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Further Analysis by Changing Flow Rate for Efficient Inerting Operation of Argon Cell

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1. Introduction

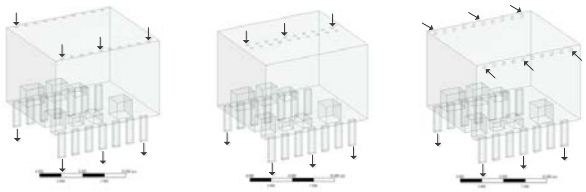
Large argon cells need to switch from an air atmosphere to an argon atmosphere in the beginning, and to switch the atmosphere of the cell for maintenance during operation. However, such an atmosphere conversion process takes considerable time and cost. Therefore, it is required to perform the inerting operation as efficiently as possible.

A CFD (Computational Fluid Dynamics) analysis was performed while changing the location and area of the inlet and outlet for an efficient inerting operation by the present authors [1]. As a result, it was concluded that the most efficient inerting operation can be conducted when the inlets are located near the top of the cell with large outlet area.

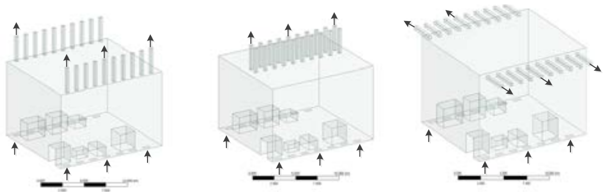
However, the flow rate will also have a significant influence on the efficient inerting operation. Therefore, an inerting analysis while varying the flow rate is planned in this paper.

2. Previous Study for Efficient Inerting Operation according to Inlet and Outlet Location

The previously simulated argon cells with horizontal, vertical, and height dimensions of 14 m, 12 m, and 9 m, respectively, were subjected to a computational fluid dynamic analysis. The analysis was performed for six different inlet and outlet locations, as shown in Fig. 1 using ANSYS CFX. The corresponding dimensions and operating conditions are shown in Table 1.



(a) Case A-1 (b) Case A-2 (c) Case A-3
(Inlets near the top)



(d) Case B-1 (e) Case B-2 (f) Case B-3
(Inlets on the bottom)

Fig. 1. Inlet and outlet position for six cases [1]

Table 1. Dimensions and operating conditions for the previous study [1]

Dimensions				
	Case A-1, B-1, C-1 (Inlet on the top of the cell)		Case A-2, B-2, C-2 (Inlet on the bottom of the cell)	
	Inlet	Outlet	Inlet	Outlet
L (mm)	0.3175	0.840	0.840	0.3175
W (mm)	0.3175	0.360	0.360	0.3175
No. of inlets or outlet	20	14	14	20
Total area, m^2	2.02	4.23	4.23	2.02
Operating conditions				
Target air fraction (average)	Below 500 ppm (=99.95%)			
Flow rate	800 m^3/h			

The argon fraction of the whole volume was evaluated and the time to achieve target argon fraction was estimated as shown in Table 2.

Table 2. Result of argon gas cost estimation [1]

Case	Time to achieve target argon fraction (99.95%)	Required argon gas, m^3	Estimated argon gas cost, $
Case A-1	88.7 h (3.7 day)	70,960	135,635
Case A-2	77.1 h (3.2 day)	61,680	117,897
Case A-3	67.8 h (2.8 day)	54,240	103,676
Case B-1	96.6 h (4.0 day)	77,280	147,715
Case B-2	83.7 h (3.5 day)	66,960	127,989
Case B-3	98.0 h (4.1 day)	78,400	149,856

It was concluded that the most efficient inerting operation can be conducted when the inlets are located near the top of the cell with a large outlet area, which is Case A-3.

3. Further Analysis to Change Flow Rate for Efficient Inerting Operation of Argon Cell according to Flow Rate

The Case A-3 was determined to the best case for efficient inerting operation. Based on the inlet and outlet location of Case A-3, additional parametric study is planned and being conducted as shown in Table 3.

Table 3. Additional Analysis Cases

No.	Flow rate, m^3/h	Time to achieve target argon fraction (99%)	Estimated argon gas cost, $
1	100	To be estimated	To be estimated
2	500	To be estimated	To be estimated
3	1,000	To be estimated	To be estimated
4	2,000	To be estimated	To be estimated
5	3,000	To be estimated	To be estimated

The inerting time will be longer when the flow rate is decreased. However, in that case, it is expected that the heavier argon will be stacked from the bottom and lighter air will be exhausted to the upper outlet without much mixing. If the flow rate is increased, the argon consumption will also be increased, but the inerting time will be decreased.

In addition, we plan to investigate the point where inerting time is no longer decreased even though the flow rate is increased.

The results of the additional parametric study are expected to be useful guidelines for large hot cell design along with the previous analysis result.

4. Conclusions

The Case A-3 was determined to the best case for efficient inerting operation. Based on the best inlet and outlet location, additional parametric study is planned and being conducted to investigate more efficient inerting operation.

The results of the additional parametric study are expected to be useful guidelines for large hot cell design.

REFERENCES

[1] J. Lim, S. Yu, H. Lee, W. Choung, W. Jo, and H. Lee, "CFD Analysis According to Inlet Position for Efficient Purging Operation of Argon Cell," Global 2017, Sep. 26, 2017.

[2] ANSYS CFX Modeling Guide, Release 15.0, 2013-11.

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