Solid Liquid Separation for the Foam Decontamination Waste Treatment Using Candle Filter

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1. Introduction

Foam decontamination technologies, in general, are advantageous to the reduction of secondary waste due to the minimized use of liquids and the delivering of decontamination agents due to the increased viscosity of foaming agents [1, 2]. The foaming agents developed in KAERI contain the silica nanoparticles to boost up the decontamination efficiency by increasing the stability of generated foams. After foam decontamination process, the treatment methods are needed to treat the waste solution of decontamination foam which is composed of radionuclides, surfactant, chemical reagent, and stabilizer (i.e. silica nanoparticles). Therefore the removal of the particulates in the waste solution is necessary to reduce the secondary waste thru the separation of solid–liquid. In this study, we investigated a candle filtration method [3] as a solid-liquid separation of silica nanoparticles from the waste solution.

2. Main subject

2.1 Selection of separation system of waste solution generated foam decontamination process containing silica nanoparticles

To choose a proper filtration system, we have considered five different systems – hydro-cyclone, tubular centrifuge, membrane, cross flow filtration, and candle filtration. In general cyclone is suitable for the particle separation in the range between 5 – 100 μm [4] and centrifugal systems could be disturbed by the foaming effect. Membrane filtration is capable to separate the particles below 100 nm, but its process is too complex and fouling in many cases can be a problem. Unlike such those direct filtration techniques, cross-flow filtration and candle filtration are known more suitable for the separation of nano-size particulates with high efficiency and capacity, but cross-flow filtration is typically used for the separation of liquid from concentrated slurry waste. The comparison of solid-liquid separation method is summarized in Table 1.

From the reasons described above, we have chosen the candle filtration system as the solid-liquid separation for the waste solution containing silica nanoparticles. It has been proven to be a cost-effective and reliable method for the removal of the contaminants with recovering of scrubbing liquid. Easy-removal as well as effective drying of cake formed on surface of the filter media is also advantageous for the post-treatment of wastes.

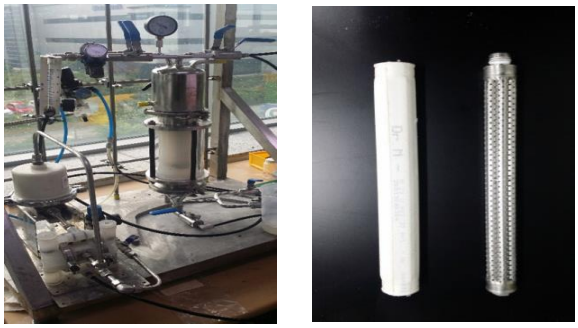
Table 1. Solid-liquid separation technology

division	Solid·liquid separation technology				
	Hydro Cyclone	Tubular Centrifuge	Membrane Filter	Cross Flow Filter	Candle Filter
Solids removal	△	△	○	○	○
Treated water recycling		△	○	○	○
Processing rate		60%	90~95%	90~95%	99%
Solid processing		△	Multiple processing	Multiple processing	Single processing

2.2 Experiment contents and results

The waste of decontamination foam solution containing silica nanoparticles were prepared using 1% (v/v) Elotant™ Milcoside 100 (EM 100, LG H & H) and 1wt.% silica nanoparticles (M-5, Cabosil). The candle filtration system (M21U002 model, Dr. M cooperation) and the filter module located inside the reactor are shown in Fig. 1 (a).

A turbidimeter (DRT-15CE, HF Scientific) was used to measure the separation and recovery efficiency of silica nanoparticles from the waste solution. The turbidity of the treated solution was measured every 30 minutes, and the test was conducted by circulating the treated solution until the particulates are removed over 99% in the turbidity value. After the filtration process is over, the air-blowing is operated to dry the cake and discharged by air-shock force from the candle filter media.



(a) (b)

Fig. 1. (a) Candle filtration experiment equipment (b) filter module.

The separation treatment for the waste solution of decontamination foam was shown in Fig. 2. As shown in the figure, about 99.4% of separation efficiency of nanoparticles was observed from 0.5 to 5 hours. It was found that the pore size of the filter was important factor for separating the silica nanoparticles.

The effect of surfactant on throughput of waste solution of decontamination foam was investigated. From the tests, the throughputs of waste solution of decontamination foam with and without surfactant were maintained at 11 and 14 L/m^2·hour for 5 hours, respectively as shown in Fig. 3.

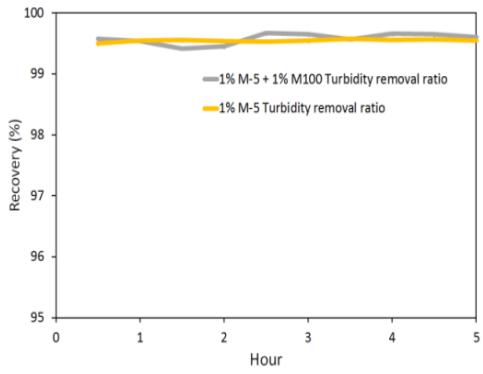


Fig. 2. Effect of Surfactants on Nanoparticle Recovery.

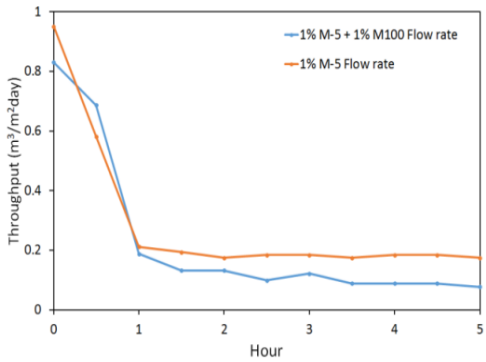


Fig. 3. Effect of surfactants on waste throughput.

In other words, the throughput of waste solution of decontamination foam in the presence of surfactants is reduced by 20% compared to the case without surfactants. It indicates that the silica nanoparticles bound to the surfactants might block the pore of candle filter. However the throughput was maintained constantly for 5 hour, which is still enough to treat the foam waste solution.

In the dry process of the cake formed on the candle filter media, the low pressure air drying about 1 bar resulted in 37% water content in the dried cake due to the suppression of crack formation. However, the water content by high pressure drying above 3 bar was 74% due to the early discharge of the cake from the filter media before it was not fully dried. From these results, the solids treatment method for candle filter by low pressure drying was suitable for the separation of silica nanoparticles.

3. Conclusion

In this study, we investigated the solid-liquid separation performance of silica nanoparticles in the waste solution generated foam decontamination process using a candle filter. The pore size of the filter was important factor to recover a various types of silica nanoparticles. The cake layer acts as a filter media, and the recovery rate increased after treated time. It is considered that the throughput of waste solution was reduced by surfactant due to the blocking of the pores in the candle filter, but the throughput of waste solution was maintained constantly for 5 hours.

Therefore, it is confirmed that the candle filtration can be an effective method for recovering silica nanoparticles in decontamination foam solution due to the formation of a cake layer in filter media.

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