A Study on the Hydrogen Distributions in a Containment for Nuclear Plant Severe Accidents

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1. Introduction

Hydrogen explosion has been considered as one of the major issues since Fukushima nuclear accident. The cause of the explosion has not been discovered, but it is clear that the explosion strongly depends on hydrogen distributions in a containment[1-6]. In this study hydrogen distributions are calculated and analyzed in the containment of APR 1400(Advanced Power Reactor 1400) .

2. Simulation Conditions

2.1Geometry and Grid Modeling

Fig. 1 shows the inner shape and grids to calculate hydrogen behavior in the containment of APR 1400 nuclear power plant in which height is 80m and inner radius is 22m. The grids are generated by NX 7.5 and ICEM-CFD, and the number of grids are 2700000.

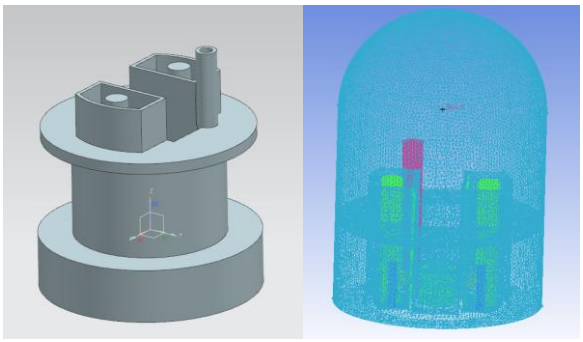

Fig. 1. Inner shape and grids for calculation

2.2 Initial Condition and Boundary Condition

As initial conditions, the pressure and temperature in the containment are 2.56 bar and 418 K respectively, and volume fractions of air, steam and hydrogen are 0.4956, 0.5044 and 0 respectively. The initial conditions are calculated from the hydrogen release figure proposed in [1]. The calculation conditions are summarized in Table 1.

Table I: Calculation and Initial Condition

Calculation Condition	
Analysis Type	*Transient*
Total time	*715 [s]*
Timestep	*0.5 [s]*

Initial Condition		
Static Pressure	*2.56 [bar]*	
Temperature	*418 [K]*	
Volume Fraction	*Air*	*0.4956*
	Steam	*0.5044*
	H_2	*0*

Table II shows inlet conditions which are the state of leakage flow from pipe failures. Mass flow rate is 6.752kg/s, temperature is 1000K, and volume fractions of air, steam and hydrogen are 0, 0.47 and 0.53 respectively.

Table II: Inlet Condition

Inlet Condition		
Mass Flow Rate	*6.752 [kg/s]*	
Total time	*1000 [K]*	
Timestep	*0.5 [s]*	
Volume Fraction	*Air*	***0***
	Steam	*0.47*
	H_2	*0.53*

3. Simulation Results

There is assumed that hydrogen is ejected from the hole caused by broken pipe between the reactor and a steam generator. The conditions are divided into 4 cases. The two cases are downward and sideward ejections from the pipe in the steam generator containment, and the other two are the same directions in the reactor containment.

Fig.2 shows hydrogen distributions in the two cases failed in the steam generator containment. In the case of downward ejection hydrogen mainly distributes in the steam generator containment, some part of above the containment, and all around near by inner wall. The hydrogen volume percents are about 25% in steam generator containment and 15% near by inner wall. In the case of sideward ejection hydrogen also distributes in the steam generator and near by the inner wall. But the hydrogen soon after out of the steam generator containment flow into side wall and forms high concentration about 25% of hydrogen, and the volume percents are over 30% in the steam generator containment.

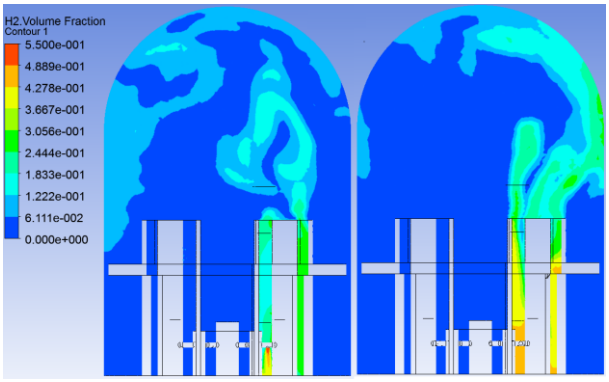

Fig. 2. Hydrogen distribution ejected in the steam generator containment

Fig.3 shows hydrogen behaviors in the two cases failed in the reactor containment. In the case of downward ejection hydrogen mainly distributes in the reactor containment and around near by the wall as that in the above case. In the case of sideward ejection hydrogen widely distributes all over the containment. Hydrogen volume percents are over 40% under the failure in the reactor containment, 20% above the reactor containment and 15% to 20% near by the inner wall.

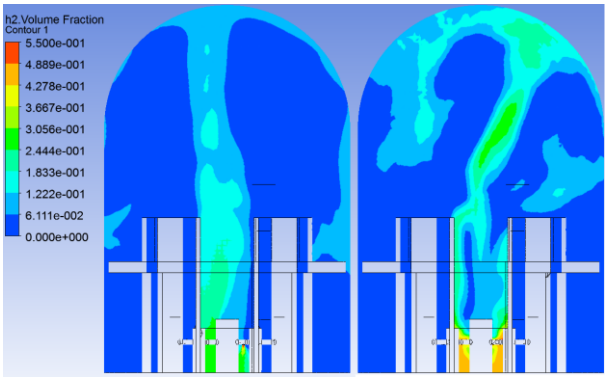

Fig. 3. Hydrogen distribution ejected in the reactor containment

4. Conclusions

Hydrogen distributes are analyzed in the containment of APR1400. The results of the hydrogen behaviors are summarized as follows;

-In the case of downward ejection hydrogen moves straight upward and distributes around the inner wall of the containment. The volume percents of hydrogen are 25% in the steam generator containment and 15% near the inner wall.

-In the case of sideward ejection hydrogen widely distributes all over the containment. The volume percents of hydrogen are 30% to 40% in the steam generator or reactor containment, and 20~25% around the inner wall.

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