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Preliminary Analysis of Corium Behavior in the Lower Plenum by using 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 reactor failure mechanism and thermal load to the outer reactor vessel under the IVR-ERVC (In-Vessel corium Retention through External Reactor Vessel Cooling). Preliminary Analysis of the corium behavior in the lower plenum of the APR (Advanced Power reactor) 1400 during a small break loss of coolant accident (SBLOCA) without safety injection (SI) has been performed by using the recent version of the ASTEC (Accident Source Term Evaluation Code) computer code, which has been developed as a part of EU (European Union)-SARNET2 (Severe Accident Research NETwork Phase 2) program.

2. ASTEC Computer Code and Input Model

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

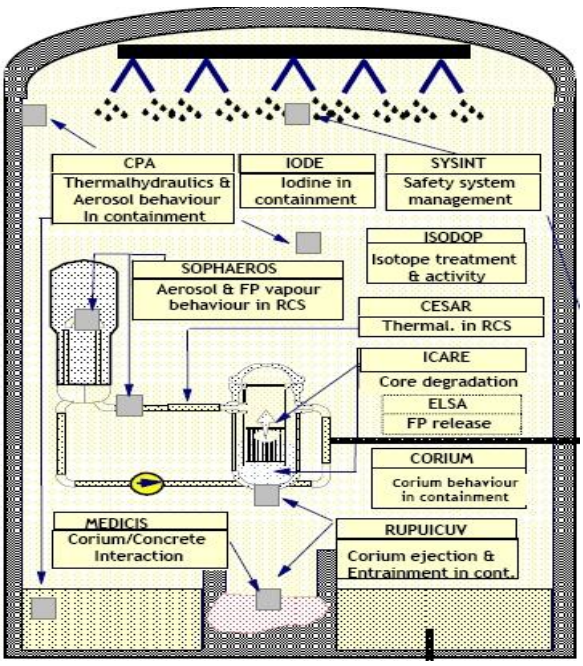

Fig.1. ASTEC code structure.

Fig. 2 shows the corium behavior model employed in the ASTEC for the lower plenum analysis. The ASTEC has zero dimensional approach with 3 liquid layers and possible debris model. Mass transport between the layers is calculated by assuming a quasi-steady relative motion of metal in the oxide and oxide in the metal [1].

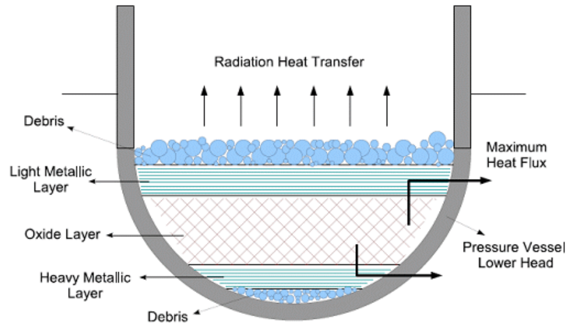

Fig.2. Corium behavior model in the lower plenum.

Fig.3 shows the two layer formation of corium expected in the lower plenum of the APR1400: the lower oxidic and the overlying metallic layers. The heights of the metallic and oxidic layers are 1.46 m and 0.464 m, respectively, which results from both SCDAP/RELAP3 and GENINI calculations in the case of SBLOCA sequence without SI [2]. This was used as an input model of the ASTEC calculation. During the calculation up to 10,000 seconds, the outer vessel is assumed to be 393 K, which is IVR-ERVC condition.

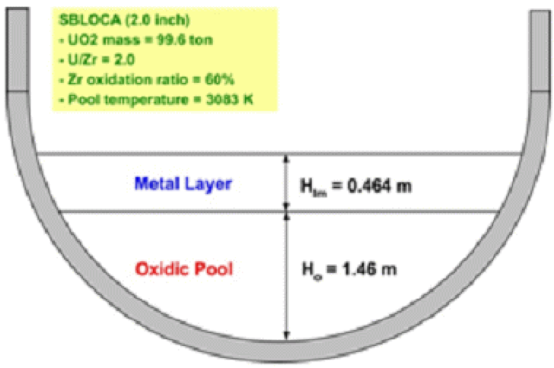

Fig.3. Two layer geometry of corium in the lower plenum.

3. ASTEC Results and Discussion

Fig. 4 shows the ASTEC analysis results on corium mass in the lower plenum of the APR1400. As the time increases, the corium mass also increases slightly due to the relocation of the melted core material in the core.

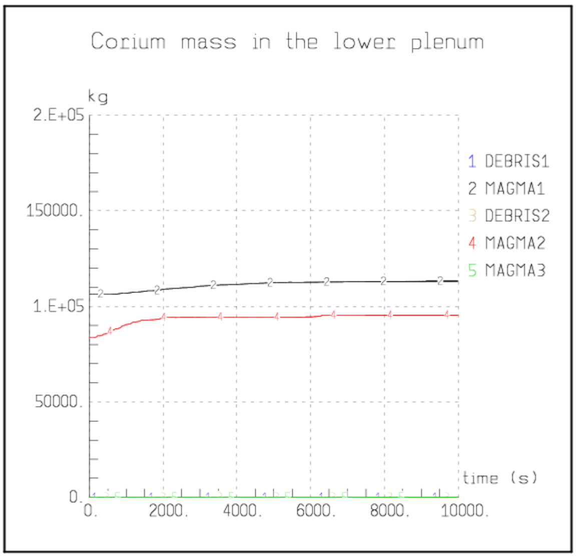

Fig. 4. ASTEC results of corium mass in the lower plenum.

Fig. 5 shows the ASTEC results of corium temperature in the lower plenum. The corium temperature in the oxidic melt increases slightly due to the continuous release of the fission product decay heats, but the metallic melt temperature decreases due to the heat loss to the upper side of the reactor vessel.

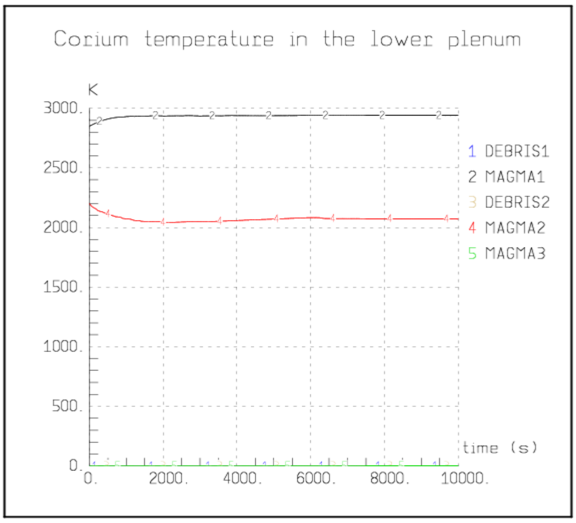

Fig. 5. ASTEC results of corium temperature in the lower plenum.

Fig. 6 shows the ASTEC results of corium temperature and final reactor vessel geometry in the lower plenum. The reactor vessel thickness of the upper side of the spherical vessel decrease due to the thermal attack of the metallic layer, but the reactor vessel does not fail.

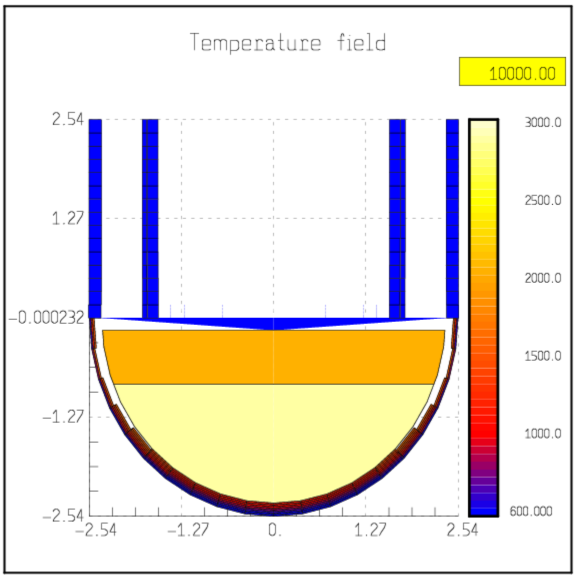

Fig. 6. ASTEC results of corium temperature and final reactor vessel geometry in the lower plenum.

4. Conclusion

Preliminary analysis of the corium behavior anticipated in the lower plenum of the APR1400 during a SBLOCA without SI has been performed by using the ASTEC computer code. The analysis results showed that the ASTEC code predicts the corium temperature and the reactor vessel geometry change as a function of time. More detailed analysis of the main parameter effects on the corium behavior in the lower plenum is necessary to determine the initial and boundary conditions for evaluation of the reactor vessel failure mechanism and the IVR-ERVC.

ACKNOWLEDGMENTS

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REFERENCES

[1] P. Chatelard, G. Guillard, ., "ICARE User's Manual for the Integral Code ASTEC V2.0," DPAM/SEMCA 2009-147, June 2009.
[2] R. J. Park, S. B. Kim, K. Y. Suh, J. L. Rempe, and F. B. Cheung, Detailed Analysis of the Late-Phase Melt Conditions for the Evaluation of an In-Vessel Corium Retention, Nuclear Technology, Vol. 156, No 3, December 2006.