Full System Decontamination by ASDOC_D-MOD Method

HanSol Im[a),*], Laura Schneider[b)], ChangSig Kong[a)], HeeDong Sohn[a)], and KyuHo Chang[a)]
[a)]Doosan Heavy Industries & Construction, 22, Doosan Volvo-ro, Seongsan-gu, Changwon-si, Gyeongsangnam-do, Republic of Korea
[b)] Siempelkamp NIS Ingenieurgesellschaft mbH, Industriestrasse 13, 63755 Alzenau, Germany
*hansol.im@doosan.com

1. Introduction

In dismantling nuclear power plant, high level radiation limits safe and efficient decommissioning. The chemical decontamination is an effective process to reduce the amount of radioactive contaminants on the inner surface of the primary circuit which has complicated shape and hard-to-reach area before dismantling. Popular chemical decontamination methods such as CORD UV and NITROX-E generally use permanganic acid ($HMnO_4$) and oxalic acid ($C_2H_2O_4$) to redox. These methods can effectively remove the contaminated layer on the surface of primary circuit through several decontamination cycles with high concentration chemicals. It could occur the corrosion of the base material which could lead to leak out of the primary circuit, and hydrogen generation when excess oxalic acid reacts with base material, which may cause safety concern.

Then we introduce the ASDOC_D-MOD (Advanced System Decontamination Oxidizing Chemistry Modified), the method which complements disadvantages of popular chemical decontamination by using low concentration of permanganic acid and oxalic acid and adjusting the pH by using additives.

2. ASDOC_D-MOD Method

2.1 Process of decontamination

Basically ASDOC_D-MOD use permanganic acid and oxalic acid for redox same as conventional methods, but it use low concentrated agent and additive to complement the reduced reactivity. For the additive, MSA(Methane Sulfonic Acid, CH_4O_3S) is used to facilitate redox. Also, ASDOC_D-MOD is economical because it does not need an external decontamination equipment, so it eliminates the risk of secondary contamination by external equipment.[3]

ASDOC_D-MOD starts with oxidation process using permanganic acid, and oxidation → removal of permanganic acid → reduction with oxalic acid → removal of oxalic acid becomes 1 cycle.

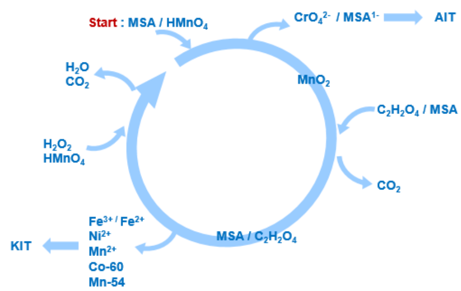

Fig. 1. ASDOC-D-MOD Process.

The oxidation process removes the chromium oxide layer (2 ~ 10 μm) using permanganic acid and the removed chromium oxide ions are filtered on the anion exchange resin. After the oxidation process, oxalic acid is injected to process a reduction and it decompose the manganese dioxide($MnO(HO)_2$) generated in the oxidation process and unreacted permanganate (MnO_4^-) after the oxidation process. The metal ions, which build oxalate-complexes with oxalic acid, are filtered out on the cation exchange resin. The rest oxalic acid is decomposed on the oxidant input of the next cycle.

The MSA added during the redox adjusts the pH to promote the reaction and increases the solubility of metal ions by its complex generating properties.

2.2 Decontamination efficiency

ASDOC_D-MOD is expected to complement disadvantages such as leakage of external equipment connection, high generation of secondary liquid waste, damage of base material and hydrogen generation by using low concentration chemical agent. In order to confirm the improvement effect of ASDOC_D-MOD, the test was carried out at the scale down model.

Fig. 2 shows the potential and pH measured during the test. Similar redox potentials were measured for each decontamination cycle, and the pH was maintained at a similar level. The MSA maintains the pH condition that suppresses the reprecipitation of oxalate and hydroxide as well as maintaining proper redox reaction for the decomposition of the corrosion oxide layer even with a low concentration of decontaminating agent.

The use of a low concentration agent can also have the effect of inhibiting excessive decomposition of base material and production of hydrogen. Fig. 3 shows the amount of Fe ion change with time. Fe ion excessive decomposition and hydrogen production are always a phenomenon followed by high concentration of oxalic acid injection, which increases with the amount of oxalic acid injected [2]. There is no direct safety problem with the excessive decomposition of Fe ions, but it induces spalling phenomenon near the injection site, disturb uniform decontamination, and rapidly increases hydrogen emission. Hydrogen generation is associated with direct safety issues.[1]

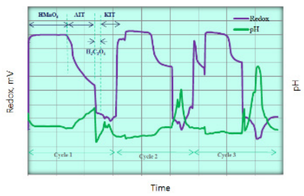

Fig. 2. Decontamination test results of ASDOC-D-MOD.

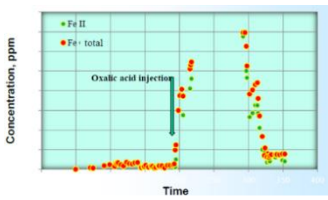

Fig. 3. Characteristics of Iron-Burst.

2.3 Decontamination equipment

ASDOC_D-MOD decontamination has the effect of reducing the cost of production of external equipment and facility manpower by using the same pump and piping as the conventional operation without using an external decontamination facility. There is no need to take risk of the connection with the external equipment which can be a weak point. The primary system operation can be carried out in the same way as that performed by the existing operation personnel of the power plant, and only the production of the permanganate production facility, the chemical injection tank / piping, and the test loop can be done. Also, the permanganic acid production facility can be installed outside the restricted area and is not limited by the radiation exposure.

3. Conclusion

ASDOC_D-MOD, a low - concentration chemical decontamination method for primary circuit decontamination was introduced. As the results of scale down model test, ASDOC_D-MOD enables the stable, uniform decontamination, suppresses the risk of base material corrosion, hydrogen generation, and reduces the amount of waste. Also the system facility and operation manpower of power plant are used as they have being, it is possible to perform stable and economical decontamination. However, in order to perform successful, quick and safety full system decontamination, close cooperation between the radiation workers, radiation safety management personnel, chemical decontamination personnel, radiological safety, chemical safety management personnel, and their respective supervisors must be carried out.

Acknowledgement

This work was supported by the National Research Foundation of Korea (NRF) granted financial resource from the Ministry of Science and ICT, Republic of Korea (NRF-2017M2A8A5041777).

REFERENCES

[1] IAEA, Safety in decommissioning of research reactors. Safety ser., 1986.

[2] H. W. Park, Decontamination and Decommissioning Technology Development of Nuclear Facilities, KAERI/RR-705/87, 1988.

[3] Andreas Loeb, Chemical System Decontamination at PWR Power Stations Biblis A and B by Advanced System Decontamination by Oxidizing Chemistry (ASDOC_D) Process Technology, 2013.