Analysis of pressure loss in piping system based on CFD

1. Research background

Among the energy consumption of buildings, the ratio of air-conditioning system energy is very large. However, research on energy saving technology for water pumping system is still insufficient. the use of decentralized pumping system is considered to reduce the energy consumption of the water pumping system.

2. Purpose of research

Understand the system characteristics of each water pumping system and predict the pressure and pressure drop in the pipe. Perform verification on prediction accuracy by comparing CFD simulation results with experimental data.

3. Modeling of piping system

Overview of the analysis target is shown in Figure 1. The size of model is the same with the experimental apparatus used in piping experiments. The red dots are pressure measurement points. In this model, The connection part with the pump outlet is set as the inflow boundary, the connection part with the pump inlet is set as the outflow boundary.

4. Overview of analysis

Turbulence model	Realizable k-ε
Analysis area	Shown in Figure 1
Analysis lattice	Reference size: 0.003m (elbow, T) Reference size: 0.01m (Straight pipe) Total amount: 122 million (Case1); 123million (Case2)
Lattice type	Center: polyhedron Wall portion: Prism layer
Type of flow	Incompressible flow
Advection term difference scheme	Second-order accurate upwind difference scheme

Piping entrance (Pump outlet)	Case1	Main inlet: inlet velocity = 0.78 m/s Turbulence intensity:0.1(Cons) Turbulent flow length scale:0.001(Cons)
	Case2	Se1&Se2 inlet: inlet velocity = 0.67 m/s Turbulence intensity:0.1(Cons) Turbulent flow length scale:0.001(Cons)
Piping outlet (Pump inlet)	Case1	Main outlet: Outlet pressure = 4.6 kPa
	Case2	Se1 outlet: Outlet pressure = 4 kPa Se2 outlet: Outlet pressure = 3.5 kPa
Wall boundary		Wall function (Based on logarithmic law) Rough wall surface (Average roughness = 0.05 mm)

Table.1 Overview of analysis

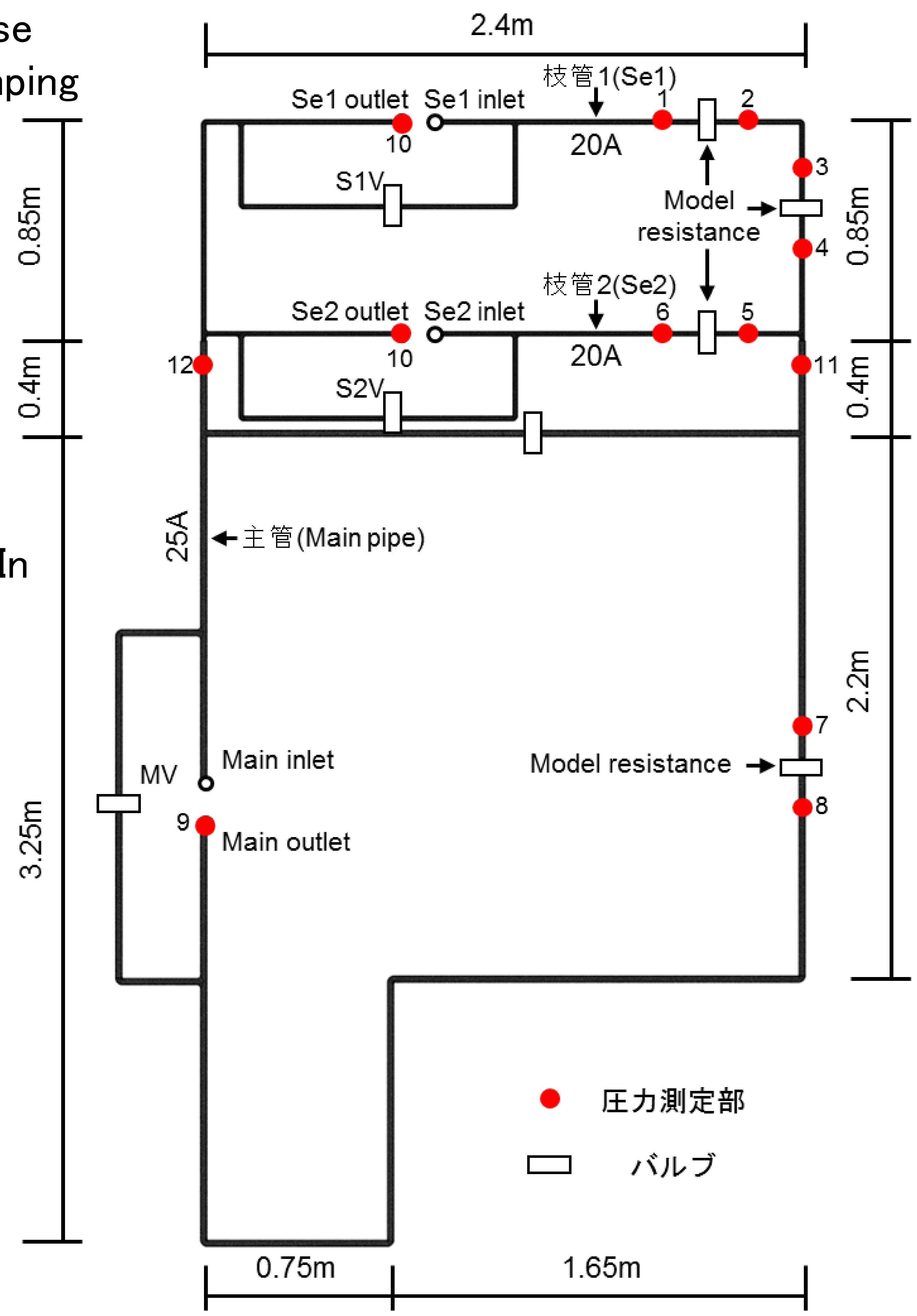

Figure.1 Overview of simulation object

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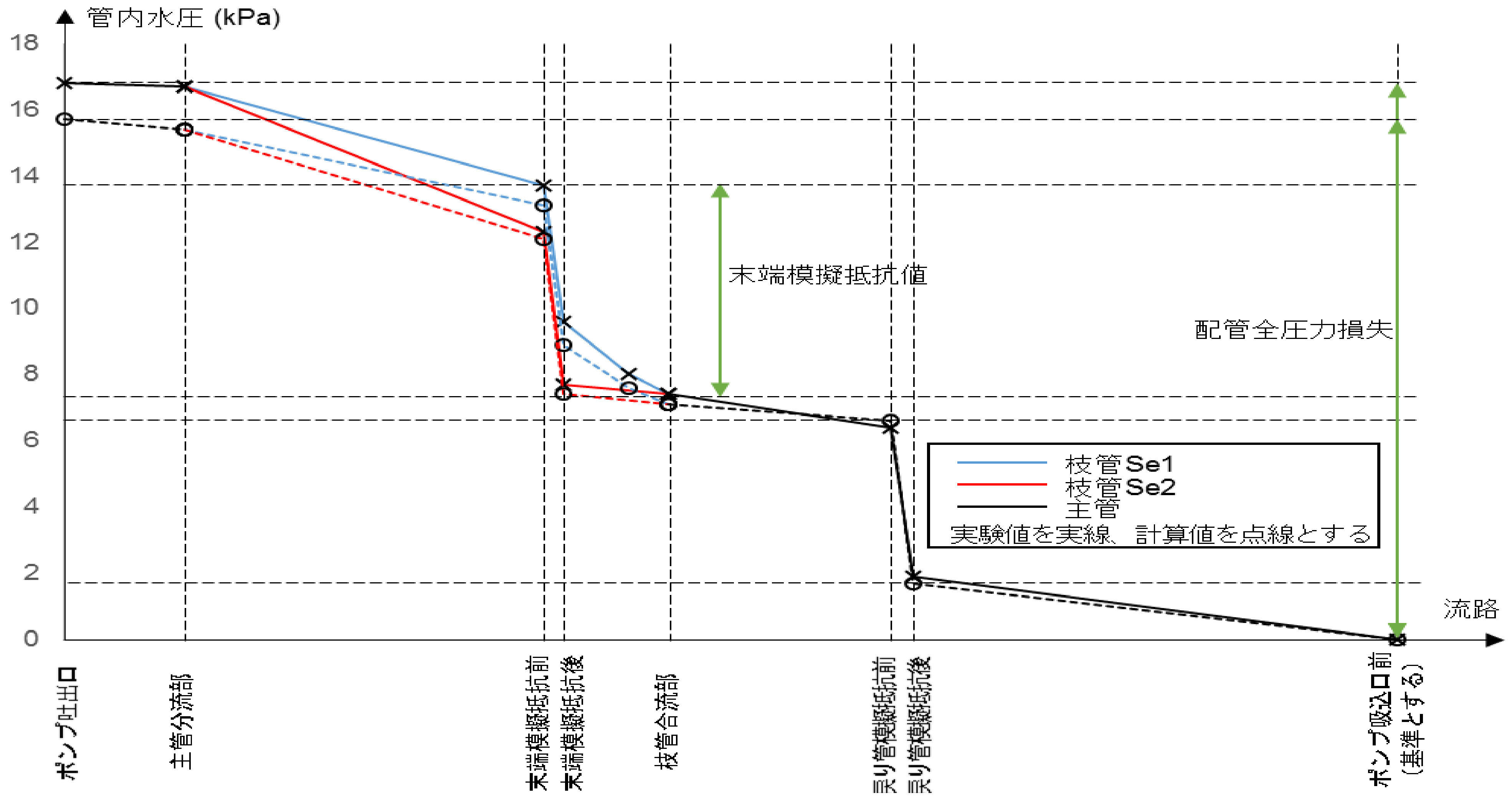
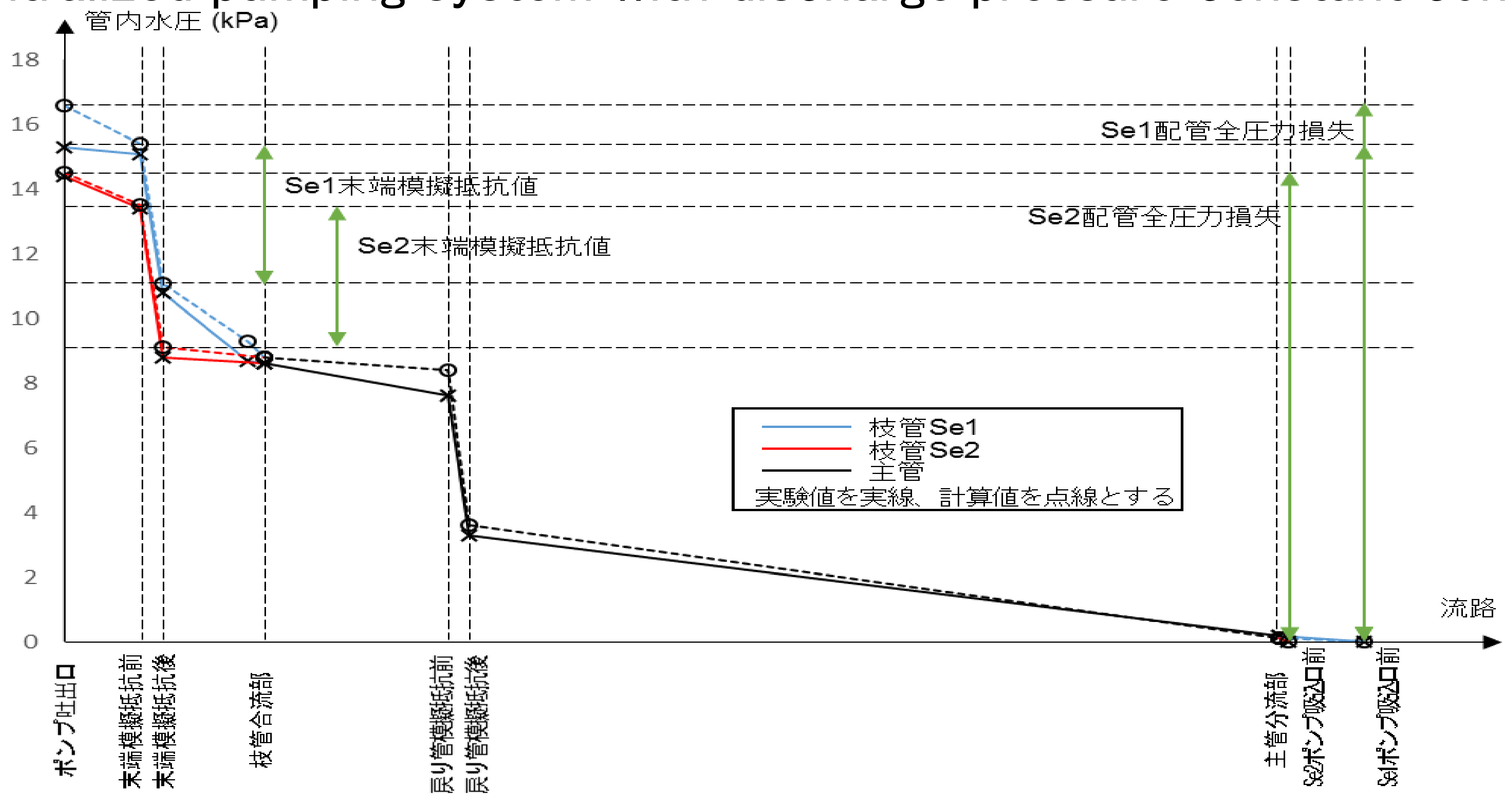
5. Analysis result



Pipe water pressure distribution for system flow path
(Centralized pumping system with discharge pressure constant control)



Pipe water pressure distribution for system flow path
(Decentralized pumping system)

Number	Case1 Experiment	Case1 Simulation	Case2 Experiment	Case2 Simulation
1	18.3	17.7(-3.3)	18.6	18.9(+1.6)
2	14.2	13.5(-5.0)	14.3	14.6(+2.1)
3	14.0	13.3(-5.0)	14.1	14.4(+2.1)
4	12.6	12.2(-3.2)	12.2	12.8(+4.9)
5	12.3	12.0(-2.4)	12.3	12.6(+2.4)
6	16.9	16.7(-1.2)	16.9	17.0(+1.0)
7	11.0	11.2(+1.8)	11.1	11.9(+7.2)
8	6.5	6.3(-3.0)	6.8	7.1(+4.4)
9	4.6	4.6	―	―
10	―	―	Se1: 4 / Se2: 3.5	Se1: 4 / Se2: 3.5

Table.2 Comparison of simulation and experiment gauge pressure [kPa] (Error rate in parentheses[%])

	Case1 Experiment	Case1 Simulation	Case2 Experiment	Case2 Simulation
Se1 PD	4.1	4.2(+2.4)	4.3	4.3(0)
Se2 PD	4.6	4.7(+2.2)	4.6	4.4(-4.3)
LPD1	1.4	1.1(-21.4)	1.9	1.6(-15.8)
LPD2	4.5	4.9(+8.9)	4.3	4.8(+11.6)
Total PD	16.8	15.7 (-6.5)	Se1: 14.8 / Se2: 14.4	Se1: 16.1 (+9.0) / Se2: 14.5 (+1.0)

Table.3 Comparison of simulation and experiment pressure drop [kPa] (Error rate in parentheses[%])