Design and Operation of Chemical Injection and Decomposition&Treatment Facility

Hak-Soo Kim*, Cho-Rong Kim
KHNP Central Research Institute, 70, 1312-gil, Yuseong-daero, Yuseong-gu, Daejeon, Korea, 34101
**Corresponding author:hskim0071@khnp.co.kr*

1. Introduction

System decontamination applied after nuclear power plants are permanently shut down is the technology to remove contaminated metal oxide films, or metal oxide deposits on the surfaces of the primary system of nuclear power plant (NPP). The goal of the system decontamination is to reduce the radiation exposure fields to which the decommissioning workers will be exposed. The oxide film formed on the surface of the primary system is a metal oxide such as iron, nickel and chromium. Chromium in these metal oxides is removed in oxidation process, and iron and nickel are removed in reduction process [1]. The metal ions dissolved from oxidation and reduction process are removed by ion exchanger resin or filter and the chemical waste from which metal ions have been removed is decomposed by the Advanced Oxidation Process. The decontamination facility is required to inject the chemical agent for removing the radioactive materials in Reactor Coolant System (RCS), and decompose and treat the chemical waste generated from RCS. This paper dealt with the conceptual design and operation concept of system decontamination facility, CIDF (Chemical Injection and Decomposition&Treatment Facility).

2. CIDF Design and System Functions

The CIDF consists of the chemical injection system and chemical waste decomposition & Treatment system [2] as shown in Figure 1.

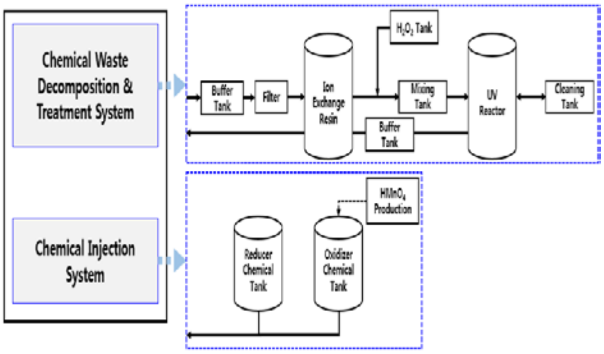


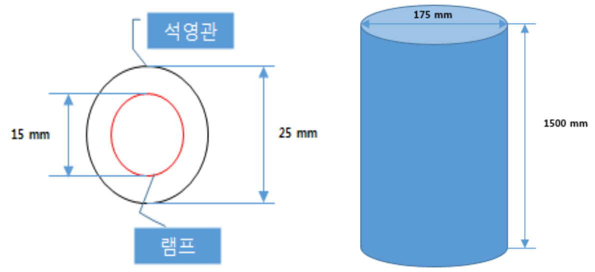
Fig. 1. Schematic drawing of CIDF

The chemical injection system consists of permanganate production equipment, chemical agent storage tank, chemical injection pump and piping. The permanganate production equipment is used to product permanganic acid, $HMnO_4$, by passing potassium permanganate, $KMnO_4$ through a cation resin. The chemical agent storage tanks store permanganic acid, which is an oxidizing agent, and oxalic acid, which is a reducing agent. The chemical injection pump is used to inject oxidant and reducing agent into the system.

The chemical waste decomposition & Treatment system consists of the following [3]:

- Filter and ion exchanger resin
- H_2O_2 injection tank
- UV reactor
- UV reactor cleaning tank
- Mixing and Buffer tank
- Booster pump, etc.

Filter and ion exchanger resin are for removing particulate and ionic metal ions in the chemical waste, respectively. H_2O_2 injection tank is used to store H_2O_2 solution. UV reactor is used to decompose the oxalic acid into water and CO_2 with H_2O_2. The lamp type in UV reactor is UVC amalgam. The structure and specification of UV reactor are shown in Figure 2.



(UVC amalgam lamp) (UV reactor)
Fig. 2. Structure and specification of UV reactor

UV reactor cleaning tank stores the chemicals used to remove the oxide attached to the surface of the UV lamp. The buffer tanks serve to relieve the supply pressure of the chemical waste to the atmospheric pressure level, and store the chemical waste temporarily and supply it to a subsequent process, and release CO_2 into the environment. The mixing tank is used to stir the chemical waste and H_2O_2 solution well, and has a stirrer and a motor. The booster pump is used to supply not only chemical agents but also the process water that has passed through the chemical waste decomposition & treatment system to RCS.

The basic design requirements of CIDF are as follows.

- Oxalic acid decomposition performance: > 99%
- Operation temperature/pressure: < 40℃ / 30 bar

- Concentration of oxalic acid: < 2,000 ppm
- Modularized or skid mounted type to easily separate and assemble each components in CIDF
- Designed to be easy to transport to the installation site and use in a small space
- Classified the components in CIDF into radioactive and non-radioactive part

The design criteria of CIDF are the same as below [4].

- Safety category: Non-Safety-Related
- Quality: A(chemical injection system : S class)
- Electric: Non-1E
- Seismic: II(chemical waste decomposition & treatment system), III(chemical injection system)

3. Operation Concept of CIDF

CIDF operation consists of two main operating modes: a chemical injection mode and a chemical waste decomposition& treatment mode. Figure 3 shows the operation flow and each operation mode is briefly described as follows.

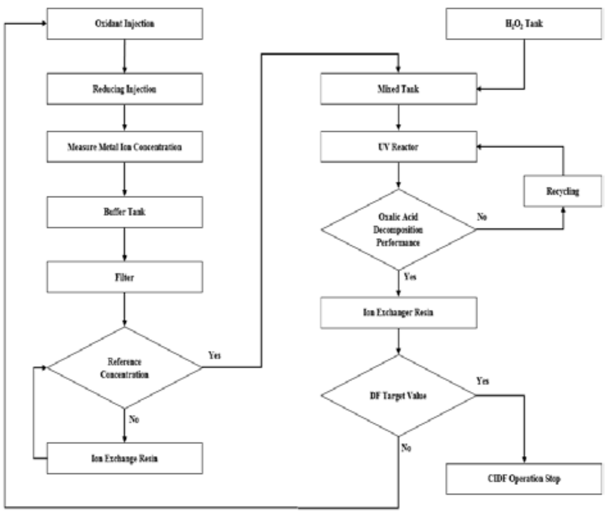


Fig. 3. Operation flow of CIDF

- A chemical injection mode

The oxidizing agent in the oxidizer chemical tank is injected into the RCS via the booster pump using the chemical injection pump. After the oxidation reaction in the RCS has sufficiently occurred, the reducing agent in the reducer chemical tank is injected into the RCS in the same manner as the oxidant injection.

- A chemical waste decomposition&treatment mode

After the chemical injection operation mode is completed, it passes through a filter to remove any particulate metal ions in the chemical waste generated in the RCS. The chemical waste passing through the filter enters UV reactor via the ion exchange resin if it is above the concentration value based on the specific ion concentration value in the chemical waste, and if it is below the concentration value, it enters immediately UV reactor. The chemical waste passing through UV reactor is injected into the RCS using the booster pump. The above process is repeated until 99% or more of the oxalic acid present in the chemical waste is decomposed.

Another operation is UV lamp cleaning operating mode. If oxides adhere the surface of UV lamp, the reaction of chemical waste with UV lamp is disturbed and the oxalic acid decomposition performance is deteriorated. In order to maintain the performance of UV lamp, the cleaning operation is performed to remove the oxide adhered to the surface of UV lamp.

4. Conclusions

KHNP has recently developed a chemical decontamination process, CRI_RWDecom (Chemical Reagent Injection and RadWaste Decomposition &Treatment Process) and completed a conceptual design of CIDF. Detailed design of CIDF is required to secure a commercial facility. KHNP plans to carry out R&D for securing the system decontamination facility in the future.

REFERENCES

[1] EPRI, Decontamination Handbook, TR-112352, 1999.
[2] H.S. Kim and C.R. Kim, Conceptual Design Report of CIDF, Korea Hydro & Nuclear Power Co. Ltd, R&D-FSD-CIDF-000, Rev 0, 2018.
[3] H.S. Kim and C.R. Kim, System Functional Description of CIDF, Korea Hydro & Nuclear Power Co. Ltd, R&D-FSD-CIDF-002, Rev 0, 2018.
[4] H.S. Kim and C.R. Kim, System Design Criteria of CIDF, Korea Hydro & Nuclear Power Co. Ltd, R&D-FSD-CIDF-001, Rev 0, 2018.