The Treatment Procedure for a Volume Reduction of the Spent HEPA Filters in KAERI - 8421

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ABSTRACT

Spent filter wastes of about 2,200 units have been stored in the radioactive waste storage facility of the Korea Atomic Energy Research Institute since its operation. Among these spent filter wastes, a HEPA filter account for about 95 %. All these HEPA filter wastes generated at KAERI have been stored inside a poly bag in accordance with the original form without any treatment of them. Therefore, in order to secure a space in a radioactive waste storage facility approaching its saturation, it is necessary to treat them by a compaction in view of a radioactive waste treatment and storage, and finally to repack the compacted spent filters into a regular drum for sending them to a final disposal site. To do that, the spent HEPA filter wastes were classified according to their generation facility, their generation date and their surface dose rate by investigating the inventory of them. And also, a nuclide assessment of them was conducted by taking a representative sample at the spot of a high dose rate at the intake surface and the outlet surface of a spent HEPA filter without a dismantlement, before compacting them. At present, for the spent HEPA filter wastes after a radionuclide assessment, a compaction treatment of them is now being conducted by using the shaping and compacting equipment developed at KAERI. Thus, to put a HEPA filter with a hexahedral form of a 610(W)×610(H)×305(T) mm into a regular drum (DOT-17H) with an inner diameter of about 572 mm, a columnar shaping with a capacity of 15 tons was conducted. From this shaping, a shaped HEPA filter waste with a diameter of about 500 mm was directly put into a regular drum. And then, the compaction treatment of a shaped HEPA filter with a capacity of about 60 tons was conducted by vertically compacting it. As a result, a volume reduction rate of a spent HEPA filter waste by a shaping and compacting of it accounted for about 1/8 when compared to its original form.

INTRODUCTION

According to the active operation of nuclide facilities and a continuous construction of them at KAERI, a great amount of spent filters which are used in a ventilation system of the nuclear facilities has been generated as a spent filter waste. These spent filter wastes have generally consisted of a HEPA filter after a filtering of all the contaminants in the air stream generated during the operation of the HANARO research reactor, the radioisotope production facility (RIPF) and the nuclear fuel cycle facility (NFCF) [1].

There are two interim storage facilities at KAERI. One is for the low level waste and the other is for the intermediate level waste. Here, the spent filter wastes have usually been stored in the waste storage facility for a low level waste. At present, it is necessary to secure space in a waste storage facility approaching its saturation, because the generation volume of the radioactive wastes which consist of combustible and non-combustible waste, spent filter wastes and so on is continually increasing. Thus, the radioactive waste treatment facility (RWTF) is carrying out a project on a volume reduction of the current wastes in storage. As a part of that project, a study on the treatment of spent filter wastes is now being conducted in the RWTF.

All the spent filter wastes have been stored inside a poly bag without any treatment of them. Therefore, it is necessary to conduct a compaction treatment of these spent filters to reduce the volume of them. And then, for sending them to a final disposal site as well as for an efficient management of them, it is desirable to repack the compacted spent filter wastes into a regular drum (DOT-17H). For a series of that treatment process, the treatment procedure for spent filter wastes has to be developed, and also, the validity of the treatment method at each stage should be confirmed.

In this study, as a first stage of the treatment procedure, all spent HEPA filter wastes were classified by investigating the inventory of them. A classificatory criterion was the generation facility, the generation date and the surface dose rate. After a classification, a nuclide analysis for them was conducted by taking a representative sample from a filter without a dismantlement, instead of a direct measurement by using a waste assay system [2]. Taking a waste assay system into consideration, there are some disadvantages in conducting an efficiency calibration because of its great bulk and specific shape. In general, after taking a representative sample from a HEPA filter, the analysis results for it are regarded as an average value for the corresponding HEPA filter. To use this method, it is essential to confirm the validity of the sampling procedure and the average value. Therefore, it is very important to decide the sampling point in a HEPA filter.

For HEPA filters after a nuclide analysis, a compaction treatment was conducted by shaping and compacting them. In some cases, as using a media stripper, a spent HEPA filter is separated into a filter frame part and a filter medium part [3]. However, for simplicity in a treatment process, spent HEPA filters were compacted at once without a separation. And finally, the compacted HEPA filter wastes were repacked into a regular drum. When repacking spent HEPA filter wastes passed through a compaction treatment process, those with the same conditions were put into a regular drum. These conditions correspond to the same facility, the same generation date and the same range of nuclide concentration of a HEPA filter.

CLASSIFICATION

There are spent filters of about 2,200 units in the waste storage facility. Among these spent filter wastes, HEPA filters which are the most widely used in a air cleaning system of a nuclear industry accounted for about 95 %, charcoal filters which are used to filter off iodine nuclides accounted for about 5 % and pre-filters which collect relatively large particles in front of the HEPA filter accounted for about below 1 % . Thus, it was possible to divide the main generation facilities into 7 categories, as shown in Table 1. Here, the irradiated material examination facility (IMEF) and the post irradiation examination facility (PIEF) are the facilities for an examination of a nuclear fuel rod, and for the other research laboratories, it is also possible to divide into 2 categories which mean laboratories using uranium, type A, and not using uranium, type B.

From Table 1, a large amount of spent filters were generated in the nuclear fuel cycle facility, and almost all the spent filter wastes belonged to a very low level radioactive waste. And also, spent filters generated at the facilities using uranium which is the nuclear fuel processing facility (NFPF) and the A laboratories accounted for about 20 % of the spent filters stored at KAERI.

Table 1. Classification of the spent filter wastes by the generation facility and the surface dose rate

Generation Facility		Main Nuclide	Volume by the surface dose rate	
			< 2 μSv/h	<2 mSv/h
HANARO		H-3, Co-60, Kr-85, Sr-90, Cs-137	208	0
RIPF		C-14, Co-60, Mo-99, Cs-137	190	14
NF CF	NFPF	U series	118	141
	IMEF/PIEF	H-3, Co-60, I-129, Kr-85, Sr-90, Ru-106, Cs-137, Ce-144	512	72
	RWTF	Co-60, Cs-137	319	409
Other Lab.	Lab A	U series	147	0
	Lab B	Co-60, Cs-137	42	9

From the results of a classification, it was possible to obtain the following characteristics of the spent filter wastes at KAERI. First, the majority of the spent filters were included in the very low level radioactive waste category. That means not only a compaction treatment of them but also a regulatory clearance is possible to reduce the volume of the stored spent filters. Also, all these spent filters had particular nuclides due to the generation facility. So, spent filter wastes generated at the same facility have to be repacked into the same drum.

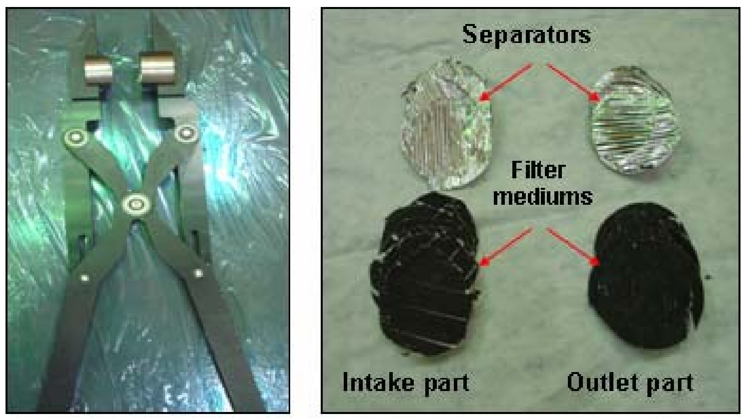
NUCLIDE ANALYSIS

In general, a radionuclide assessment for bulky wastes is conducted by taking a representative sample from them. At that time, the homogeneity in the whole region of a bulky waste has to be confirmed through a proper processing, such as a mixing, crushing and any other process. However, in the case of spent HEPA filter wastes with a non-homogeneity, it is desirable to use a conservative assessment for them such as taking a representative sample at the spot of a high surface dose rate rather than crushing a HEPA filter to secure a homogeneity.

When taking a representative sample from a spent filter waste, it is generally taken from the filter medium except for the filter frame. Also, it is desirable to take a sample without a dismantlement because of the possibilities of a contamination and an exposure, and an excessive preparation time. Therefore, a tendency for a distribution of the captured nuclides in a HEPA filter medium should be investigated. If a regular tendency for the distribution of the captured nuclides is maintained in a HEPA filter medium, it is possible to utilize this distribution as a guide for taking a representative sample.

After selecting several HEPA filters generated in the main generation facility, the distribution of the captured nuclides in a filter medium was investigated by cutting it into 12 pieces in the direction from the intake to the outlet. As a consequence, a high concentration of the captured nuclides generally showed at the intake and the outlet part, when compared with the middle part of a filter medium [4, 5].

For taking a representative sample without a dismantlement of a HEPA filter, a punch device with a diameter of about 2 inch was developed for cutting a part of a filter medium as a regular size, as shown in figure 1. This device was able to cut about ten sheets of the filter medium and aluminum separators respectively at just one manual press. And also, it was not difficult to insert a device into the proper position in a deep pleated filter medium. Therefore, circular samples of a 2 inch diameter from a filter medium were able to be obtained from the intake and the outlet part which showed a high concentration of the captured nuclides by using this punch device.



(a) Punch device (b) Circular filter mediums of a 2 inch diameter

Fig. 1. A punch device for taking a representative sample from a HEPA filter (a) and filter mediums taken by using a punch device with a diameter of 2 inch (b)

The sampling procedure for a nuclide analysis of a HEPA filter waste was developed in the RWTF as follows. After measurement of a surface dose rate at the 16 segments which were optionally designated and accounted for about 15×15 cm, samples were taken at the 6 segments of a high dose rate or at the randomly selected 6 segments if a hot spot was not measured. And then, only filter mediums were put into a plastic cylindrical bottle with a volume of 20 cc and a height of 1 cm. This bottle can contain about 30 sheets of a filter medium with a diameter of about 2 inch.

In this way, two bottles taken at both the intake and the outlet part could be considered as a representative sample of a HEPA filter for a radioactive analysis. Therefore, 60 sheets of a filter medium with a diameter of about 2 inch were taken and a total mass of them was about 10 g. So, the sampling rate of a filter medium from a HEPA filter accounted for about 0.5 % compared with a total mass of a filter medium, about 2,000 g. From these bottles, a gamma analysis was directly conducted with a HPGe detector, and then, a gross alpha and beta analysis was conducted with a low-background counter through a random sampling from 60 sheets in 2 bottles into about 20 sheets.

COMPACTION TREATMENT

Treatment status of spent HEPA filter wastes is usually that it is processed as a dry active waste (DAW) through a compacting or shredding treatment. At that time, as using a media stripper, a HEPA filter is separated into a filter frame part and a filter medium part. In case, when only treating the filter medium, it is possible to obtain the best compaction rate. However, because of the separation of the filter frame and its individual treatment, there are some disadvantages such as a complicated treatment process and an excessive treating time.

The treatment plan for a HEPA filter at KAERI is that filters are packed into a regular drum, with a 200 liters volume, as a HEPA filter waste drum through a compaction treatment. Also, a simultaneous compaction method is used without a separation of a frame and a filter medium. From this method, a complicated treatment process of which a filter frame and a filter medium have to be individually compacted and treated at the different process will be improved as a simplicity in process. And also, it is possible to remove a spring-back phenomenon of a filter medium after compacting them, because a filter frame plays a role to prevent a filter medium from springing back.

There are now two compactors at KAERI, as shown in figure 2. One is for vertically compacting spent filter wastes as well as any other compactable wastes and the other is for shaping only spent filter wastes to put them into a regular drum. A shaping compactor consists of a moving shaping mold, a fixed shaping mold and a shaping cylinder with a capacity of 15 tons.

(a) Compactor (b) Shaping compactor

Fig. 2. A compactor with a capacity of 60 tons (a) and a shaping compactor with a capacity of 15 tons (b)

Figure 3 shows the schematic diagram for a shaping and compacting of a spent HEPA filter. A shaping cylinder with a capacity of 15 tons was used in order to put a spent HEPA filter with a hexahedral form of about 610(W)×610(H)×305(T) mm into a regular drum (DOT-17H) with a inner diameter of about 572 mm. Due to the specific structure of the shaping molds, a spent HEPA filter was shaped into a columnar form with a diameter of a fixed shaping mold, about 500 mm as shown in figure 4. And then, a shaped HEPA filter was vertically compacted by using a compaction cylinder with a capacity of 60 tons. At that time, it was possible to put vertically compacted filters up to 8 units into one regular drum with a height of about 870 mm.

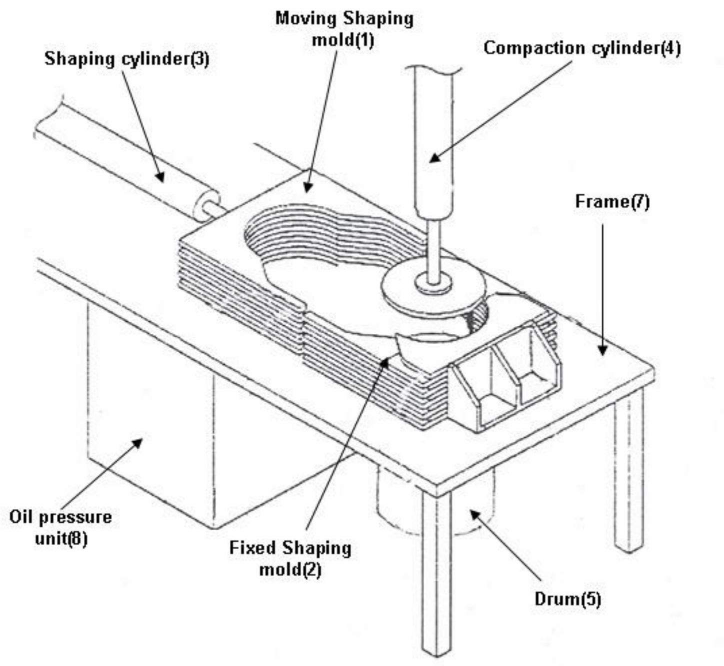


Fig. 3. The schematic diagram for a shaping and compacting a spent filter waste

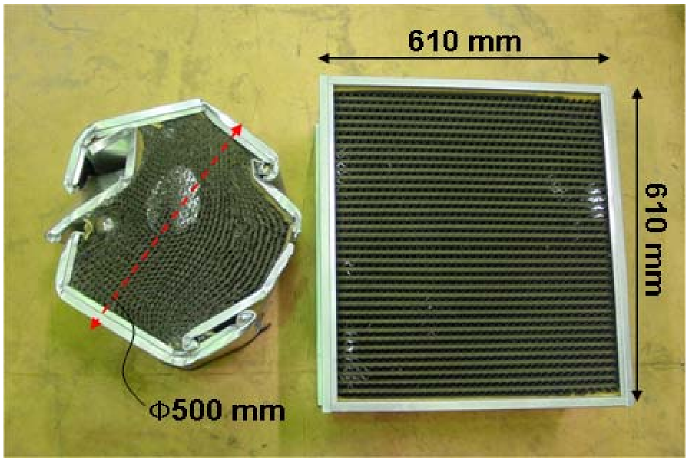


Fig. 4. A HEPA filter waste after and before a columnar shaping

REPACKING

In the repacking stage, it would be advisable to put compacted filters with the same conditions as much as possible into a drum. These conditions correspond to the same generation facility, the same generation date and the same range of the nuclide concentration of a filter. In the case of a pressure drop at the ventilation system, several filters are replaced with new ones. So, those the filters generated at one facility have the same generation date and it is possible to expect them to have the same nuclide information, when compared with others which have a different generation date. Therefore, the generation date could be an important criterion for repacking spent filter wastes into a drum.

For sending a radioactive waste drum to the final disposal site, all drums have to satisfy the waste acceptance criteria (WAC) for that site. Here, the immobilization for dispersive particles has to be confirmed in the spent filter wastes. The immobilization criteria is that a waste of which the particles below 10 ㎛ in diameter account for above 1 % or particles below 200 ㎛ in diameter account for above 15 % when compared with the total weight of the wastes must be stabilized.

As a rule, process-generated particles are divided into two fields which mean a mechanical field produced by a machining, grinding, polishing and other mechanical operations and a chemical field produced by an evaporation, condensation and so on. Figure 5 shows the filter mediums and those SEM images of a HEPA filter after capturing the particles generated in nuclear facilities. A filter medium caused by a chemical and mechanical process showed a dark color and there was no dispersive particles because of an agglomeration with a vapor, and a filter medium mainly caused by a mechanical process showed a very light gray color and a considerable amount of dispersive particles.

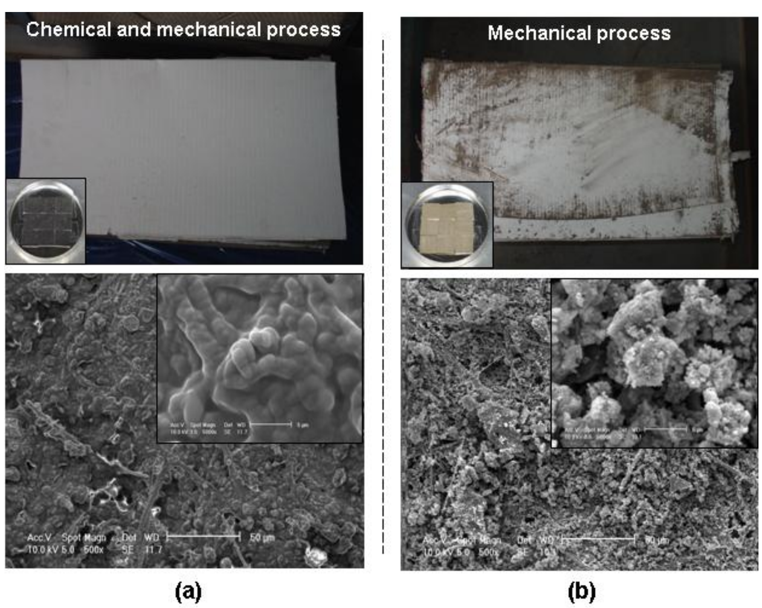


Fig. 5. Filter mediums and SEM images of a HEPA filter after capturing particles generated by a chemical and mechanical process (a) and by a mechanical process (b)

In the case of a mixture of chemical and mechanical processes, the spent HEAP filters were not immobilized after repacking them. On the other hand, as they were mainly caused by a mechanical process, those spent HEPA filters had to be immobilized by a proper immobilization material, such as cement, asphalt and so on. Depending on the state of a filter medium at the time of taking a representative sample from a HEPA filter, it was possible to divide the spent HEPA filter wastes into two categories which mean the filters that need to be immobilized and those that do not.

CONCLUSIONS

The spent filter wastes that had been stored for a long time in a waste storage facility, since its operation, were grouped by the generation facility and the generation date. And then, they were reclassified with the same range of nuclide concentration, after conducting a radionuclide assessment by taking a representative sample from them. A representative sample for a HEPA filter waste was taken at the spot of a high dose rate at the intake part and the outlet part without a dismantlement, by using a punch device with a diameter of about 2 inch. At that time, the sampling rate of a filter medium from a HEPA filter accounted for about 0.5 % when compared with a total mass of a filter medium. After a nuclide analysis, spent filter wastes were repacked into a regular drum (DOT-17H) through a shaping and compaction treatment without a separation of a frame and a filter medium. It was possible to put compacted HEPA filters of up to 8 units into one regular drum, with a 200 liter volume.

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