thermal environment between 579 ^{0}F and 590 ^{0}F or not. Each temperature monitor having the 579 ^{0}F of melting point in surveillance capsule of YGN unit 1 is laid on upper and lower.

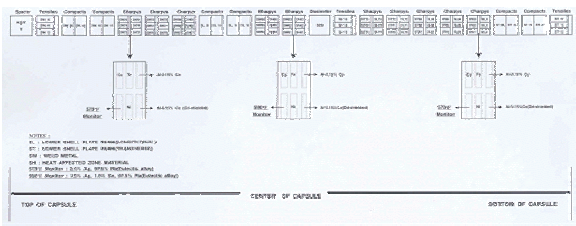

Fig. 2 Diagram of temperature monitor

And one temperature monitor having the 579 ^{0}F of melting point is laid on middle. But melting evidence of temperature monitor was detected during the tests following the 14th end of cycle (EOC).

In this paper, the temperature distribution of the temperature monitors has been evaluated to examine the causes of the melting which should be avoided under normal operation condition.

2. Analysis Method

In this study, two kinds of approach methods were used to evaluate the temperature monitors. One is the numerical analysis approach using the finite difference method (FDM) to find the general trends and severe cases according to various conditions. Another is the finite element method (FEM) approach using the ANSYS code to confirm the trends from FDM approach and to assess more realistic temperature distributions in the temperature monitors or the surveillance capsule.

2.1 Numerical analysis method

In the FDM approach, the surveillance capsule was simplified into two dimensional flat as shown in Fig. 2. If the three tubes located in control volume are assumed to be in the same properties, it could be treated though a quarter of the cross sectional area (Fig. 3).

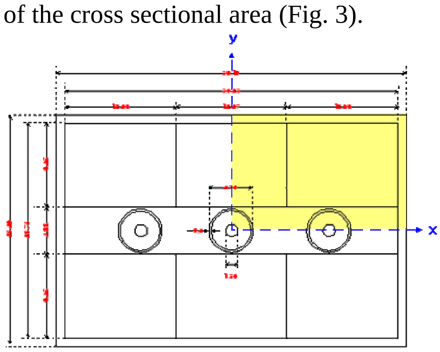

Fig. 3 Simplified geometry of temperature monitor

When it is assumed to be quarter as Fig. 3, the bottom and left side could be assumed as in insulation conditions under bilateral symmetry consideration. Also upper and right side can be represented as a forced-convective cooling region by the downcomer flows.

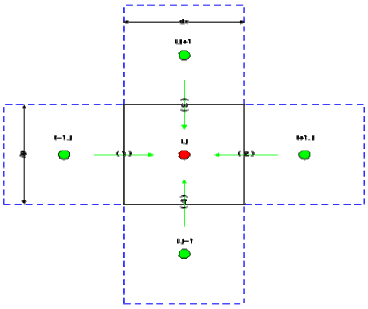

Fig. 4 Basic grid used for the FDM approach

Under above considering, the governing equations are conducted using FDM for the quarter region.

2.2 The analysis method using the FEM code

ANSYS is a finite element analysis code widely used in the computer-aided engineering (CAE) such as structural mechanics, vibration, heat transfer, electromagnetic field, sound, thermal hydraulics, *etc*. To express the three dimensional temperature distributions, the surveillance capsule is modeled as shown in Fig. 5.

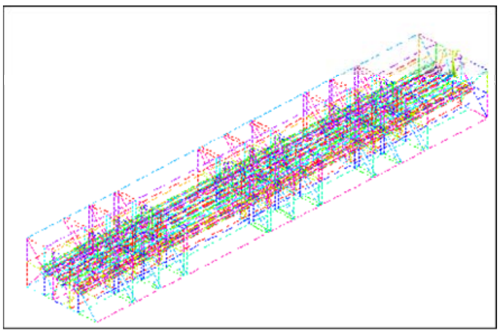

Fig. 5 Entire ANASYS model for the surveillance capsule

Three temperature monitors were assumed to be composed of the same properties. The whole body of the capsule handled as the heat source caused by the irradiation of the fast neutron flux of gamma ray flux from the core. And the capsule was assumed to be exposed in the downcomer flow, so the surface of it could be cooled by the forced convective heat transfer of the coolant continuously.

3. Result

3.1 Numerical analysis

The results are showed that temperature of the center is higher than lower part one. The temperature of lower part is higher than upper part one in spit of the same condition. It is caused by the difference of Reynolds number and heat transfer coefficients on the surface. If axial direction power at the upper is higher than the other parts, the result may indicate somewhat different behavior. But above state is not expected under normal condition. The various gas compositions in the Pyrex surrounding temperature monitors were also considered. In this analysis, results are indicated that if ratio of helium keeps coming down, maximum temperature keeps going up.

3.2 FEM analysis

As presented in the two dimensional numerical analysis, maximum temperature is appeared at the midst of temperature monitors and gas regions in the Pyrex.

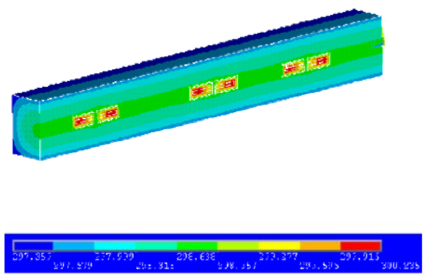

Fig. 6 Sectional diagram of the results using ANSYS

The temperature monitor in center of surveillance capsule which is located most far from outer wall indicate maximum temperature because of cooling effect which flows on outside.

4. Conclusion

To evaluate the thermal distribution of temperature monitors on plant operation, analysis using the FDM is performed to two dimensional plates and general temperature distribution analysis is calculated using the ANSYS code for detail evaluation.

Temperature of surveillance capsule and temperature monitors does not exceed to the melting point of them. Therefore, it was concluded that the melting was not induced by any operational conditions of the plant, YGN unit 1 and it would be caused by any other reasons, such as mal-treatment during the welding the capsule or else.

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