Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 8-10, 2024

Optimal Abrasive Selection considering etching rate and recycling rate of abrasive for Blasting Decontamination

You-jin Kang [a], Hyo jeon Kim [a], Kyungmin Kim [a], Dongjun Lee [a], Insun Sung [a], Hogeun Ryu [b], Yongtae Kim [b], Dongik Lee [b], Sungwook Lee [c], Jaehee Lee and Yongsoo Kim [a*]

[a]*Dept. of Nuclear Engineering, Hanyang University, 222, Wangsimni-ro, Seongdong-gu, Seoul, Republic of Korea*
[b]*Soosan Industries Co., 10, Bamgogae-ro 1-gil, Gangnam-gu, Seoul, Republic of Korea*
[c]*KOREA SHOT BLAST Co., 11, Emtibeui 28-ro, Siheung-si, Gyeonggi-do, Republic of Korea*
[*]*Corresponding author: yongskim@hanyang.ac.kr*

***Keywords :** decommissioning, blasting decontamination, abrasive, radioactive waste, waste management

1. Introduction

The global aging phenomenon of nuclear power plants is gaining momentum. According to the latest data from the IAEA PRIS (Power Reactor Information System) as of March 2024, 413 nuclear power plants exist approximately 68% surpassing the 30-year [1]. Presently, the decommissioning target for Kori Unit 1, excluding soil waste, aims to accommodate around 14,500 drums based on a 200L drum [2]. Insights from countries with prior decommissioning endeavors reveal that a significant portion of decommissioning costs, excluding labor expenses, exceed 30% of waste disposal costs [3]. Notably, in South Korea, the disposal cost for a 200L drum stands at 15.11 million won as of 2024 [4]. Hence, successful decommissioning mandates the decontamination of extensively generated very low-level and low-level waste to clearance levels, thereby curtailing overall waste volume. In leading nations of decommissioning technology, surface-contaminated large-scale low and very low-level wastes are removed through abrasive blasting decontamination [5-7].

To reduce the amount of waste generated during decommissioning, it is important to minimize the volume of secondary waste. In this study, we conducted experiments to optimize the selection of abrasives considering the etching rate and recycling rate of abrasives, and to systematically reduce the amount of secondary waste.

2. Material & Methods

2.1 Decontamination method

Abrasive blasting techniques are commonly classified into dry and wet methods. In radioactive environments, the dry technique is frequently employed to mitigate the dispersion of contaminants caused by liquids [8]. Dry abrasive blasting involves the generation of a high-pressure fluid and the introduction of abrasive particles in a granular state. These particles utilize collision energy to decontaminate surfaces by removing fixed or adsorbed substances such as oil, rust, and paint. When selecting abrasive to remove contaminated crud on metal surface, characteristics of contaminated crud and material properties of substrate should be considered.

2.2 Characteristic of abrasive

There are various variables to consider when selecting abrasives [9]. These included the crystal structure, hardness, and density of the abrasive, as well as the mechanical characteristics of the abrasive particles, particle size distribution, shape, and average size. The selection of optimal abrasive for reducing secondary waste depends on satisfying both the etching rate and recycling rate of abrasive.

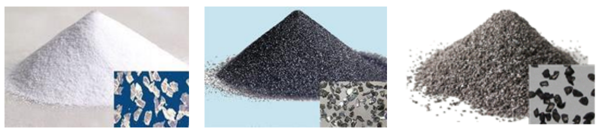

Fig. 1. Abrasive (Aluminum Oxide, Silicon carbide and Steel grit).

Table I: Properties of Abrasives [9]

	Aluminum Oxide	Silicon carbide	Steel grit
Function	Rust removal, Burr removal	Rust removal, Sanding	Metal etching, Sanding
Chemical Composition (%)	Al_2O_3 : 99.6 TiO_2 : 2.3 SiO_2 : 1	Sic : 99.5 Free C : 0.2 SiO_2 : 0.1	Fe : 97 Si : 1 C : 0.9
Weight (g/cm^2)	3.90	3.96	3.96
Density (g/cm^3)	3.95	3.21	4.4
Melting Point (℃)	2072	2072	1535
Mohs Hard	8	9	9

2.3 Experimental

In this study, direct pressure blasting equipment known for its high efficiency and decontamination performance was used.

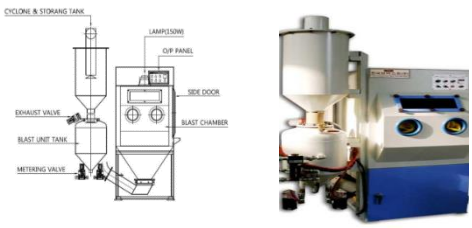

Fig.2. Direct pressure blasting equipment.

2.3.1 Etching rate evaluation.

This experiment conducted seven times for each abrasive at pressure of 5 bar, distance of 150mm, at degree of 90° in 1 min. Experimental specimen is STS304 with dimensions of 30mm * 30mm * 3mm. To compare etching rate for each abrasive, we calculated etching rate using weight comparison. The density of STS 304 material is 7.93 g/cm^3 and surface of specimen is assumed to be uniformly etched.

$$\rho = \frac{m}{v},\ v = A \times H \qquad H = \frac{m}{\rho \times A} \qquad Etching\ rate = H\ /\ t \tag{1}$$

2.3.2 Recycling rate evaluation.

To evaluate the recycling rate of each abrasive, we conducted recycling rate evaluation test. We prepared STS-304 specimen with 200mm * 200mm* 5mm. This experiment conducted a five-cycle test on all abrasive materials using the same amount of abrasive. And abrasives were removed and compare their weights between before and after. And we calculated recycling rate using equation (2).

$$\frac{Input\ of\ abrasive}{Output\ of\ abrasive} \times 100 = recycling\ rate(\%) \tag{2}$$

3. Results

3.1 Etching rate evaluation.

We compared etching rates of each abrasive. Aluminum oxide showed the best etching rate among the abrasives with an etching rate of approximately 162 ㎛/min, followed by silicon carbide, steel grit 2 and steel grit 1 (Fig.3). Table II shows comparison of average weight difference between before and after experiment.

Table II: Comparison of Average Weights Before and After Test by Abrasive

(Unit: g)

Material	Before	After	Difference
Aluminum Oxide	34.02	32.84	1.18
Silicon carbide	34.07	33.37	0.70
Steel grit 1 (Korea)	34.04	33.45	0.59
Steel grit 2 (Germany)	33.98	33.30	0.68

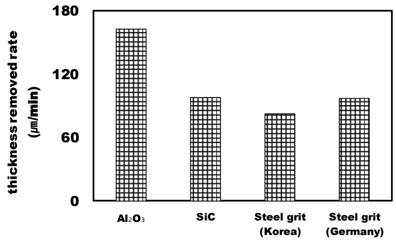

Fig.3. Comparison of etching rate for each abrasive.

3.2 Recycling rate evaluation.

We compared weight difference between before and after 5 cycle decontamination for each abrasive. Steel grit 1 has highest recycling rate and steel grit 2 has also high recycling rate more than 98%.

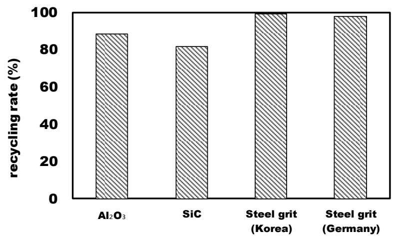

Fig.4. Comparison of recycling rate for each abrasive.

4. Conclusions

In this study, we conducted optimal abrasive selection test by evaluating etching rate and recycling rate for 4 types of abrasive. All abrasive has high etching rate more than 60 ㎛/min. And steel grit has highest recycling rate. Therefore, steel grit selected as the optimal abrasive and further research will be conducted to find the best process condition using steel grit abrasive.

Acknowledgement

This research was supported by the Korea Institute of Energy Technology Evaluation and Planning (KETEP), funded by the Ministry of Trade, Industry & Energy (MOTIE), Republic of Korea (No. RS-2023-00247243).

REFERENCES

[1] Age Distribution. (2024.03). Retrieved from https://pris.iaea.
[2] Kihyun Park. (2022). Study of Local Application Possibility towards Local Decommissioning Waste by using Hot Isostatic Pressing Technology (pp. 69-79). n.p.: JOURNAL OF RADIATION INDUSTRY.
[3] IAEA. (2008). Managing Low Radioactivity Material from the Decommissioning of Nuclear Facilities (Technical Reports SeriEs No. 462)
[4] 산업통상자원부. (2022.01.11). 방사성폐기물 관리비용 및 사용후핵연료관리부담금 등의 산정기준에 관한 규정
[5] EPRI. (2004.04). Decommissioning License Termination Plan Documents and Lessons Learned
[6] R. walthery. (2005.03). Experience and developments from decommissioning of the former Eurochemic reprocessing facility reprocessing plant in Belgium.
[7] Bo Wirendal. Co-operation development project for new treatment of STEAM GENERATORS – Impact on final disposal volumes and recycling in Nortern Europe.
[8] KAERI. (2002). The Study on Recycle Scheme of the Metallic Radioactive Wastes.
[9] A.Mober. (n.d.). Blast cleaning Technology (ISBN 978-3-540-73644-8). n.p.: springer.