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The Effect of Air Separator Geometry on the RVCS in PGSFR

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1. Introduction

Korea Atomic Energy Research Institute (KAERI) has been developing a conceptual design of the Prototype Gen-IV Sodium-cooled Fast Reactor(PGSFR), Which is the pool type sodium cooled fast reactor with the thermal power of 150MW and the core loaded with metal fuel.

PGSFR operates at higher temperature than existing light-water reactor. Because of reactor vessel and supports must have integrity and be protected from thermal stress, RVCS (Reactor vault cooling system) placed outside of containment vessel to cooling reactor vessel and supports. Flow path is inlet duct – cold air downcomer – hot air riser – outlet duct. This system`s cooling method is cold air cooling containment vessel outer surface directly.

In this work, multidimensional thermal analysis for the RVCS was carried out numerically and the numerical results were compared with several cases and find optimized air separator design using CFD.

2. Numerical Method

Fig. 1 shows the RVCS`s analysis region.

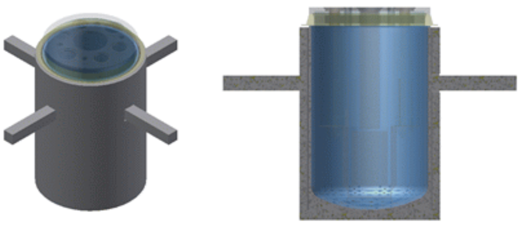
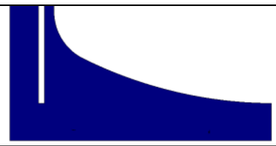
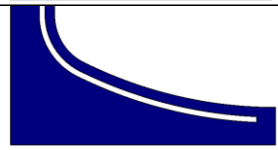
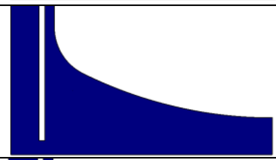
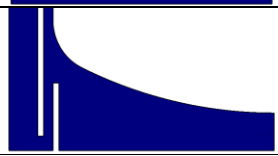


Fig. 1. Analysis Region.

Analysis region is setting RVCS`s air flow path, air separator`s thermal transfer between hot air riser and cold air down comer is not considered. Analysis region include Inlet duct and outlet duct to 6m length. Air separator of basic model and containment vessel has same level of bottom height. But this model has problem about reversed flow between air riser and air down comer. This problem makes air down comer temperature too high more than design temperature. To solve this problem, we add three case of air separator. So we analyze four case of air separator model.

Table 1 shows four case of air separator model

Table I: Four cases of Air Separator Geometry

	air separator geometry
case 1. Basic model	
case 2 . extended model	
case 3. Longer Separator model	
case 4. Barrier structure inserted model	

Numerical simulations were carried out using the commercial computational fluid dynamics package, STAR-CCM+ V9.02.007. The assumptions and analysis method used for analysis are as follows.

- 3-D steady state: 1/2 symmetric
- Turbulent model: Standard k-ε Two-Layer Model
- Two-Layer All y+ Wall Treatment
- Solver: Segregated Flow& Segregated Fluid Temperature
-Radiation calculated with the S2S model and gray thermal model

The polyhedral mesh is used, and three prism layers are applied at near wall region. Base size of mesh is 0.1m and surface size at Air riser region is 0.05m air downcomer region is 0.15m. Prism layer thickness is 0.01m.

The boundary conditions are as follows.

- Inlet Mass flow rate: 7.65kg/s(half of 15.3kg/s)
- Inlet temperature: 20℃
- Heat source temperature: 426℃
- Pressure Outlet (0 pa)

The containment vessel`s temperature is setting by considered accident condition. This temperature is result of radial 1-D mode calculate. In fact we need more analysis about vertical temperature gradient.

3. Numerical Result

Table 2 shows the result of analysis.

Table II: Problem Description

	case 1	case 2	case 3	case 4
outlet temperature	127℃	142℃	131.4℃	112.7℃
pressure drop	74.6pa	1009pa	89.1pa	79.9pa
highest temperature at outer wall	237.6℃	21.7℃	133℃	27.4℃

Case 1 is reference model and it has reversal flow at lower section. This cause hot spot at downcomer and outer wall temperature is higher than the limit. In case 2,3,4 there was no reversal flow of air and the highest air temperature in downcomer was lower than 175degree in celsius , which means that thermal stress against supports was lower than the limit. In case 2, outlet temperature was the highest because of heat transfer but high pressure and air stagnant in air raiser cause a big hot spot. Case3, case4 also have the problem of hotspot in air riser, but those were small and have lower temperature.

3. Conclusions

Using CFD, this paper shows fluidic property and efficiency of RVCS depending on structure of air separator. To Reduce reverse flow in downcomer, three model added. The Result of calculation including the three additional transformed structure satisfied design temperature in downcomer. Case 2 has lowest temperature at downcomer, but case 3 is the simplest way to satisfy the condition of design in terms of temperature distribution in upstream and structure of reactor.

ACKNOWLEDGEMENT

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