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Portable Filtered Air Suction System for Released Radioactive Gases Prevention under a Severe Accident of NPPs

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1. Introduction

When released radioactive gases from the broken containment building in the severe accident of nuclear power plants (NPPs) such as the Chernobyl and Fukushima accidents occur, there are no ways to prevent the released radioactive gases spreading in the air [1]. In order to solve this problem, several European NPPs have adopted the filtered vented containment system (FVCS), which can avoid the containment failure through a pressure relief capability to protect the containment building against overpressure. However, the installation cost of FVCS for a NPP is more than $10 million [2] and this system has not been widely welcomed by NPP operating companies due to its high cost.

In this paper, the portable filtered air suction system (PoFASS) for released radioactive gases prevention under a severe accident of NPP is proposed. This technology can prevent the release of the radioactive gases to the atmosphere and it can be more economical than FVCS because PoFASS can cover many NPPs with its high mobility. The conceptual design of PoFASS, which has the highest cost effectiveness and robustness to the environment condition such as wind velocity and precipitation, is suggested and the related previous research is introduced in this paper.

2. Review of Previous Related Research

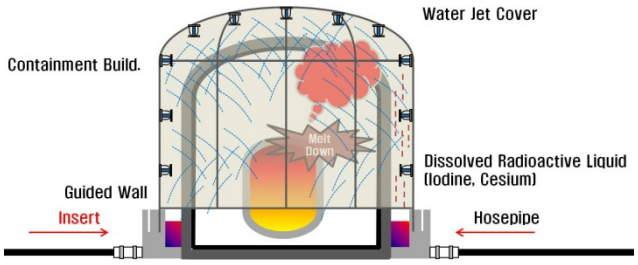

Fig. 1 Proposed Spray Based Barrier System

In order to prevent the released radioactive gases from the containment building under a severe NPP accident, the spray based barrier system (SBBS) was proposed [3] as shown in Fig 1. When there are the leakage points of radioactive gases after a severe accident, the water jet cover is installed in the guided wall and the radioactive gases such as iodine which is one of the most harmful gases to human body can be captured by spraying water including the chemical compounds of NaOH. If the dissolved radioactive liquid containing iodine gas is dropped, the liquid flows into a storage facility through water flow paths on the guided wall as shown in Fig 1. As a result, the radioactive gas propagation to the atmosphere can be prevented and the liquid should be treated as a nuclear radioactive waste.

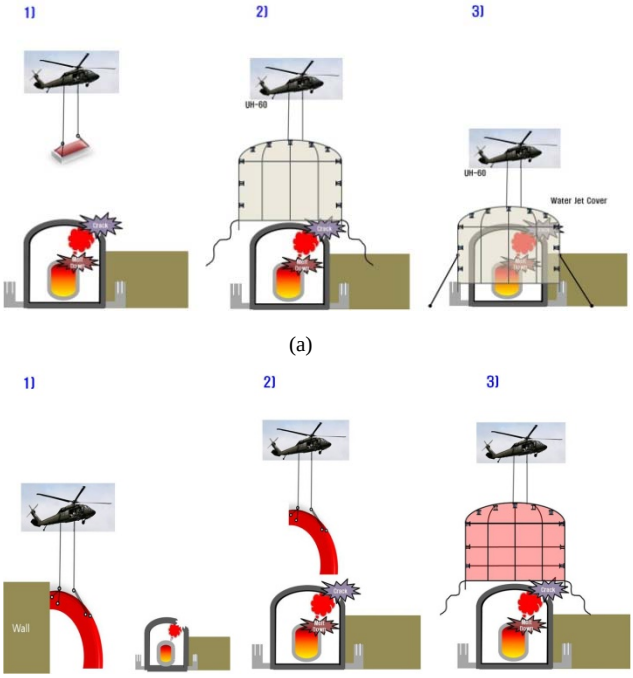

Fig. 2 Schematics of Deploying Methods for SBBS
(a) Flexible Type, (b) Rigid Type

Moreover, it is also important issue for SBBS to develop the deploying methods due to its large volume and two of the deploying method examples are presented as shown in Fig. 2.

3. Conceptual Design of Potable Filtered Air Suction System (PoFASS)

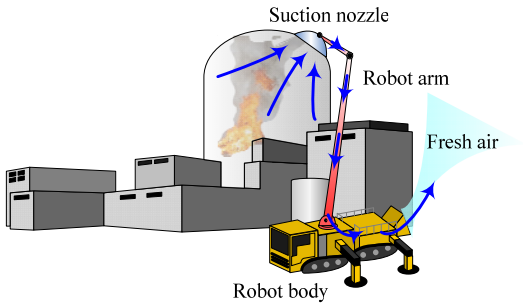

Fig. 3 Proposed Portable Filtered Air Suction System

In practice, SBBS has two constraints on the realization; One of the constraints is the storage problem of SBBS due to its large volume. The other is

its high cost for fabrication. If the material which has chemical resistant of iodine, deployable and low density properties is used for the water jet cover, the fabrication cost of SBBS is too much expensive due to its large volume.

In this paper, the conceptual design of the PoFASS is introduced, which has the high cost effectiveness and robustness to the environment conditions. If the number of leakage points is only one and the leakage point can be found by NPP operators or mobile detection equipment, PoFASS can be the best method to mitigate the release of radioactive gases. As shown in Fig. 3, the PoFASS has physical barrier named suction nozzle to isolate the leakage point and suck the gases. Then, the gases pass through a filter and then they are emitted into the atmosphere as fresh air.

3.1 Configuration of PoFASS

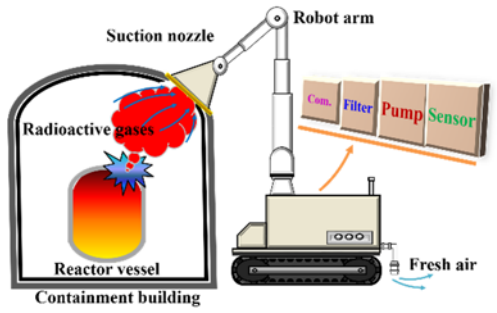

Fig. 4 Proposed Configuration of PoFASS

PoFASS, as shown in Fig. 4, includes two sub-systems; a suction nozzle and a robot body. The robot body includes the robot arm to support the nozzle, sensors to perceive the information of incoming radioactive gases, a filter to purify the gases, a pump and a communication link.

3.2 Proposed Flexible Robot Suction Nozzle

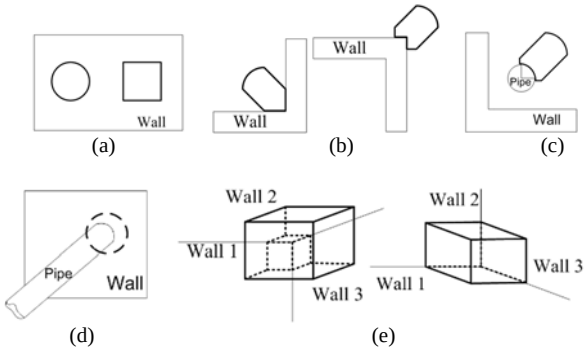

Fig. 5 (a) Side of wall, (b) Corner of wall, (c) Side of pipe, (d) Joint between wall and pipe, (e) Vertex of walls

In NPP accidents, diverse broken shapes of the leakage points can be occurred and all the possible shapes should be investigated in advance to cover the leakage points by PoFASS. As shown in Fig 5, it can be classified into seven cases and different suction nozzles should be needed to isolate the leakage points for each case due to the different broken shapes. However, it is quite inefficient and time-consuming to select a proper suction nozzle after detecting the broken shape.

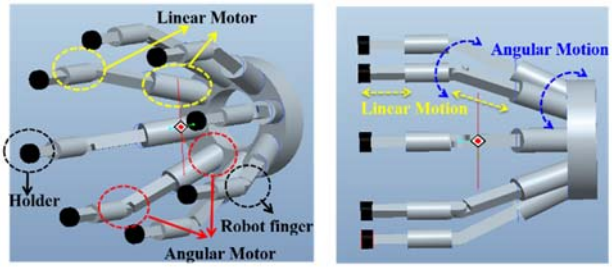

Fig. 6 Configuration of Flexible Robot Suction Nozzle
(a) Bird's view, (b) Side view

As a remedy for this problem, the flexible robot suction nozzle, which can be transformed to cover all the broken shapes, is proposed. As shown in Fig. 6 (a), the flexible robot suction nozzle includes holders of rubber as shock absorber, robot fingers, which have linear motors and angular motors, and the extensible cover. Although, the extensible cover is not appeared in Fig. 6, it covers all the gaps between robot fingers to isolate the leakage point from the atmosphere. The one of examples for the extensible cover can be a rubber having accordion shape as shown in Fig. 7. It can be extended in lateral and longitudinal directions by both unfolding and elastic deformation.

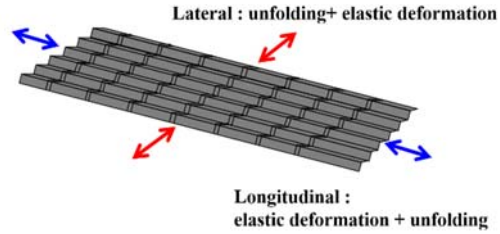

Fig. 7 Proposed Extensible Cover

4. Conclusions

The portable filtered air suction system (PoFASS) for released radioactive gases prevention can play a key role to mitigate the severe accident of NPP with its high cost effectiveness and robustness to the environment conditions. As further works, the detail design of PoFASS to fabricate a prototype for a demonstration will be proceeded.

REFERENCES

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[2] R.O Schlueter and R.P. Schmitz, "Filtered vented containments," *Nuclear Engineering and Design*, vol. 120, issue 1, pp. 93-103, June. 1990.

[3] Man S. Yim, Chun T. Rim, Su Y. Choi, and Kyo N. Kim, "System and method for preventing diffusion of radioactive materials," appl. No. 10-2012-0026538, patented.