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TECHNICAL FEASIBILITY STUDY ON VOLUMETRIC REDUCTION OF RADIOACTIVE WASTES USING PLASMA TECHNOLOGY

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ABSTRACT

The radioactive waste arising from nuclear reactors, hospitals, industry and research institutes are generated daily with a considerable amount. To final dispose of these radioactive waste safely and cost effectively, they must be transformed into physical and chemical compounds suitable for radionuclides immobilization with maximum volume and exhaust gaseous reduction. In this scope, among the promising technologies for the radioactive waste treatment, plasma technology allows reducing substantially the waste volume after exposing them to temperatures above 2,500ºC. In the planning and management of radioactive waste, the challenges related to plasma technology are presented as a motivation factor for the possible implantation of plasma reactors in nuclear plants and research centers aiming at improving the process of radioactive waste management.

1. INTRODUCTION

Regarding the benefits produced by the use of nuclear energy, there is an important question to be assessed. In the activities involving the application of nuclear techniques are generated wastes. These wastes are generated in practices that includes the use of radionuclides in industry, medicine and research [1]. These wastes when presents activity concentrations above the exemption limits of the National Nuclear Energy Commission (CNEN), published in the regulation CNEN–NN-8.01 "Gerência de Rejeitos Radioativos de Baixo e Médio Níveis de Radiação", are denominated radioactive wastes [2]. These radioactive wastes must be treated and conditioned following specific procedures and regulations to ensure the protection of human health and environmental, even in the present and in the future [3]. Radioactive Waste Management Department (GRR) of the Nuclear and Energy Research Institute (IPEN) is one of the institutes of the CNEN that is answerable for receiving, processing and store the radioactive waste generated at research centers and others non-nuclear installations around the country. The radioactive wastes receipted and stored at IPEN are classified as class 0, 1 and 2, according to CNEN–NN-8.1 [2].

Almost 80% of these radioactive waste consists of compactable waste (laboratory, safety and hygienic materials, such as gloves, special clothing, glassware, tapes, plastic tubes and others). Considering this fact, it is necessary to develop new methodologies to treat these radioactive waste in order to obtain some volume reduction. In this scope, among the promising technologies for the treatment of radioactive waste is the plasma technology generated by torches of thermal plasmas. This technology substantially reduces the volume of the radioactive wastes after exposing them to temperatures that can reach above 1,800°C in the process region and temperatures above 2,500°C in the plasma regions (plasma jet and arc).

This processing condition has the property of decomposing the volatiles materials contained in the processed wastes into simpler molecules reducing emissions, and transforming the inorganic fraction of the residue into a glassy matrix with reduced rates of leaching obtained by the addition of fluxes (sand, glass). The limiting factor in the development of plasma technologies for the treatment of radioactive waste is the high degree of production of volatile radionuclides [4].

In this aspect, the work aims to investigate, in a systematic way, the feasibility of the use of plasma technology to treat radioactive waste, from the technical, operational and environmental points of view. The proposal consists in presenting the concept of applicability of plasma technology to decision makers in the development of strategies and policies for the management of radioactive wastes, considering your volume optimization for storage.

The main objective of this research is the study of a project to enable the volume reduction of radioactive waste using plasma technology. The important point in the development of this project is the partnership between the IPEN and the Laboratory of Plasmas and Processes (LPP) of the Technological Institute of Aeronautics (ITA). The IPEN research group will contribute with the supply of simulated radioactive waste samples, which will be fed into the plasma system for the tests for a study of the volume reduction. The LPP of the ITA will contribute with all infrastructure and expertise in terms of the plasma reactor.

2. PLASMA TECHNOLOGY

Plasma gasification is an alternative to conventional gasification processes. Plasma can be considered as a high-energy gas, which has a significant fraction of its particles in the ionized form. In this condition, the gas is a good conductor of electricity, making possible the stabilization of this condition by means of an electric discharge, as illustrated in Fig.1, which schematizes the two main electrode configurations used for the generation of thermal plasma in direct current.

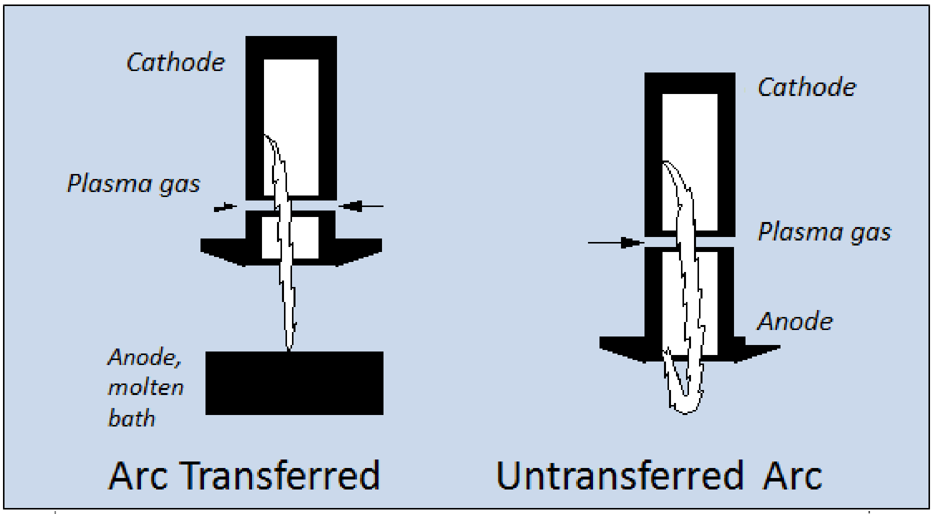

Figure 1: Two main configurations used for thermal plasma generation.

The plasma assisted reform process must take into account: the ability of plasma to conduct high power to the process; flexibility in choosing the type of material to be reformed; rapid response time; simple building materials; high conversion efficiencies; and, possibility to operate in a variety of selective configurations of chemical processes, including partial oxidation, steam reforming and pyrolysis (with minimal CO_2 and NO_x emissions). Plasma is the state of matter that has as its main characteristic the coexistence of electrically charged particles (electrons and ions) and also neutral (atoms and molecules) in fundamental or excited states, that in the case of the use of water vapor is summarized in H_2O, H_2, H, H^+, H^*, O_2, O, O^-, O^* and all other states highly unstable and reactive. These species react with the waste at temperatures above 1,500°C and produce gases of elemental compositions as well as molten residues that after cooling become glassy and non-leachable solids made up of a range of non-volatile chemical elements. In addition, the enthalpy of water plasma exceeds in many orders of magnitude that of other types of plasma formed by gases such as air, oxygen and nitrogen. The exception is the plasma of hydrogen that is considered as superior in enthalpy. However the cost of hydrogen is the main disadvantage forbidden the use of this type of plasma for industrial applications [5]. Consequently, water vapor plasma combined with different types of organic material provides many advantages for production of synthesis gas [2, 5]. Besides, to high enthalpy and the absence of nitrogen oxides, which are harmful to the environment, water plasma has advantages for the treatment of many components harmful to human health compared to other types of gases used in plasma production, even when compared to the use of the most abundant and least expensive medium that is air [4, 6, 7].

3. MATERIALS AND METHODS

The proposal of the project is the realization of a preliminary experiments at the plasma reactor (laboratory scale) of the LPP at ITA, using different types of plasma torch (transferred arc as well as no transferred arc) and different types of oxidizing agents (air, water steam). The main elements of the plasma experimental system are showed in Fig.2.

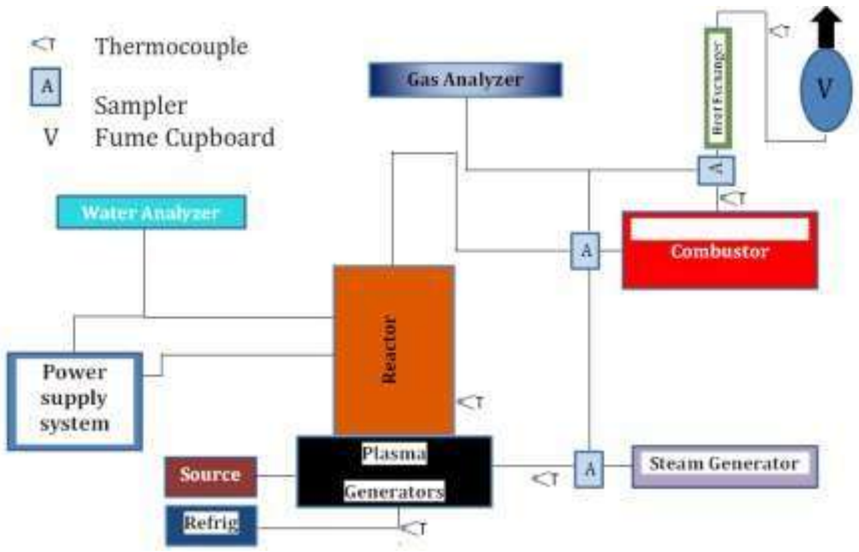

Figure 2: Experimental system for the evaluation of the radioactive waste gasification process.

The electrical and thermal characteristics of the auxiliary systems of the plasma reactor will be obtained using transducers and thermocouples. The composition of gases in the process will be analyzed using mass spectrometer and spectrophotometer. The data collection will be performed automatically by the use of data acquisition boards managed by the LabView software base.

4. CONCLUSIONS

It is important to mention that the application of the plasma technology in the nuclear area for radioactive waste treatment was not yet used in Brazil, with the aim of volume reduction. Nowadays the storage building for treated radioactive waste of IPEN, that has a total area of 425 m^2, is with his capacity compromised in 80%. For this scenario, it can be concluded that this project is very important to manage and reduce the volume of stored radioactive waste.

Tests will be carried out in order to identify the main limitations and advantages in the plasma gasification process compared to other technologies used. In these tests, volume reduction factor of radioactive waste in the vitrified solid (slag) and the gases emission in the exhaust line will be evaluated, considering the concentration of nonradioactive isotopes simulating the contamination of the wastes that are sent to IPEN.

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