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Evaluation of Thermal Load to the Lower Head Vessel Using the ASTEC Computer Code

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1. Introduction

Corium behavior in the lower plenum of the reactor vessel during a severe accident is very important, because this affects the reactor vessel failure mechanism and heat flux to the outer reactor vessel under the IVR-ERVC (In-Vessel corium Retention through External Reactor Vessel Cooling). The thermal load from the corium to the lower head vessel in the APR (Advanced Power reactor) 1400 during a small break loss of coolant accident (SBLOCA) without a safety injection (SI) has been evaluated using the ASTEC (Accident Source Term Evaluation Code) computer code [1], which has been developed as a part of the EU (European Union)-SARNET (Severe Accident Research NET work) program.

2. ASTEC Computer Code and Input Model

Since 1996, the IRSN in France and GRS in Germany have developed a severe accident integral code of the ASTEC for an evaluation of the source term in the water cooled reactor of the initial PWR including the VVER, BWR, and recently, CANDU. Fig. 1 shows the ASTEC code structure. This code calculates a severe accident sequence from an initiating event to a containment failure.

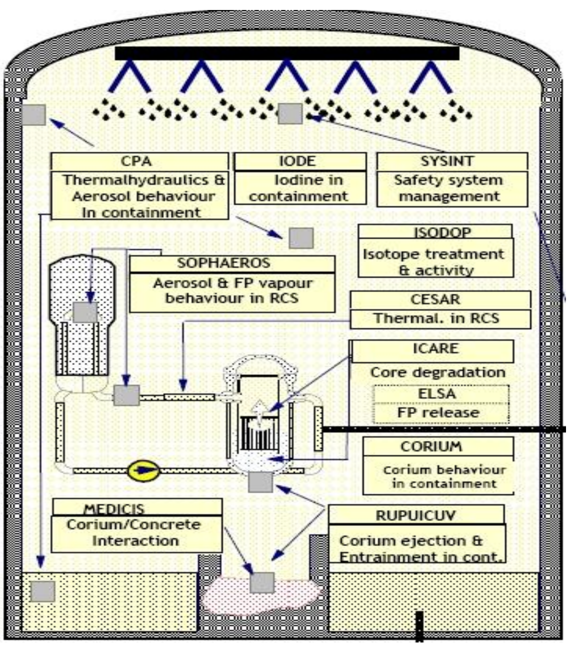

Fig. 1. ASTEC code structure.

Fig. 2 shows the two layer formation of the upper metallic and lower oxidic in the lower plenum of the APR1400. The heights of the metallic and oxidic layers are 1.46 m and 0.464 m, respectively, which results from the SCDAP/RELAP5 and GENINI results in the SBLOCA without SI [2]. This is an input model of the ASTEC calculation. In the base case calculation to 50,000 seconds, the outer vessel is assumed to be 393 K, which is the IVR-ERVC condition.

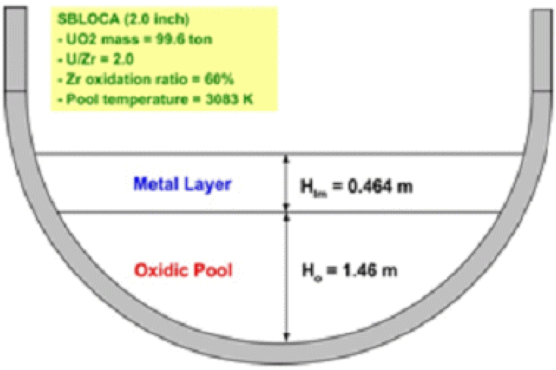

Fig. 2. Two layer formation in the lower plenum.

3. ASTEC Results and Discussion

Fig. 3 shows the base case ASTEC results of corium mass in the lower plenum of the APR1400. As the time increases, the corium mass increases slightly owing to the relocation of the melted core material in the core.

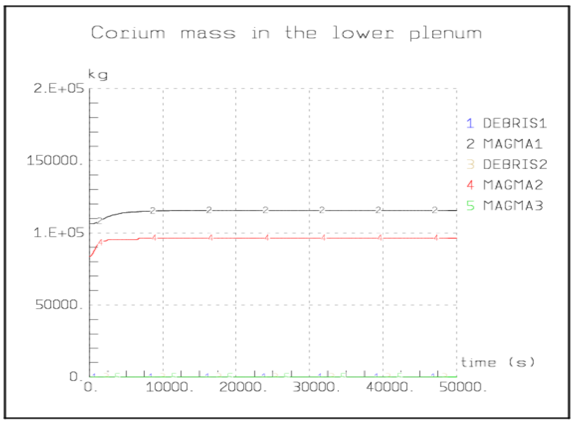

Fig. 3. ASTEC results of corium mass in the lower plenum (base case).

Figs. 4&5 show the ASTEC results of the lower head temperature in the base case. The reactor vessel thickness of the upper side of the spherical vessel decreases owing to the thermal attack of the metallic layer, but the reactor vessel does not fail.

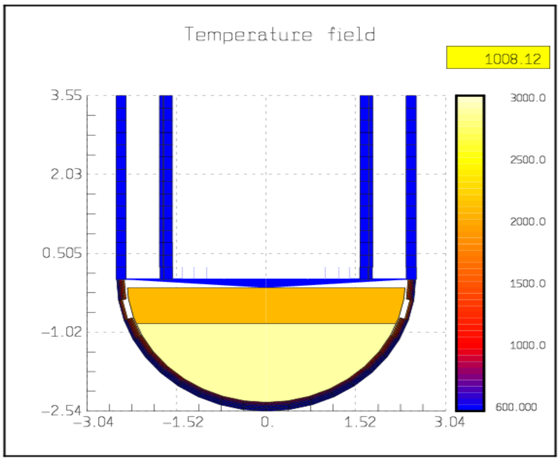

Fig. 4. ASTEC results of lower head temperature at 1,008 s (base case).

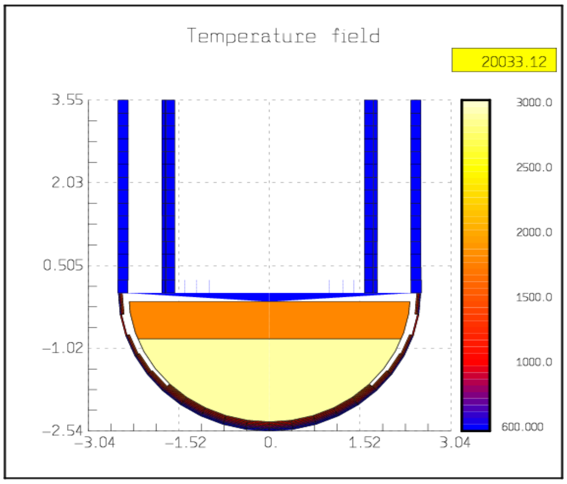

Fig. 5. ASTEC results of lower head temperature at 20,033 s (base case).

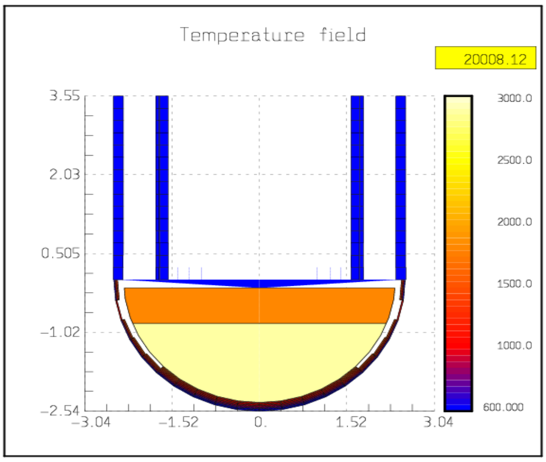

Fig.6. ASTEC results of lower head temperature at 20,008 s (outer surface temperature change case).

As shown in Figs 6&7, the outer surface condition at a temperature increase from 393 K to 413 K, and a 50 % increase of the heat transfer coefficient to the coolant, are not effective on the vessel geometry change, which are preliminary results.

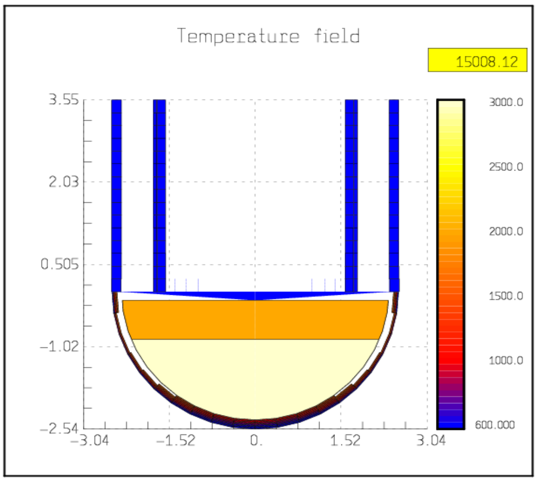

Fig.7. ASTEC results of lower head temperature at 15,008 s (heat transfer coefficient change case).

4. Conclusion

The ASTEC results predict that the reactor vessel did not fail by using an ERVC, in spite of the large melting of the reactor vessel wall in a two-layer formation case of the SBLOCA in the APR1400. The outer surface conditions of the temperature and heat transfer coefficient are not effective on the vessel geometry change, which are preliminary results. A more detailed analysis of the main parameter effects on the corium behavior in the lower plenum is necessary to evaluate the IVR-ERVC in the APR1400, in particular, for a three-layer formation of the TLFW. Comparisons of the present results with others are necessary to verify and apply them to the actual IVR-ERVC evaluation in the APR1400.

ACKNOWLEDGMENTS

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REFERENCES

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[2] K. H. Kang, R. J. Park, S. W. Hong, “Thermodynamic Analysis for the Three-layered Melt Pool during the Severe Accidents in the APR1400,” NURETH-13, Kanazawa City, Ishikawa Prefecture, Japan, 2009.