Study on HyBRID Chemical Decontamination and Waste Water Treatment by Using Pilot Scale Equipment

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1. Introduction

Chemical Decontamination technology is widely used in primary system of the nuclear power plant. It is essential to develop chemical decontamination process for minimizing secondary waste along with increasing decon factor. HyBRID(Hydrazine Based Reductive metal Ion Decontamination) is chemical decontamination process using a reducing agent containing a metal catalyst without using organic acid. Most of the decontamination agent as well as the metal ions are precipitated, thereby reducing the amount of waste. This study was carried out to demonstrate HyBRID decontamination and waste water precipitation process for the pilot scale.

2. Process equipment

The chemical decontamination pilot is a 1/3 scale commercial RCP internal chemical decontamination equipment consist of decontamination tank (400L), chemical injection tank, DI water/storage tank, IX Column (4 EA), cooling tank/cooler etc. The waste water precipitation equipment consists of mixing tank (500L) and filter press to separate sludge.

Fig. 1. Chemical decontamination pilot equipment (L).
Fig. 2. Filter press(R).

3. Experiments

3.1 Experimental method

The STS304 test specimen (50*50*2 mm, 20EA) with 10 um oxide film that has similar composition to the PWR nuclear power plant were used for the pilot scale demonstration test. After filling 300 L DI water in the decontamination tank of the chemical decontamination pilot, the test specimens were placed in a basket and placed in the decontamination tank. The oxidation process was carried out for 3 hours after reaching the temperature 95℃. After HyBRID chemical decontamination process, the process water was cooled and transferred to the mix tank of the waste water precipitation equipment. In the mixing tank, Precipitation process and Hydrazine decomposition process were performed, and SiO_2 was injected to grow the precipitate particle size. Precipitate in the process water was separated by using a filter press and finally purified with an ion exchange resin. The final purified water was re-used in the second HyBRID chemical decontamination process, and the chemical concentration for each step is as below.

Table 1. Chemical concentration conditions of HyBRID decontamination process

Step	Chemical	Concentration
Oxidation	H_2SO_4	3.25 mM
	$KMnO_4$	6.33 mM
Reduction	$N_2H_4{\cdot}H_2O$	33.77 mM
	H_2SO_4	57.91 mM
	$CuSO_4$	0.5 mM
Precipitation	$Ba(OH)_2{\cdot}8H_2O$	40 mM
N_2H_2 decomposition	H_2O_2	230 mM
Particle growth	SiO_2	0.5 wt%

3.2 Experimental result

The ICP-OES analysis result of the process water sampled in HyBRID chemical decontamination

revealed that the spinel structure of the oxide film was destroyed in the oxidation Step and Cr ion was dissolved. In the reduction step, it was confirmed that the dissolved Fe and Ni ion concentration was increased and the oxide film was removed. After precipitation process, Fe^{2+} / Ni^{2+} / Cu^{2+} / Mn^{4+} ion were completely removed, but Cr^{3+} and SO_4^{2-} ion remained a little. It was confirmed that only 45.9% of K^+ ion was precipitated and remains in the process water. The remained ions in the process were mostly removed through the ion exchange resin.

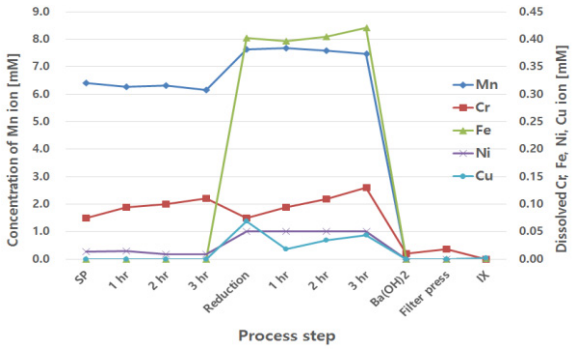

Fig. 3. ICP-OES analysis result.

Table 2. The residual ion concentration(before and after the precipitation process)

Step	K^+ [mM]	SO_4^{2-} [mM]
Reduction	6.60	43.8
Precipitation	3.572 (45.9% removal)	1.83 (95.8% removal)
After IX	0.037	0.034

4. Conclusion

In this study, HyBRID chemical decontamination was demonstrated by using a pilot scale decontamination system. As result of the test, the oxide film was removed and most of the reagent and metal ions in the process water were precipitated by the precipitation step.

It is expected that HyBRID chemical decontamination process can be applied to commercial decontamination process, if the precipitation step is improved.

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