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Study on Plasma Degradation Technology for Vitrified Treatment of Decommissioning Wastewater

Min-ho Kwak[a], Ki-man Park[a], Kyung-ho Lee[b] Do-hyung Kimand[b], Unjang Lee[b]

[a] VITZROTECH Co., Ltd. *#327, Byeolmang-ro, Danwon-gu, Ansan-si, Gyeonggi-do, Republic of Korea*
[b] ORIONENC Co., Ltd. *#305, 37, Seongsui-ro 22-gil, Seongdong-gu, Seoul, Republic of Korea*

Email address: ujlee@orionenc.com

1. Introduction

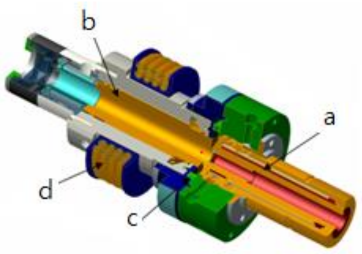
Decontamination and Decommissioning works of the nuclear facilities is one of the biggest projects in these days. During the dismantle of NPPs, it is very important to treat safely wastes generated during decommissioning because many kinds of wastes could be produced. In particular, technology development to treat the wastes in safe and to reduce the volume is continuously proceeding since few decades because low-level and very low-level wastes are produced in large quantities during NPP operation as well as decommissioning.

The low and intermediate radioactive liquid wastes generated are stored for long-term period in nuclear power plant before the transportation to disposal site by the stabilization with paraffin or mortar after evaporation and concentration process. Among the liquid wastes, because the concentrate liquid as a toxic liquid generated from chemical cleaning and decontamination is not easy to treat and dispose many countries around the world make efforts to develop new technology to treat this concentrate liquid.

This study shows the installation of facility to treat safely liquid type wastes and relevant experiment is proceeded via 200KW class high efficiency torch development and subsequent design for stable reactor and the related devices on targeting low and intermediate level concentrate liquid waste treatment and vitrification.

2. Waste treatment system

2.1 200kW Plasma Torch and Reactor



	PARTS
a	Anode
b	Cathode
c	Air supply unit
d	Spin Coil

Figure 1. Schematic of plasma torch system

Figure 1 shows the incision of a small plasma 200 kWatt torch designed and fabricated for the refractory waste liquid. The construction of the torch is largely composed of an anode, a cathode, an air inlet tube, and a magnetic coil. In Figure 1, the anode is connected to the outlet where the gas changes to a hot plasma state, and the cathode is connected to the opposite side of the outlet where the hot electrons are emitted. The working gas line injects the gas tangentially through the orifice and forms a vortex between the two electrodes to cause the relatively cold gas to flow toward the wall and the hot gas to the central arc axis due to the difference in centrifugal force.

2.2 Waste liquid pre-treatment facility

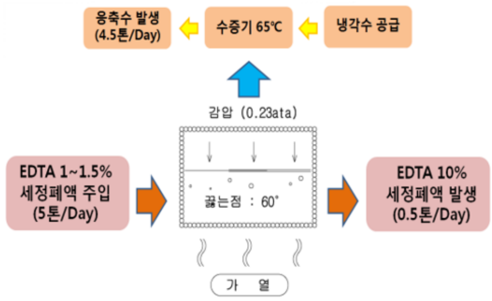


Fig. 2. Liquid waste pre-treatment system

Radioactive waste liquid pre-treatment device to be injected is made up of the injection unit and the heating container consisting of a waste liquid storage container and a pump and a nozzle that can handle up to 5 tons a day, as shown in Figure 2. And the amount of waste liquid to be supplied to the reactor is controlled by a bypass valve.

EDTA can treat about 1% waste liquid about to 5 tons per day. After heating and concentrating, EDTA will produce about 10% of 0.5 tons of waste and 4.5 tons of condensate.

2.3 Reactor design for waste liquid treatment

This study furnace for the treatment of radioactive waste liquid produced in this study is designed and manufactured as shown in Fig3. When the wastewater is pyrolyzed and treated, the inside of the reactor is maintained at a high temperature so that the concentrated wastewater can be effectively incinerated.

Since the waste water supplied is 99% of general water, it is designed to have a water characteristic as a whole, assuming that the required amount of heat and water vapor is 900 ° C until the water evaporates. The amount of waste solution supplied was determined by Trial &

Error method and the amount of waste solution supplied was determined to be about 1.5g/s.

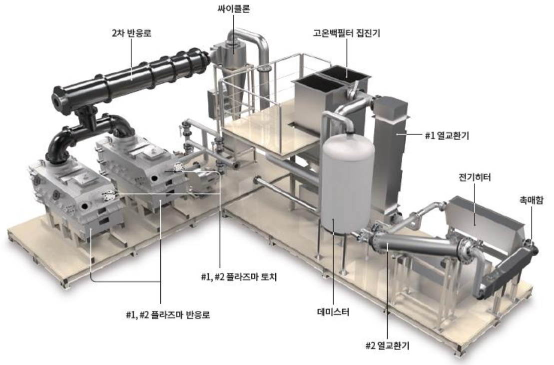


Fig. 3. Plasma treatment system

3. Operation and treatment

In order to operate stably during initial ignition, the igniter was operated with a voltage of 300 V applied between the positive and negative electrodes of the torch. The air flow rate to the torch was about 1.5g/s, and the operating conditions were determined as 100 V, 100 A at the initial stage of ignition. The plasma torch is a non-transporting huels type, designed to withstand internal temperatures up to 20k °C and outlet temperatures up to 10k °C. The internal temperature of the plasma reactor can be operated up to 950 ℃ and the EDTA decomposition temperature is about 600 ℃.

In this performance test, the total amount of the waste water for washing the steam generator was set at 30m^3. And to calculate the capacity of the ash produced to be finally subjected to the vitrification treatment.

4. Treatment results

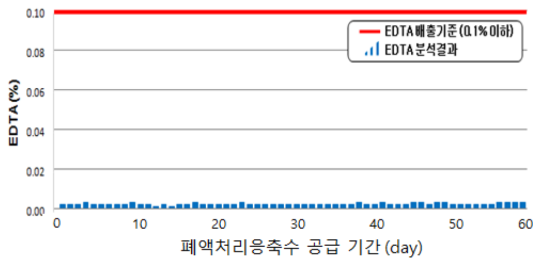


Fig. 4. EDTA Vol. in condensed waste water

Fig. 4 and 5 show the treatment results of the supplied liquid waste. The chemical agent simulator for steam generator cleaning wastes were injected and treated for a total of 60 days. In order to test the components and the treatment capacity of the liquid waste to be decomposed through the reactor, a recovering machine was installed to store the liquid and the solid falling below the reactor, and the steam discharged to the top of the reactor was injected into the analyzer using a pressure gauge and a nozzle.

The concentrations of environmental pollutants in treated water and exhaust gas were analyzed by GC and HPLC (High Performance Liquid Chromatography). The concentration of EDTA in the treated water is shown in Fig. 4, which is much lower than the discharge limits. It is also analyzed that it is much lower than the limit of Co_2, NOx, and SOx.

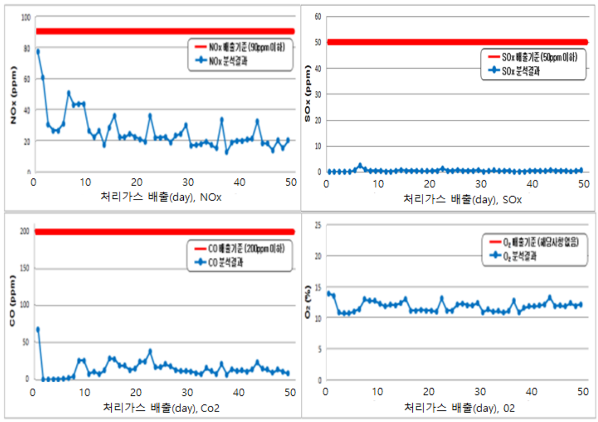


Fig. 5. Co_2, NOx, SOx, O_2 Vol. in treated gas

The concentration of EDTA in the condensed water was measured to be less than 0.02% of the concentration of the injected solution by HPLC analysis of the condensed water of the exhausted gas. This means that the EDTA solution in contact with the plasma shows a decomposition efficiency of about 99% or more.

Also, CO_2 analysis by GC in the exhaust gas was performed by calculating chemical equilibrium and stoichiometry of the amount of CO_2 generated in the complete decomposition of EDTA contained in the solution, and the conversion rate was measured based on the calculated value. The overall conversion of EDTA to CO_2 was about 96%.

5. Conclusion

In this study, a 200kW plasma torch, power supply devices, and the related accessories were designed and fabricated to test the effluent treatment. As a result of the performance test, a degradation efficiency of about 99% for EDTA and a conversion efficiency of 96% for typical CO_2 among environmental pollutants were obtained. In the future, optimization research is required to develop commercialization technology for the vitrification treatment of wastes using a plasma incinerator.

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