

# Preliminary Study on HyBRID Chemical Decontamination Demonstration for the Reactor Coolant Pump Shaft

Ki-Chul Kim\*, Bum-Chul Seo, Sun-sik Yoon, Jung-Yeop Cha, Nam-Kyun Kim, Kwang-Hee Joo,  
Do-Yong Kwon, Dong-Yeon Kim, Keun-Woo Kim, and Ju-Hyeon Park  
KEPCO KPS, 69-46, Munsan 2sandan 1-ro, Oedong-eup, Gyeongju-si, Gyeongsangbuk-do, Republic of Korea  
\*KICKIM@kps.co.kr

## 1. Introduction

In the previous research, KEPCO KPS performed pilot scale test applying HyBRID chemical decontamination process and confirmed high Decontamination Factor (DF) and low waste generation [1]. Based on previous research, we will demonstrate HyBRID process using contaminated Reactor Coolant Pump (RCP) shaft in Hanul#1. The loop test equipment for HyBRID process demonstration was manufactured and tested by RCP shaft mock-up.

## 2. Test Equipment and Experiments

In this experiment, we use RCP shaft mock-up and ultrasonic decontamination jacket (15 L). The loop test system (30 L) contains decontamination part and precipitation part. The decontamination part is designed to circulate the process water and control the temperature through the line heater and pump. The precipitation part is consisted of precipitation tank (30 L), diaphragm pump, and membrane filter designed to filter the precipitate.

### 2.1 Experimental Method

The three STS304 specimens (50×50×2 mm) with simulated corrosion oxide film were mounted on the RCP shaft mock-up and ultrasonic decontamination

jacket was fastened. After 30 L of DI water was added to the decontamination part, heat up the DI water to 95 °C, and the oxidation/reduction process were carried out for 3 hours each. After the oxidation/reduction process, the process water was cooled to 40 °C, and conducted ultrasonic cleaning for 10 minutes, and the process water transferred to the precipitation tank. The concentration of chemicals is same as pilot scale test [1] except for SiO<sub>2</sub>. The oxidation, reduction, and precipitation processes were carried out for 3 cycles.



Fig. 1. RCP shaft, mock-up and ultrasonic decontamination jacket.

### 2.2 Thickness Reduction Calculation of Specimen

The mole of metal for weight loss before and after the HyBRID chemical decontamination process of STS304 specimen is expressed as  $x \text{ mol}_{M^{n+}}$ , and the thickness reduction formula is as follows:

$$d_{M^{n+}} = x \text{ mol}_{M^{n+}} \times \frac{F.W(g/mol_{M^{n+}})}{\text{Oxide layer density}(g/cm^3)} \quad (1)$$

After the HyBRID chemical decontamination process, the weight loss for each of the three specimens in each cycle was added up and averaged, and the weight of the measured metal was substituted into the above formula to calculate the thickness reduction of the specimen.

### 2.3 Analysis Method of Precipitated Process Water

In the precipitation process, the filtered process water was sampled and the TSS (Total Suspended Solids),  $\text{SO}_4^{2-}$  (sulfate ions), and  $\text{N}_2\text{H}_4$  (hydrazine) concentrations were measured by spectrometer (HACH DR1900, USA).

## 3. Experiments Result

### 3.1 HyBRID Chemical Decontamination Result

The HyBRID chemical decontamination results show that an average of 2.0 ~ 2.2  $\mu\text{m}$  oxide film is removed in each cycle and the thickness reduction is shown in Table 1.

Table 1. Measurement results of Average Thickness Reduction by HyBRID decontamination

Average Thickness Reduction [ $\mu\text{m}$ ]	
1 Cycle	2.21
2 Cycle	2.01
3 Cycle	2.16

### 3.2 Analysis Result of Precipitated Process Water

In the precipitation process, TSS was filtered to 1 mg/L and  $\text{SO}_4^{2-}$  was measured less than 1 mg/L within 1 hour. The  $\text{N}_2\text{H}_4$  concentration was measured to 0.18 mg/L.

Table 2. Filtrated process water analysis result

Time	TSS [mg/L]	$\text{SO}_4^{2-}$ [mg/L]
5 min	5	1
30 min	3	1
60 min	1	0
90 min	0	0

## 4. Conclusion

The loop test using RCP mock-up and coated specimens showed that 6  $\mu\text{m}$  of oxide film was removed by 3 cycles. In the precipitation process, all  $\text{SO}_4^{2-}$  was removed by  $\text{Ba}(\text{OH})_2$ , and the removal rate of  $\text{N}_2\text{H}_4$  was also very high.

Based on these results, we will apply HyBRID chemical decontamination demonstration test to Hanul#1 RCP shaft.

## ACKNOWLEDGEMENTS

This work was supported by the National Research Foundation of Korea (NRF) and the Ministry of Science and ICT (MSIT) of the Republic of Korea. (NRF-2017M2A8A5041776)

## REFERENCES

- [1] K. C. Kim, J. H. Park, J. H. Lee and D. Y. Kim, "Study on HyBRID Chemical Decontamination and Waste Water Treatment By using Pilot Scale Equipment", Proc. of the KRS 2018 Spring Conference, 16(2), 10.31- 11.02, 2018, Jeju.