Comparative Study of the Two PFC Decontamination Methods

Hui Jun Won, Gye Nam Kim, Wang Kyu Choi, Chong Hun Jung, Jei Kwon Moon
Korea Atomic Energy Research Institute, # 150, Dukjin Dong, Yu-Seong Gu, Daejon, nhjwon@kaeri.re.kr

1. Introduction

PFC(perfluorocarbon, C_7F_{16}) is a non-toxic, non-flammable, easily vaporizable compound. Especially, it is not harm to the ozone layer of the stratosphere. Because of the good chemical properties, it is used in the semiconductor chemistry. The contaminated metal surface of the hot cell should be cleaned periodically to improve the working environment. The decontamination method should generate a small volume of the secondary waste. Dry decontamination method would be a good solution. There are two PFC decontamination methods. The on is the PFC ultrasonic decontamination method and the other is the PFC spray decontamination method. In this study, decontamination performance of the two PFC decontamination methods was investigated. The feasibility study of recycling the spent PFC solution was also performed.

2. Methods and Results

In this section some of the experimental methods, procedures and results are described.

2.1 Specimen Preparation

Tube type, plate type, double plate type and plate type welded with cylindrical stainless steel were prepared. The double plate type was used to simulate the crevice contamination. Plate type welded with stainless steel was used to simulate the material attached on the surface of hot cell. Before test, the surface of every specimen was cleaned with papers wetted with ethyl alcohol. For artificial contamination, a small amount of methyl alcohol which contains 10 wt% of 99.95% Eu_2O_3 powders were thrown down on the specimen surface.

2.2 Decontamination solution

PFC used was PF 5070 from 3M Company. Anionic surfactant used was Krytox from Dupont Company. The characteristic of PFC + 0.1 vol% of anionic surfactant mixed solution was investigated by FT-IR and UV spectrophotometer. The UV spectra under various anionic surfactant concentrations are shown in Figure 1.

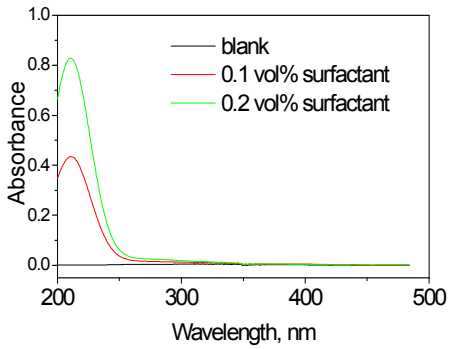

Figure 1. UV spectra of PFC solution under various surfactant concentration.

2.3 Decontamination Test

Ultrasonic decontamination test equipment was designed and fabricated. The reactor size was 150(W) X 130(L) X 200(H) mm^3. Specimen chamber in the reactor was rotated by the geared motor. The rotation speed was controlled and the speed was in the range from 10 to 44 rpm. After the artificially contaminated specimen was put into the specimen chamber, the reactor was filled with PFC solution. Then the contaminated specimen was decontaminated by ultrasonic method. The weight of specimen was measured three times. In order to examine the characteristics of PFC spray decontamination process on the several shapes of the metal specimens, the decontamination tests were performed in the hot cell of the radioactive waste drum examination facility in KAERI. The method to estimate the decontamination efficiency is shown in elsewhere [1]. Figure 2 is a photograph which shows the application of the PFC spray decontamination process on the disc type specimen. The spray pressure was 41 kgf/cm^2, orifice diameter was 0.2 mm and spray velocity was 0.2 L/min. The manipulator is holding a spray part of the decontamination equipment. Disc specimen is held by the specimen cradle. During the application, the manipulator was holding a spray part well and most of the contaminants were satisfactorily removed. For the two decontamination methods, the application time was 5 minutes. Recycling of spent PFC solution was also tested in the distillation equipment.

Figure 2. Decontamination test in a hot cell.

2.4 Test Results

The effect of the anionic surfactant concentration on the decontamination performance was investigated. Fig. 3 shows the plot of the remained portion of the contaminants against the ultrasonic application time. The decontamination efficiency of PFC solution is higher than that of water. And, most of contaminants were removed by the PFC ultrasonic decontamination method. This figure also shows that the remained portion of contaminants is decreased with the increase of the surfactant concentration. In the decontamination of crevice specimen, however, some of the contaminants were remained on the edge of specimen.

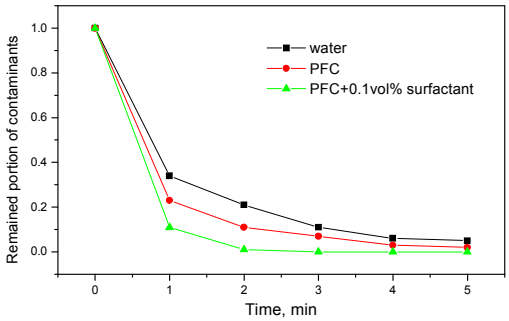

Figure 3. Remained portion of contaminants according to the application time.

The decontamination factor of PFC spray method was in the range from 9.6 to 62.4. From the test results, we found that more than 90 % of the contaminants were removed during the 5 minutes' of application time. Contrary to the ultrasonic method, most of contaminants on the crevice specimen were removed. As the roughness of the specimen increased, the PFC spray decontamination efficiency decreased.

From the result of the distillation test of spent PFC solution, it was found that more than 95 % of spent PFC was recycled by distillation.

3. Conclusion

PFC ultrasonic and PFC spray decontamination tests using the several shapes of metal specimens were performed. For all the tested specimens, it was found that PFC decontamination was satisfactorily applicable. The recycle of PFC solution by distillation made the process more reliable. Decontamination work was performed with a little loss of main decontamination agents. As the PFC solution is a non-conducting substance and it is easily separated from the contaminants, the PFC decontamination process is a promising method to decontaminate the various shapes of metal surfaces loosely contaminated with radioactive particles

Acknowledgement

This work has been carried out under the Nuclear R & D Program funded by the Ministry of Science and Technology.

REFERENCES

[1] H. J. Won, G. N. Kim, C. H. Jung, J. H. Park and W. Z. Oh, J. of the Korean Radioactive Waste Society, Vol. 3, No. 4, pp.293-300, 2005.