Study on Effect of the perforated plate by Hole Size in CFVS system

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1. Introduction

In case that critical accident occurs in atomic power plant by overpressure and has possibility of damage risk, CFVS(Containment Filtered Venting System) is a device of minimizing the risk of radioactive matter release which is fully able to filter radioactive matter and release it into the atmosphere. Fig. 1 shows schematic information of CFVS as below.

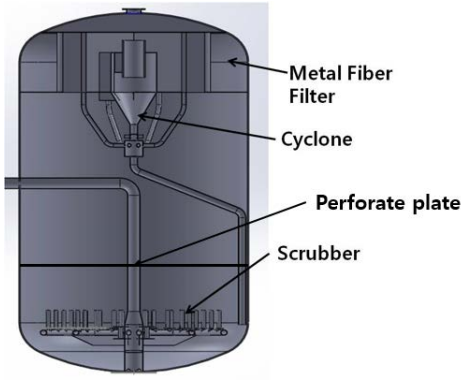

Fig. 1. Containment filtered venting system [1)]

General CFVS has several phases of filtering. It begins with scrubber filtering phase and cyclone, then Metal filter. First phase is venturi scrubber for removing aerosol. Venturi scrubber sprays a Droplet which removes aerosol in the air by contacting gas and liquid. A speed difference is occurred between Gas and Droplet when it's sprayed. For this reason, particle of aerosol floating on the gas is collided with Droplet and it will be removed.
Venturi scrubber is a state immersed in water up to a certain level in the CFVS Vessel. Pollutants that been leaked through a Venturi scrubber are filtered while rising through the water to the certain water level.
In this case the smaller the size of the pollutants increases the efficiency of filtration. Therefore, in this study, install Perforated plate which has a large number of Hole in order to improve the filtration efficiency. The purpose of installing perforate plate has two effects on performance. First, to reduce swelling level of the internal by gas ejected from the nozzle scrubber. Second, to increase the reaction with the solution because they can broaden the reaction area becomes smaller size of the bubble. In the structural side it can be used as a passageway for maintenance of the vessel internals exhaust filtration. So, In this study we carried out CFD Analysis by Fluent 15.0 in order to perforate plate optimum design. Based on the CFD analysis result, We derived Perforate plate optimum design.

2. Methods and Results

2.1 Analysis Model

We decide Analysis cases to analysis to examine the influence of the size reduction of the bubble in accordance with the punching of perforate plate.

Table I: Analysis Cases

Design Factor	case	Perforate plate		
		Plate Thickness [mm]	Hole Size [mm]	Number of Plate
Standard Case	Case 1	10	20	1
Hole Size	Case 2	10	18	1
	Case 3	10	16	1
	Case 4	10	15	1
	Case 5	10	12	1
	Case 6	10	10	1

Fig.2 shows analysis shape of perforate plate. Inlet boundary condition was applied to 0.8016 m/s average flow rate based on total flow rate for one nozzle scrubber. Outlet boundary condition was applied to pressure condition, internal pressure is over 10 bar.

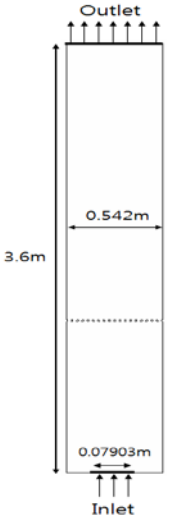

Fig. 2. 2D shape (Perforate plate) [2)]

Fig.3 shows the results of analysis confirm the location. The analysis results are compared by dividing the results before and after the passing of the perforated plate. When dispersity evaluation, there is no way to measure the maximum size and minimum size of the plate, since the previous passing through. IF the previous passing through to fixed region where the height is 0.3m based on the area occupied by the gas. When after passing through, Dispersity evaluates basis of the area occupied by the previous gas becomes the same height X passing through. The criteria for evaluating the degree of dispersion is a gas around the road and the height X. Fig.3 is a location for measuring the analysis results.

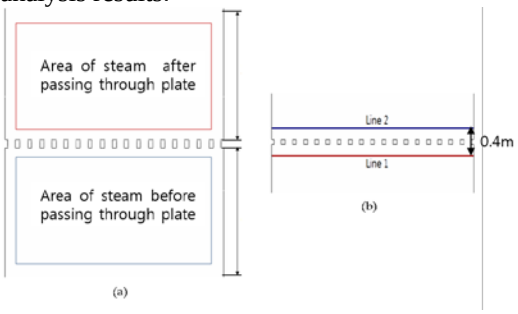

Fig. 3. Location for Result analysis [3)]

2.2 Base on Analysis Model

Fig.4 is an analysis result of the case is not installed perforated plate. Fig.4 (a) shows the volume fraction of the steam. When location is kept rising, steam seems constant size. This should decrease the surface area in contact with the water. This is an important factor reducing the efficiency of the primary filtration steps. Fig. 4(b) shows pressure drop(△P) based on the plate before and after. The average pressure drop of the Line 1 and Line 2 is 374Pa. There is no resistance element in the steam rises, it results that rises by the volume density of the drive force due to the water steam. Due to the installation plate is increased if the pressure drop, serious problem occurs in CFVS system. So pressure drop is important factor perforate plate design.

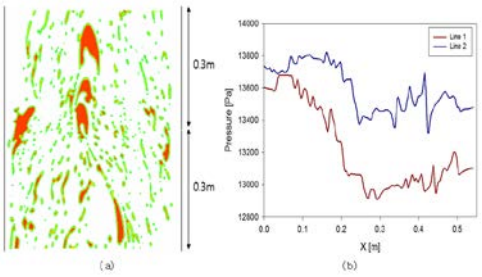

Fig. 4. Before installation of perforate plate[4)]

In this study, a design variable hole size, Case 1 is standard that Hole dimeter is 20mm and the Hole peach is 30mm.

Case 1 as compared with the case without the plate and it can be confirmed that the size of the steam been reduced after passing the plate before starting the pass. This effect is also confirmed by the increase of the height X. And also the circumference of the steam increases from about 4.328m may indicate that the increased surface area. Pressure drop of Line 1 between Line 2 caused by the installation of a Plate of about 420Pa pressure drop is increased more than 50Pa. This is a small difference that does not need to be considered. It is determined that they do not cause a problem due to the the presence of installation plate in CFVS system.

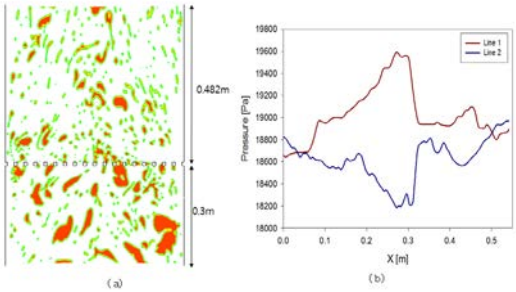

Fig. 5. Installation of perforate plate(Case 1)

2.3 Analysis result

Perforated plate punching rate was always adjust the design parameters are the same. Therefore , If hole size increased, number of hole is decreased. Fig.6 Volume fraction(case 2 (a) ~ 6 case (e)) is the analysis result according to hole size. A comparison of the height X Case 5 having a diameter of 18mm as compared to Case 1 of 0.482m showed increases in 0.490m. When 16mm hole size, X height is 0.77m but there are exist large size steam. However, it can be confirmed that visually smaller than in Case 1 as a whole. This means that steam of passing through Hole is well distributed by decreasing diameter. However, this tendency is adverse effects when the diameter becomes smaller up to 15mm. The result is that the cause of the decreased up to the interval between Hole. The reason is because the dispersion steam is combined again after one pass. Water is more strong adhesion than cohesive force attached to the wall around plate. The narrower the distance between Hole means increases the probability of the steam forming a chunk again.

For this reason, the size of the steam is increased with the decrease in diameter visually compared to 16mm. Numerically 15mm in height X is shrinking rapidly as 0.573mm, 12mm, 10mm are respectively reduced to 0.495m and 0.39m. Fig.7 is a pressure drop compared to Line 1 and Line 2, respectively. And fig.8 is a graph to compare the perimeter of the steam at a time. When hole size 16mm, height X and surface area increase to maximum. From hole size 15mm start decreasing height X and surface. Result of the pressure difference

according to the presence of perforate plate installation does not have a significant impact. In this study the best case is Case3 (16mm). Hole size 16mm pressure drop is about 496 pa, it seems 70Pa difference compared to Case 1. This is a small difference that does not need to be considered. Circumference of the steam has a good effect on about 1.4 times the size reduced to 5.981m.

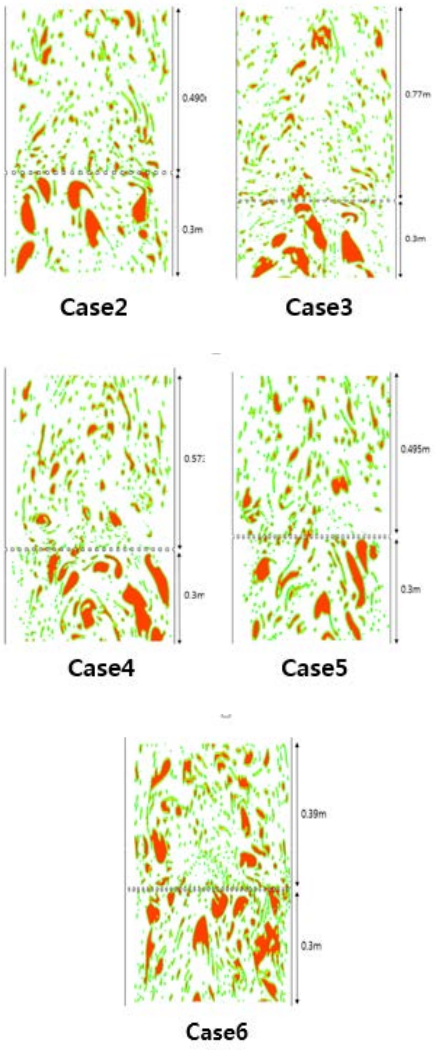

Fig. 6. Volume fraction(case2(a)~case6(e))

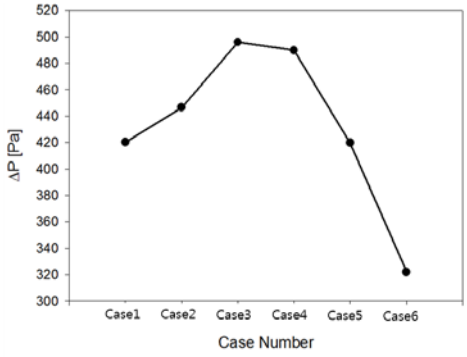

Fig. 7. Pressure drop (case1~case6)

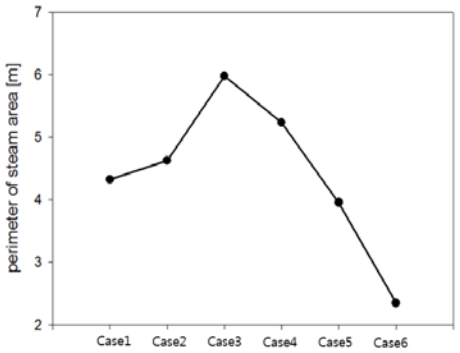

Fig. 8. Perimeter of Steam area (case1~case6)

3. Conclusions

When determining the result based on analysis, Hole size 16mm is the best that can increase the case surface area of the steam. It is necessary to perform experiments in order to ensure the quantitative basis. Additionally, We will perform analysis the impact of Perforated plate number and thickness in CFVS system.

REFERENCES

[1] Philipp Rollbusch, Marc Becker, Martina Ludwig, Andre Bieberle, Marcus Grunewald, Uwe Hampel, Robert Franke, Experimental investigation of the influence of column scale, gas density and liquid properties on gas holdup in bubble columns, International Journal of Multiphase Flow 75 (2015) 88–106

[2] Vahid Akbaria, Tohid Nejad Ghaffar Borhania, Roya Arameshc,Mohd. Kamaruddin Abd. Hamida, Ahmad Shamiric, Mohamed Azlan Hussain, Evaluation of hydrodynamic behavior of the perforated gas distributorof industrial gas phase polymerization reactor using CFD-PBMcoupled model, Computers and Chemical Engineering 82 (2015) 344–361

[3] Sinan Sal, Ömer F. Gül, Mustafa Özdemir, The effect of sparger geometry on gas holdup and regime transitionpoints in a bubble column equipped with perforated plate spargers, Chemical Engineering and Processing 70 (2013) 259– 266