Development of an Incinerator System for Processing Chemical Cleaning Waste of Nuclear Steam Generator

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1. Introduction

In this paper, we designed an electrical incinerator system for processing chemical cleaning waste of nuclear steam generator. The incinerator system is composed of an electrical incinerator, an oxidation reactor, two catalyst reactors, a condensed water reactor and a filter. The electrical incinerator is designed to have separate two electrically heated chambers to increase heat transfer area. The oxidation reactor use natural gas to heat up and decompose remaining toxic gas. The catalyst reactor further neutralize hazardous vapor still remaining. Finally, purified condensed water and gas is accumulated in the condensed water reservoir. Gas is vented to atmosphere, and water is vented after filtering.

2. Incinerator System Design

2.1 System Design

The incinerator system is designed to process about 220 cubic meters of liquid EDTA waste. The liquid waste is concentrated by separate vacuum evaporator which is not described here. After concentration, initial volume of the waste decreases to about 17 cubic meters. 17 cubic meters of concentrated liquid waste should be processed within 90 days which is 2,160 hours. As the concentrated liquid waste contains a lot of EDTA, specific weight is 1.233. Therefore, 17 cubic meters of waste weigh about 21 tons. By simply dividing 21 tons by 2,160 hours, we get 0.0097 tons or 9.7kg per hour. Actually, we designed the incinerator system to supply 12.34kg of concentrated liquid waste to get 27 percent of allowances in processing capacity.

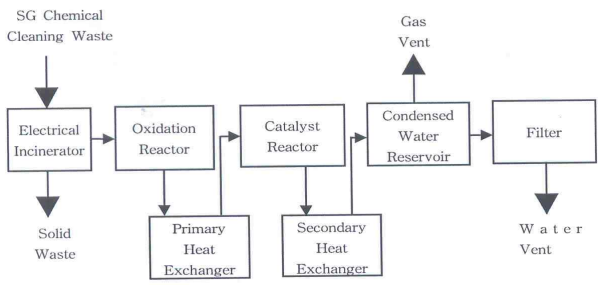

Fig.1 Block Diagram of the Incinerator System

2.2 Block Diagram 3-D Component Design

Figure 1 shows the simplified block diagram of the incinerator system. The concentrated waste of SG chemical cleaning waste is processed by the electrical incinerator. In the incinerator, the chemical cleaning waste which is liquid evaporates. Remaining solid waste should be removed periodically. We expect operators should evacuate solid waste twice a day. Evaporated gas from the electrical incinerator is processed again in the oxidation reactor. Oxidation reactor is designed to use gas as a fuel. Temperature at the oxidation reactor is designed to be 800 degrees centigrade. Remaining toxic gas after primary incineration is completely processed in this oxidation reactor. Other gases which could not be processed by the relatively high temperature of 800 degrees centigrade in the oxidation reactor are removed in the catalyst reactor at relatively lower temperature of 236 degrees centigrade. The primary heat exchanger is used to lower the temperature from 800 to 236 degrees centigrade. Secondary heat exchanger is used to lower further the temperature of 235 degrees centigrade at the exit of the catalyst reactor to ambient temperature of 20 degrees centigrade. All the processed gases and condensed water are accumulated in the condensed water reservoir. Water is discharged after filtering, and gases are released to the environment after real time check. Quality of water and gases are continuously monitored before release to protect environment.

2.3 Design of the Electrical Incinerator

Figure 2 shows 3-dimensional model of the electrical incinerator. The electrical incinerator is composed of the lower tray (1) and the upper head cap (2). The lower tray (1) moved up and down by the two ball screws (3) and the four guide bars (4). The two ball screws (3) are connected to a geared motor via bevel gear. By rotating geared motor, the movement of lower tray (1) is adjusted. Two circular baskets (5) in the lower tray are heated by electrical heater surrounding it. Three auxiliary heaters (6) located at the upper head cap (2) also supply heat. The leg (7) supports the upper head cap (2). The four guide bars (4) and the two ball screws (3) are all attached to the leg (7).

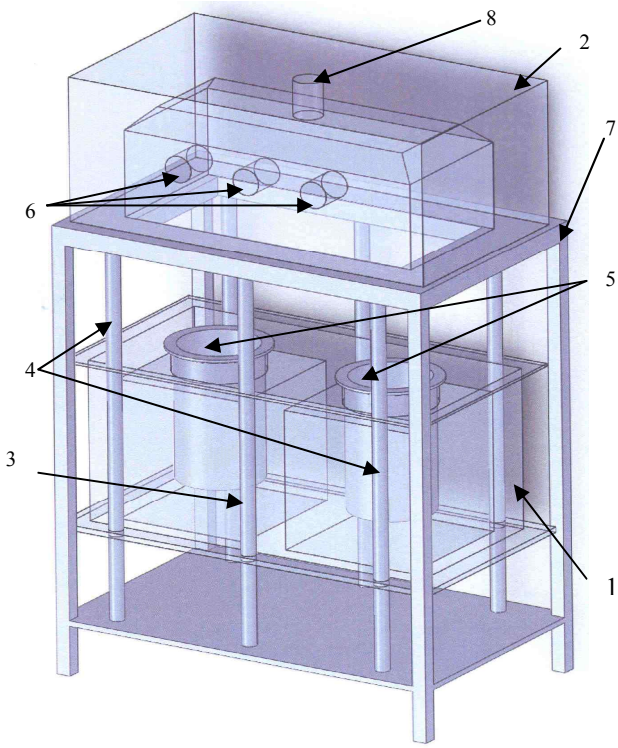

Fig.2 3-D Model of the Electrical Incinerator

By rotating the ball screw (3), the lower tray (1) moved upward or downward. When the lower tray (1) meets the upper head cap (2), the movement of the lower tray (1) stops. Liquid waste is transferred to the two circular baskets (5) via a feed pump. The amount of the liquid waste are measured automatically. Therefore autonomous charging is possible.

Silicon rubber is used to ensure air tightness between the lower tray (1) and the upper head cap (2). Air tightness is very important to prevent possible release of radio-nuclides to environment during incineration. However, it is not easy to maintain air tightness because the electrical incinerator is very hot. Therefore, we designed to maintain negative pressure in the inside of the electrical incinerator.

The three auxiliary heaters (6) are designed to be easily removed for repair. By adding auxiliary heater, the processing capacity of the electrical reactor could be increased. All the gases and vapor leave through the vent hole (8) on top of the upper head cap (2).

2.4 Three Dimensional Model of the Incinerator System

Figure 3 shows three dimensional model of the incinerator system. The incinerator system is installed in a container of 2,000mm width x 5,000mm length for easier transportation. The electrical incinerator (9) is located at the leftmost area for easier access by an operator. The primary heat exchanger (10) and the oxidation reactor (11) are located beside the electrical reactor. The catalyst reactor (13) is located at the center of the container. The front face of the catalyst reactor is directing front for easier access for replacing catalyst. The secondary heat exchanger (12) is located behind the catalyst reactor.

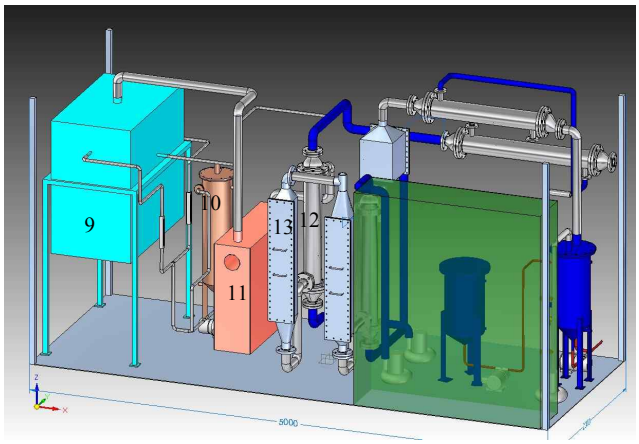

Fig.3 3-D Model of the Incinerator System

3. Conclusions

A design for developing an incinerator system for processing concentrated chemical cleaning liquid waste of 12.34kg per day is completed. Two processing stages by the electrical incinerator and the oxidation reactor are suggested.

The electrical incinerator composed the lower tray (1) and the upper head cap (2), with two circular baskets, is designed. The inside chamber of the electrical incinerator is designed to maintain negative pressure in the inside of the electrical incinerator to prevent release of radio-nuclides to environment.

Finally, the layout of the incinerator system is designed. The whole incinerator system is designed to be installed in a container of 2,000mm width x 5,000mm length for easier transportation.

REFERENCES

[1] Woo-tae Jeong et al, "Treatment of ASCA Chemical Cleaning and Waste Solution of Secondary Steam Generator in Kori Unit 4," KHNP internal report, December 2007.