Active Carbon Demonstration Case Using Plasma Treatment Equipment

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1. Introduction

Nuclear power plants (hereinafter referred to as "nuclear power") generate various types and forms of radioactive waste during operation and decommissioning. "Radioactive waste" refers to materials containing radionuclides or contaminated by them that are subject to disposal. Since radioactive waste can emit harmful radiation to humans, safe management is required. Due to stricter regulations on the disposal of radioactive waste, unclear acceptance criteria, and lack of treatment technologies, nuclear power plants have been storing large amounts of radioactive waste for long periods of time. To ensure stable comprehensive management (processing and disposal) of radioactive waste generated during the operation and decommissioning of nuclear power plants, Korea Hydro & Nuclear Power Co., Ltd. (hereafter "KHNP") has developed plasma processing technology. Plasma processing technology uses an electric arc phenomenon similar to lightning to melt metals, concrete, soil, and asbestos at around 1,600°C, reducing their volume by about one-fifth. In order to conduct high-temperature pyrolysis demonstration tests using the plasma processing facility with activated carbon generated in the air conditioning system of nuclear power plants, KHNP plans to use the plasma processing facility.

2. Plasma treatment demonstration

2.1 Sample preparation

For this test, we prepared mock activated carbon (100%), which is used in air conditioning systems at nuclear power plants. We prepared each composition with weights of 1, 2, and 3 kg to verify the possibility of continuous processing per hour for the mock samples.

Fig. 1. Activated carbon samples

Table 1: Activated carbon composition and proportion

Items	Activated carbon						
Composition	C	CaO	P_2O_5	MgO	K_2O	S	$T-N$
Proportion(%)	62.9	4.69	0.61	0.67	0.574	0.37	0.293

2.2 Plasma Treatment

The plasma torch was ignited (at 13:30), and after switching to convective operation at 16:00, the internal temperature was raised up to 1,343°C to form conditions for introducing simulated activated carbon.

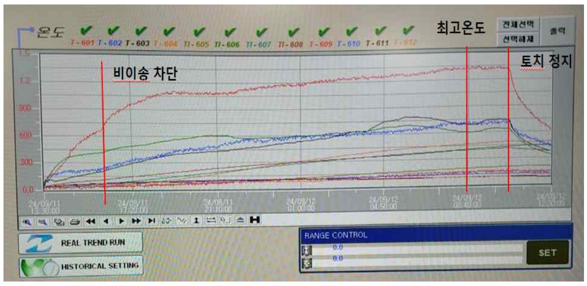

Fig. 2. Furnace temperature

Simulated activated carbon was introduced in total of 12 times as shown in Table 2.

Table 2: Time table of the sample input

No.	1	2	3	4	5	6	7	8	9	10	11	12	Sum
Time	9/11 14:30	15:30	21:30	22:30	23:30	9/12 00:30	01:30	02:30	03:30	04:30	06:30	07:30	12hr
Mass[kg]	1	1	1	1	1	2	2	2	3	3	2	2	21
Quantity	1	1	1	1	1	1	1	1	1	1	1	1	12

Main operating parameters using the plasma treatment facility were found to be voltage 566 V, current 165 A, and output power 93 kW.

Table 3: Parameter range according to operation modes

Mode / Parameter range	Non-transfer mode	Transfer mode
Torch distance[mm]	50 ~ 110	50 ~ 150
Ampere[A]	140 ~ 160	150 ~ 180
Voltage[V]	483 ~ 566	491 ~ 640
Power[kW]	72 ~ 90	87 ~ 98

3. Test Results

It was confirmed that by using plasma to treat simulated activated carbon, both volume and weight decreased, leaving only final ash-like residues behind. Despite performing pyrolysis in an oxygen-free environment, some of the activated carbon could be seen oxidizing due to external air inflow through CCTV. As more activated carbon was added, the temperature inside the furnace and flue gas increased consistently. During plasma treatment of simulated activated carbon, there were temporary boiling phenomena caused by rising slag levels and flue gas flow, but mostly stable pyrolysis conditions were maintained, with emissions remaining undetected due to low amounts of fed activated carbon. Upon confirming major operating variables (temperature, pressure, etc.) during plasma treatment of waste activated carbon, the operational stability of the facility was verified, and for increasing processing capacity of waste activated carbon, creating an oxidative atmosphere for plasma treatment was considered the most efficient method.

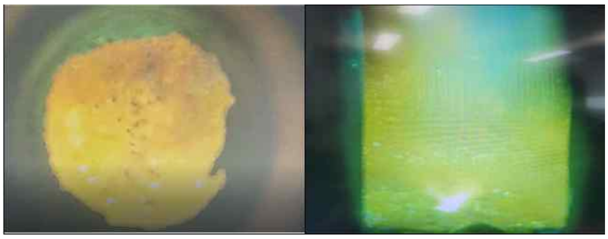

Fig. 3. Addition of activated carbon and Melting pool

4. Future Plans

In order to secure the stability of the mock activated carbon treatment using the plasma processing facility, long-term continuous operation demonstration, validation of waste process data, and optimization of operating parameters will be carried out.

REFERENCES

[1] Development of Advanced Plasma Torch Melter System (KHNP CRI, 2023)
[2] IAEA-TEDOC-1527 Application of Thermal Technologies for Processing of Radioactive Waste, (2006)