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Hydraulic Analysis of SMART Fuel Assembly

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1. Introduction

It is very important for engineer to design energy and momentum balance of nuclear reactor. In this work, pressure drop is calculated for the SMART fuel assembly. In additional, mixing effect is evaluated due to porosity scheme.

2. Pressure Drop

2.1 Configuration and grid

For pressure drop of the SMART fuel assembly three-dimensional 1/8 configuration is designed as shown in Fig. 1. Fuel assembly is composed of diameter 9.5 mm rod of 264, diameter 12.24 mm guide tube of 24, and 12.6 mm of pitch in regular quadrilateral of 215.04 mm. Height is about 2300 mm [1].

Total number of grids is about 12.6 X 10^6. In order to exact simulate behavior around wall inflations of 5 are added with proportional 1.2.

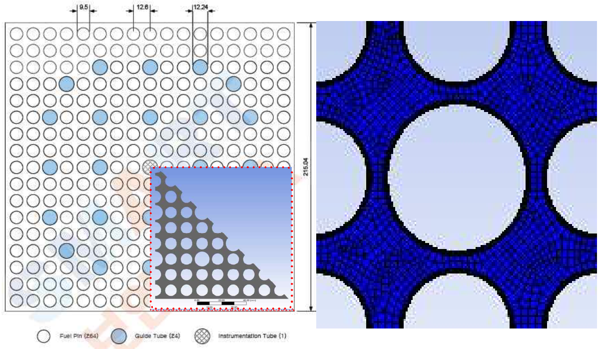


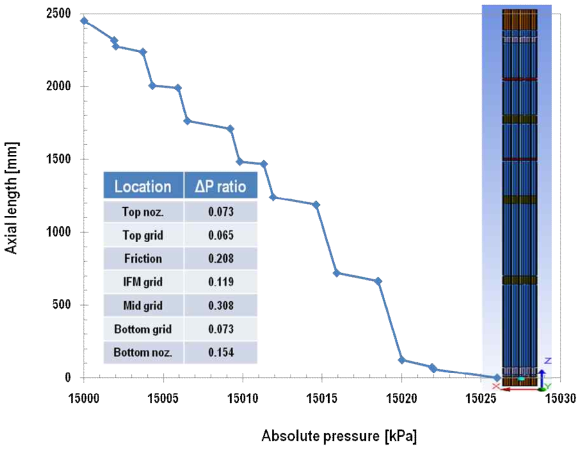
Fig. 1. x-y plane configuration of fuel assembly

2.1 Calculation

The SMART fuel assemble consists of top nozzle, top grid, IFM grid, mid grid, bottom grid, bottom nozzle, and Flow regimes. Pressure drop through these components is calculated adopting porosity scheme and loss coefficient as shown in Fig. 2. Boundary condition is described in Table 1. In this analysis, adiabatic condition considering density of working fluid is used. Calculation of pressure drop is conducted with the CFX code [2]. The shear stress transport is applied as turbulent model, and the second order is employed to solve differential equation. Overall pressure drop is calculated 26 kPa [3]. In order to verify result, handed calculation is operated with equation (1) [4]. Handed result is estimated under of 6 %. It is reason that flow behavior is assumed fully developed flow in handed calculation while flow redistribution is happened at each regime because of porosity scheme in the CFX code.

$$\Delta p = \sum_{i=1}^{n}\left[\left(K + \frac{fL}{D_e}\right)_i \frac{\rho_i u_i}{2} + \Delta\left(\frac{G_i^2}{\rho_i}\right) + \left(\rho_i L\right)\right] \tag{1}$$

where, *n, K, f, L,* D_ε, *ρ, u,* and *G* mean axial step, form loss coefficient, friction factor, length, hydraulic diameter, density, velocity, mass flux, respectively.



Location	ΔP ratio
Top noz.	0.073
Top grid	0.065
Friction	0.208
IFM grid	0.119
Mid grid	0.308
Bottom grid	0.073
Bottom noz.	0.154

Fig. 2. Resultant pressure drop of the SMART fuel assembly

Table 1. Information on initial condition

Boundary condition	
Average velocity at inlet	2.117 m/s
Temperature (adiabatic)	309.9 °C
Pressure at outlet	15 MPa
Loss coefficient (1/m)	
Top grid	61.4
Mid grid	30.0
IFM grid	58.3
Bottom grid	21.7

3. Flow Redistribution

In the CFX analysis, grid effect about pressure drop is controlled by porosity scheme. In this case, flow redistribution is happened due to difference of loss coefficient at each regime as described in Fig. 3. Flow behavior during redistribution process is similar with flow swirling due to grid. Quantitatively, Cross flow in flow redistribution is increased over of 8.7 % against fully developed flow.

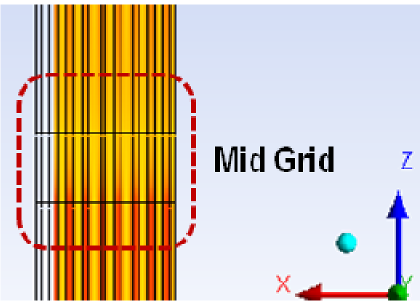


Fig. 3. Velocity feature at each grid

4. Conclusion

In order to design the SMART, hydraulic analysis about fuel assembly was conducted. Pressure drop was calculated 26 kPa. There is difference of 6 % between the CFX result and handed result due to flow behavior.

In the CFX analysis, flow redistribution with variable loss coefficient of each regime was occurred. It is cause of increased cross flow. This phenomenon is more similar to real state behavior through mixing grid effect.

REFERENCES

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