A case of improving the plasma torch of radioactive waste

Jeongsu Jeong*, Sunghoon Hong, Seoyong Choi
KHNP-CRI, 70, Yuseong-daero 1312beon-gil, Yuseong-gu, Daejeon, Republic of Korea
*happytiger13@khnp.co.kr

1. Introduction

Plasma melting technology uses electrical arc phenomena such as lightning to create high-temperature flames of about 1,600°C or more, not distinguishing radioactive wastes generated during the operation and dismantling of nuclear power plants
according to their physical characteristics. It is a technology that can meet waste disposal requirements through treatment and reduction.

The advantage of plasma torch melting technology is that it is possible to treat various types of waste in the same reactor without pretreatment with clean high-temperature heat sources that cannot be obtained by conventional technology (fossil fuel incineration).
It is widely used in general industries because it is easy to manage waste and exhaust disposal processes.

Table 1: IAEA-TEDOC-1527, Dec.2006[3]

Technique	Waste type							
	Rubber/ plastic	Cellulose	Ion exchange resins	Biological material	Mixed solids	Lubricants	Organic solvents	Other liquids
Non-destructive techniques								
Drying and evaporation	N	Y	Y	Y	Y		Y	Y
Distillation	N	N	N	N	N		Y	
Physical conditioning			N	N	Y	N	N	N
Decontamination	Y	Y	N	N	Y	Y	Y	
Absorption	N	N	N	N	N	Y	Y	Y
Compaction	Y	Y	Y		Y	N	N	N
Direct immobilization	Y	Y	Y		Y	N	N	N
Destructive techniques								
Incineration	Y	Y	Y	Y	Y	Y	Y	Y
Pyrolysis/steam reforming	Y	Y	Y	Y	Y	Y	Y	Y
Alkaline hydrolysis (TBP-odourless kerosene (OK))	N	N	N	N	N		Y	
Vitrification	Y	Y	Y	Y	Y			
Plasma treatment	Y	Y	Y	Y	Y	Y	Y	Y
Molten salt oxidation	Y	Y	Y	N	Y		Y	

2. Plasma torch connection diagram and design

The power supply connection for each plasma torch operation mode is as follows. In the non-transfer operation, high voltage electricity flows from the electrode between E1 and E2 and ignites (SW1: Closed, SW2: Open). Plasma formed after SW1 and SW2 are subjected to E1-E2 and E1-E3. As SW1 is finally opened and SW2 is closed by receiving energy, plasma is formed together with current distribution between E1-E3 and E1-E4.

In the mixed operation, currents are distributed between E1-E3, E1-E4, and E1-N after the formation of non-transferable plasma, and finally, the mixed plasma discharge is performed through arc transition between E1-E4 and E1-N by IGBT.

The transfer type operation is a transfer type plasma discharge by conducting all current of E1-E4 to E1-N by the IGBT after the mixed type discharge.

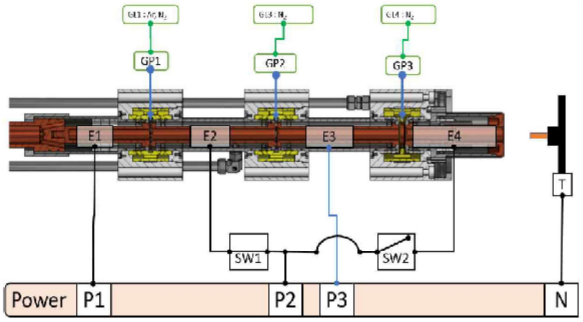

Fig. 1. Plasma torch and power supply connection diagram

3. Results of plasma torch and power supply improvement

The multi-electrode plasma torch distributes current to each electrode and adds a gap, thereby increasing the electrode life by using a high voltage and a low amount of current compared to output power.
However, due to the complex torch structure, maintenance convenience is low, and there are many electrodes and gas injection ports, so there are many operating variables for forming plasma arcs, and thus operability is very low.

In addition, it was confirmed that long-term continuous operation was difficult for damage caused by high-temperature oxidation of the torch nozzle carbon cover.

It is expected that the improved torch simplifies the internal structure, so that it is easy to control the arc inside the electrode, and the facility failure rate caused by abnormal arc generation would be very low. In addition, when maintaining plasma torches, existing torches are completely decomposed. Maintenance is possible, but the improved torch is very efficient in terms of convenience of maintenance as it can replace interior parts by removing only the front electrodes. By reducing the number of torch electrodes and improving the operation mode, the arc is transferred to the cathode (floor electrode, molten metal) outside the plasma torch, so that not only plasma arc heat but also Joule's heat can be utilized to have high thermal efficiency. The plasma

front electrode was used only for initial ignition to improve torch life.

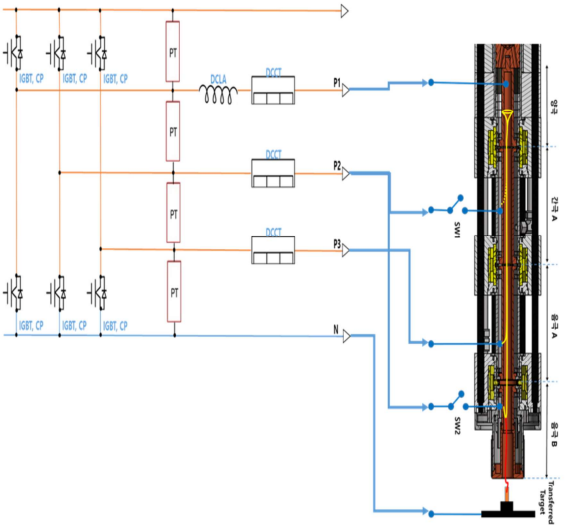

Fig. 2. (before) Power supply connection diagram

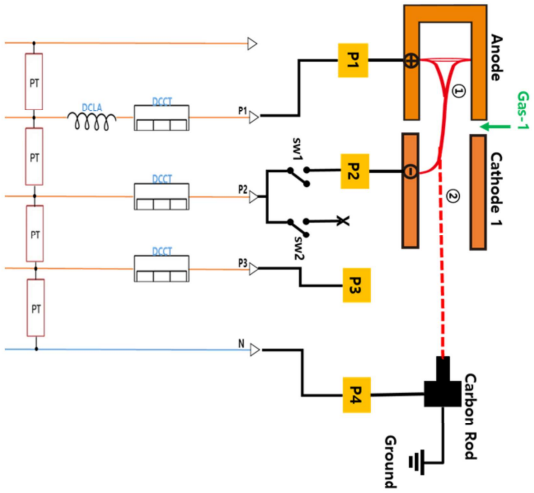

Fig. 3. (after) Power supply connection diagram

4. Future plans

Radioactive waste generated by operating and dismantling nuclear power plants by demonstrating facility operation stability through long-term continuous operation using improved torches, verifying process data by waste, and optimizing operating variables. It will be used for processing, and efforts will be made to strengthen technology competitiveness for overseas exports.

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)