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Curvature Effects on the Pressure Perturbation of the DVI+ Duct

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1. Introduction

To minimize the ECC bypass of safety injection flow through a break during a late reflood phase, the DVI+ (advanced and optimized DVI system) has been developed for the APR+ (Advanced Power Reactor Plus) by KAERI. The DVI+ duct is attached to the outer surface of a core barrel. In this numerical study, the surface curvature effects of core barrel on the pressure perturbation characteristics around the DVI+ duct are tested using both a 1/5-scale cylindrical model and a 1/5-scale flat plate slab model. If the surface curvature effects of the core barrel on the pressure perturbation are removed, the simplified flat-plate 2D model is applicable, while the cylindrical model has a centrifugal force effect.

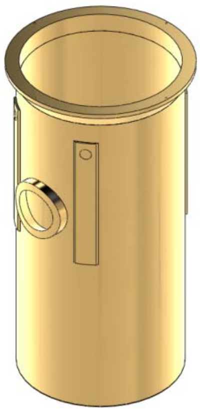


Fig. 1 DVI+ Duct

2. Numerical Model

Two numerical models were established for the 1/5-scale APR+ downcomer flow geometry; (1) a flat plate channel slab model, and (2) a cylindrical channel slab model. The fluid is water. A uniform velocity profile is assumed for the inlet boundary condition. The water temperature and pressure are assumed to be 15^{o}C and 2 bar. A symmetric boundary condition is applied for the lower and upper cutting surfaces of the downcomer. The other surfaces are applied as a wall boundary condition. Figs. 2 and 3 show the tested geometry and working boundary conditions. Fig. 4 shows the sampling points of the pressure perturbation.

In the inlet boundary, the RCP perturbation effects are not considered for the time history inlet velocity. The pressure fluctuation signals at the front and rear of the DVI duct are induced by the impinging jet effects of the cold leg and vortex shedding passing the DVI duct. The energy transfer between the fluid and structure was not modeled.

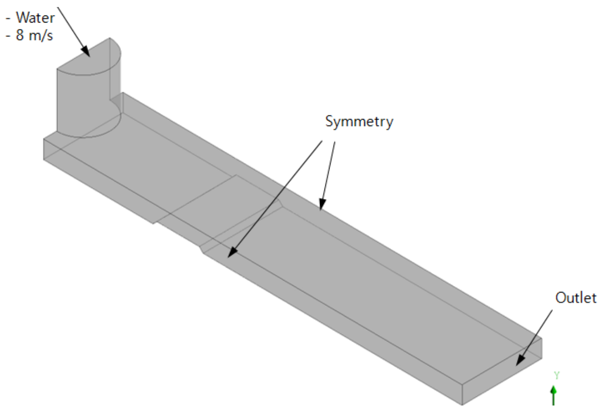


Fig. 2 Flat plate channel model

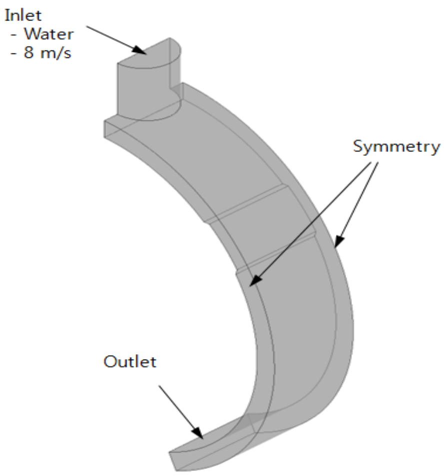


Fig. 3 Cylindrical channel model

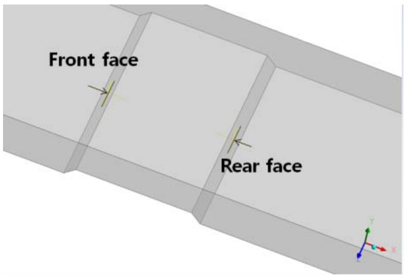


Fig. 4 Pressure sampling location

3. Calculation Results

The main objective of this test is to investigate the surface curvature effects on the pressure distortion of a slab model between flat-plate and cylindrical slab models. Thus, the sampling location and time history signal are treated by the same method.

Fig. 5 shows the velocity and pressure distributions for the flat-plate slab model. Fig. 6 shows the velocity and pressure distributions for the cylindrical slab model.

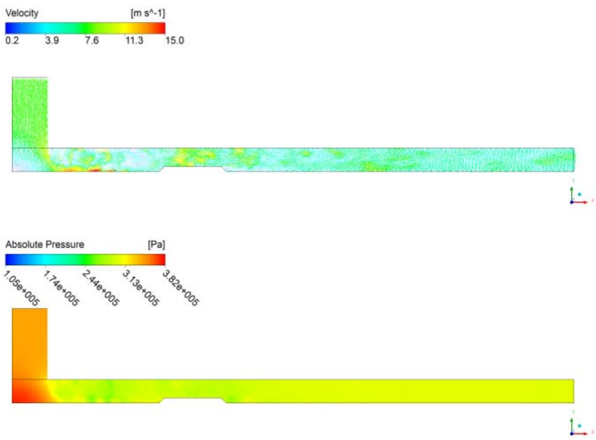


Fig. 5 Velocity and pressure of flat-plate model

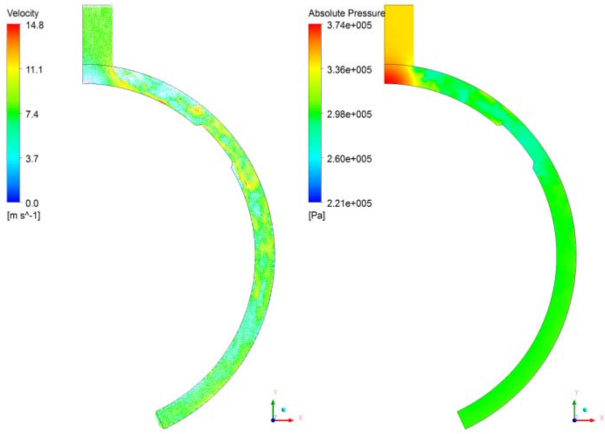
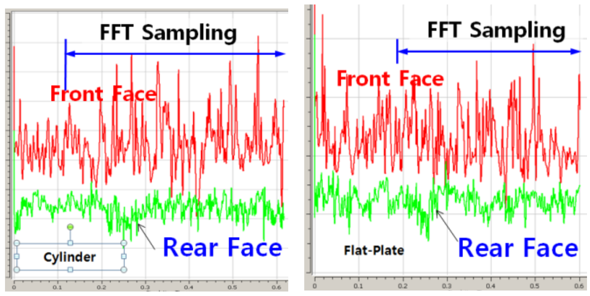


Fig. 6 Velocity and pressure of cylindrical model

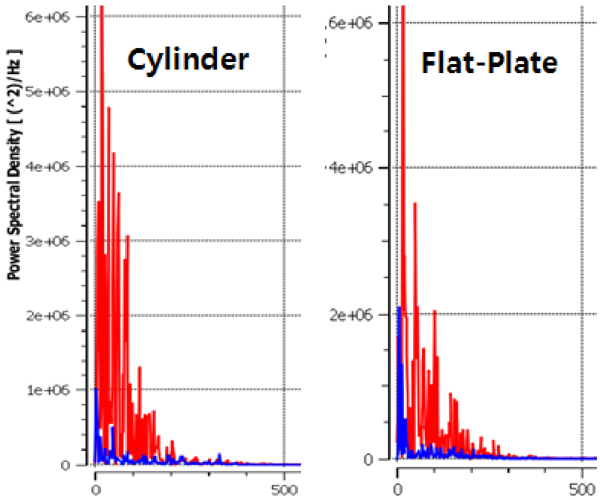
Fig. 7(a) shows the pressure perturbation signal of the cylindrical slab model at the front and rear faces of the DVI. Fig. 7(b) shows the pressure perturbation signal of the flat-plate slab model at the front and rear faces of the DVI duct. The amplitude and fluctuation time interval are very similar.

Fig. 8(a) shows the power spectral density of the pressure perturbation signal of the cylindrical slab model at the front and rear faces. Fig. 8(b) shows the power spectral density of the pressure perturbation signal of the flat-plate at the front face and rear faces. The amplitude and frequency interval of spectral density between two signals coincide well.



(a) Cylindrical **(b) Flat-plate**

Fig. 7 Pressure perturbation signal



(a) Cylindrical **(b) Flat-plate**

Fig. 8 Power Spectral density

4. Conclusions

A numerical calculation was performed to evaluate the surface curvature effects on the pressure perturbation around the DVI+ duct for flat-plate and cylindrical slab models. From the present results, it can be concluded that the surface curvature effects of the core barrel on the pressure perturbation is very weak. Therefore, a flat-plate scaled down test model is applicable for the pressure perturbation study around the DVI+ duct as the surface curvature effects of the core barrel are very weak on the pressure perturbation around the DVI duct.

Acknowledgement

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REFERENCES

[1]. Pressure perturbation characteristics on the ECBD and reactor vessel downcomer, Seungtae Lee and Tae-Soon Kwon, NTHAS-2012 (to be published)