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Arc Plasma Application for Solid Waste Processing

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Abstract : Hygiene and sanitary study of typical medical-biological waste made in Kazakhstan, Russia, Belarus and other countries show that their risk to the environment is much higher than that of most chemical wastes. For example, toxicity of solid waste (SW) containing cytotoxic drugs and antibiotics is comparable to toxicity of radioactive waste of high and medium level activity. This report presents the results of the thermodynamic analysis of thermal processing of SW and experiments at the developed plasma unit for SW processing. Thermodynamic calculations showed that the maximum yield of the synthesis gas at plasma gasification of SW in air and steam mediums is achieved at a temperature of 1600K. At the air plasma gasification of SW high-calorific synthesis gas with a concentration of 82.4% (CO – 31.7%, H2 – 50.7%) can be obtained, and at the steam plasma gasification – with a concentration of 94.5% (CO – 33.6%, H2 – 60.9%). Specific heat of combustion of the synthesis gas produced by air gasification amounts to 14267 kJ/kg, while by steam gasification - 19414 kJ/kg. At the optimal temperature (1600 K), the specific power consumption for air gasification of SW constitutes 1.92 kWh/kg, while for steam gasification - 2.44 kWh/kg. Experimental study was carried out in a plasma reactor. This is device of periodic action. The arc plasma torch of 70 kW electric power is used for SW processing. Consumption of SW was 30 kg/h. Flow of plasma-forming air was 12 kg/h. Under the influence of air plasma flame weight average temperature in the chamber reaches 1800 K. Gaseous products are taken out of the reactor into the flue gas cooling unit, and the condensed products accumulate in the slag formation zone. The cooled gaseous products enter the gas purification unit, after which via gas sampling system is supplied to the analyzer. Ventilation system provides a negative pressure in the reactor up to 10 mm of water column. Condensed products of SW processing are removed from the reactor after its stopping. By the results of experiments on SW plasma gasification the reactor operating conditions were determined, the exhaust gas analysis was performed and the residual carbon content in the slag was determined. Gas analysis showed the following composition of the gas at the exit of gas purification unit, (vol.%): CO – 26.5, H2 – 44.6, N2–28.9. The total concentration of the syngas was 71.1%, which agreed well with the thermodynamic calculations. The discrepancy between experiment and calculation by the yield of the target syngas did not exceed 16%. Specific power consumption for SW gasification in the plasma reactor according to the results of experiments amounted to 2.25 kWh/kg of working substance. No harmful impurities were found in both gas and condensed products of SW plasma gasification. Comparison of experimental results and calculations showed good agreement. Acknowledgement—This work was supported by Ministry of Education and Science of the Republic of Kazakhstan and Ministry of Education and Science of the Russian Federation (Agreement on grant No. 14.607.21.0118, project RFMEF160715X0118).

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