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MOBILE PLASMA UNIT FOR TOXIC WASTE DESTRUCTION

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Abstract. Mobile plasma unit for different types of toxic waste treatment was developed and constructed. Plasma unit is based on a of DC plasma torch. At present, the plasma unit is operational to the purpose of investigating technologies for different kinds of toxic waste processing.

Toxic waste is a serious problem for many countries all over the world. One of the solutions of this problem is plasma technology. In many cases transport of waste is too dangerous process. That's why it is very useful to process them at places of storage. Mobile plasma unit is the most interesting variant (Mosse et al. 2007, Zhdanok and Mosse 2008).

Mobile plasma unit for different types of toxic waste treatment was developed and constructed. Some foreign similar units are currently in use. Nevertheless, proposed technical decision supposes its modular build as in completely technological scheme as in separate elements. It allows to combine different technological scheme on one fundamental base (20 feet shipping container) for treatment a great number of types of organic and non-organic waste, including halogen organic waste, withdrawals pesticides, PCB and other toxic substances.

The main advantages of this unit are its mobility, simplicity and safety in installation and operation, possibility of waste treatment direct in junkyard. Proposed plasma unit is optimal in productivity and dimension. It is very important factor for mobile unit.

Engineering documentation of plasma unit was developed. Details and components were produced. Installation work was done. Plasma unit was tested with model mixtures of toxic waste and manufactured sewage water processing (Mosse et al. 2009).

The basis for engineering documentation design was requirements listed below:

Plasma flow mass average temperature – 3500-5000 ºC;

Temperature in combustion (pyrolysis) zone – 1200-1800 ºC (depending on waste composition);

Pyrolysis products residence time in reaction zone – more than 2 seconds, waste processing degree – 99.98 %.

The unit consists of DC plasma torch, counterflow plasma chemical reactor, plasma torch power supply system, gas and water supply systems, exhaust gases purification system, technological process control system (control panel, gas flow controllers, water flow controllers, pressure sensors, temperature sensors, high-current drives and so on). Plasma unit technological scheme is shown in the Fig. 1.

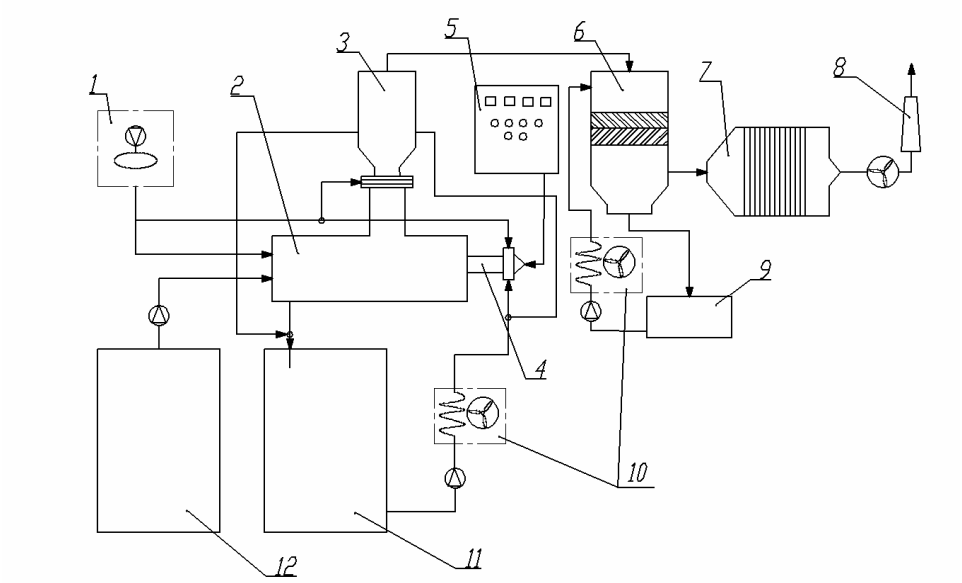

Figure 1: Technological scheme of plasma unit for toxic waste destruction: 1 – air compressor, 2 – plasma reactor, 3 – burning camber, 4 – plasma torch, 5 – power supply system, 6 – centrifugal bubble apparatus (scrubber), 7 - ion-exchange filter, 8 – smoke-stack, 9 – tank with scrubber water, 10 – radiator, 11 – water supply system, 12 – tank with waste.

Plasma unit contains special equipment to control all technological parameters such as plasma torch power, plasma forming gas consumption, waste consumption, quenching air consumption and others. Air pressure for plasma unit fictionalization is realized by autonomous air compressor with fine filter and air-preparation unit. If it is necessary, additional air can be added from air blower. To smooth air pressure pulsations receiver is used. Special slide damper controls exhaustion made by smoke exhauster. Waste materials are loaded and dispersed by pneumatic injector. Afterburning and cooling of exhaust gases is in the three section quenching module by addition air supplying. temperature in gas purification system is 150 – 520 ºC.

Gas purification is realized by combined method with two apparatus combination (centrifugal bubble apparatus (scrubber) and ion-exchange filter). Exhaust gas analyses is realized by gas analyzer “Ecspert Universal”.

Portability of the unit (reactor, gas purification module, supply modules and control system are placed in shipping container) provides ease in transport, minimize installation work. It also allows correcting technological parameters of the unit to adapt it to any special conditions (waste composition and consumption, or to work with enterprise system).

Figure 2: Power supply system and air compressor.

Plasma unit was tested with processing of model mixtures of toxic waste and manufactured sewage water from epoxide resin production “Kolteks-specreagenty Ltd”. Mixture of diesel oil and water at ratio 3:2 and mixture of isopropyl alcohol and water at ratio 1:1 were used as model of conversion waste.

Figure 3: Counterflow plasma reactor with plasma torch PDS-3/50.

Chemical composition and thermophysical properties of treated waste are shown below. Sewage water density is 1.1-1.2 g/sm^3. It contains following admixtures: toluene – 2 000 mg/l; epichlorhydrin – 400 mg/l; sodium chloride – 15 000 mg/l; tarry matters – 700 mg/l; suspended matters – 250 000 mg/l.

Plasma unit operating parameters are shown below:

Electric arc current in plasma torch – 110-210 A;

Voltage – 200-320 V;

Plasma forming gas (air) consumption – 15-18 m^3/h;

Cooling water in plasma torch and reactor consumption – 715 g/s;

Productivity (waste processing) – 8.0-50.0 kg/h (depending on waste composition);

Quenching gas (air) consumption – 100 m^3/h;

Off gas temperature at the inlet of scrubber – 120-500 ºC (depending on waste composition);

Exhaust gas velocity – 14.7 m/s;

consumption – 1 265 m^3/h.

Design parameters of plasma unit are following:

Electric power is 45-65 kW;

Heat power transferred to plasma flow is 35-40 kW;

Plasma flow temperature is 4 300-5 000 ºC.

Analysis of exhaust gas composition is shown below:

1. When mixture of diesel oil and water is processed exhaust gas contains 200-2 140 mg/m^3 CO, 130-145 mg/m^3 NO_x, 240-280 mg/m^3 SO_2, up to 54 mg/m^3 H_2S, up to 284 mg/m^3 CH.

2. When manufactured sewage water is processed exhaust gas contains 300-390 mg/m^3 NO_x, 160-220 mg/m^3 SO_2, 45-160 mg/m^3 H_2S, 12-14 mg/m^3 CH and doesn't contain CO.

3. When mixture of isopropyl alcohol and water is processed exhaust gas contains 730-1 500 mg/m^3 CO, 190-360 mg/m^3 NO_x, 3.0 mg/m^3 H_2S, up to 10-16 mg/m^3 CH and doesn't contain SO_2.

When we processed some variants of model waste there were a lot of CO. It means that underburning of organic part of waste takes place. To solve the problem we have to use more additional air. When we processed manufactured sewage water there is no any problem with exhaust gas. Nevertheless, in condensed phase there is a lot of salt especially on reactor inside surface. X-ray phase analysis of the salt composition shows that the material consists only of NaCl.

In present, the plasma unit is in operation to investigate technologies for different kind of toxic waste processing.

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