DEVELOPMENT OF ECOLOGICALLY FRIENDLY TECHNOLOGY FOR GASIFICATION OF MUNICIPAL SOLID WASTES

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Abstract: Ukraine as well as other countries all over the world has a problem of municipal solid waste utilization. One of the most popular technologies is combustion of MSW. However, MSW combustion cannot provide permissible level of harmful matters emission without very difficult and expensive gas cleaning systems. Especially it applies to polychlorinated dibenzo-(p)-dioxins and furans – global superecotoxicants, which have strong mutagenic, immunosuppressive, carcinogenic, teratogenic, and embryotoxic activity. Dioxins are always generated with presence of oxygen, chlorine, and organic compounds at high temperature (above 300°C). In the waste chlorine is mainly present in such compounds as kitchen salt and polyvinyl chloride. Existing technologies of MSW combustion do not decrease dioxin emissions with 100% effectiveness. The most powerful method of dioxin formation suppression is based on deactivating potential of its formation precursors, such as: chlorine, oxygen, and catalysts. One of possible technological approaches is gasification of chlorine-containing fuels or wastes: absence of oxygen effectively blocks dioxin formation routes. Product gas cleaning from ashes and halogens eliminates dioxin reformation after combustion. In the Institute of Technical Thermophysics the experimental fluidized bed installation for chlorine containing waste gasification is under development.

Keywords: gasification, MSW, gasifier, producer gas, dioxins

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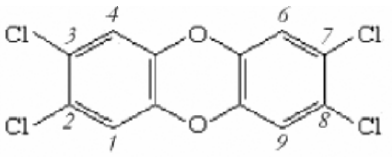
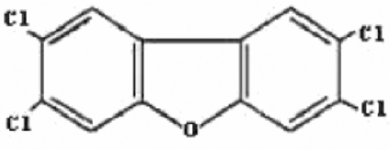
1. Dioxins and furans

Dioxins – global superecotoxicants, which have strong mutagenic, immunosuppressive, carcinogenic, teratogenic, and embryotoxic activity.

- They are crystal substances with high melting temperature (200–400°C).
- They are easily solved in organic solvents, fats, not in distilled water.
- They have strong adhesion properties.
- The period of degradation in soil is 10–20 years, in water up to two years.
- They have high thermal resistance. Thermal degradation under temperature less than 1,250°C is reversible.



Dioxin
2,3,7,8 tetrachloro dibenzo - p- dioxin



Furan
2,3,7,8 tetrachloro dibenzo - p- furan

The causes of decreasing of dioxins and furans emission by gasification process:

In case of combustion dioxins are always generated with presence of oxygen, chlorine, and organic compounds at high temperature (above 300°C).

Decon reaction is one of the main stages in the process of dioxins generation:

$$2HCl+1/2O_2 \Leftrightarrow Cl_2 + H_2O$$

Reaction goes with presence of Cu, Pb, Sn catalysts, and Cl_2 formation.

$$Cl_2+O_2+C_xH_y + \text{time and } 250–350°C = \text{DIOXINS/FURANS}$$

The main idea of dioxin formation suppression is based on deactivating potential of its formation precursors, such as: Cl_2, O_2, or catalysts.

Gasification of chlorine-containing fuels or wastes in reduction atmosphere leads to forming HCl. Product gas cleaning from ashes and HCl eliminates dioxin reformation after combustion.

2. Gasification unit with two fluid bed reactors

The basic idea of the gasifier concept is to divide the fluidized bed into two zones: a gasification zone and a combustion zone. Between these two zones

a circulation loop of bed material is created but the gases should remain separated. The circulating bed material acts as heat carrier from the combustion to the gasification zone. The principle is shown graphically in Figure 1.

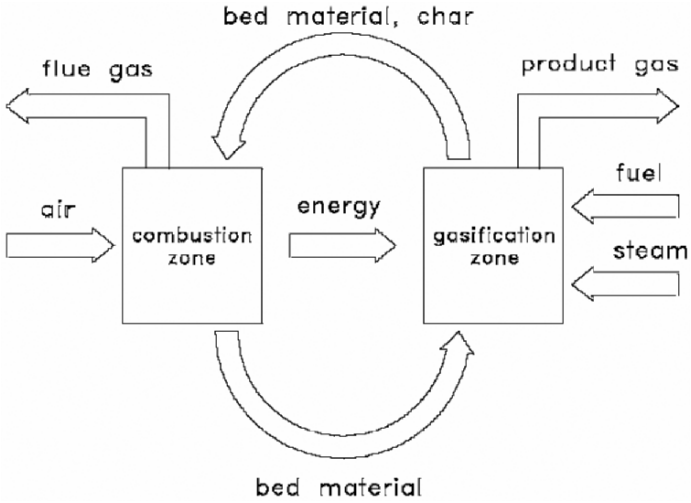


Figure 1. The principle of the gasifier concept

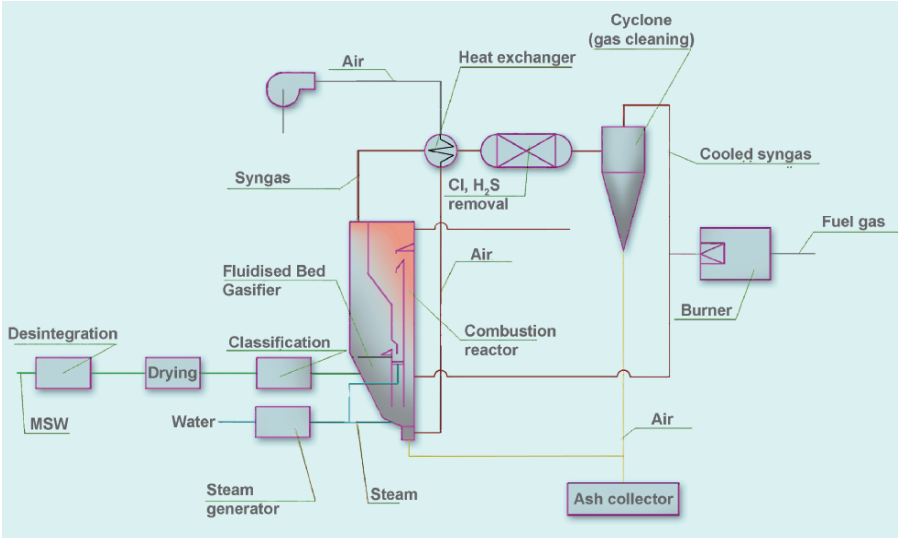


Figure 2. General flowchart of two fluid bed gasification unit

3. General description of the unit

Municipal solid wastes (MSW) gasification unit which is under development in the project consists of two fluid bed reactors (Figure 2). The first reactor is a gasifier, the second reactor is a combustion chamber for charcoal. To obtain producer gas of middle calorific value water steam is applied as a blowing. Fluid bed is organized by supplying water steam to gasifier (inert material is sand) and air to combustion chamber. The installation is equipped with all necessary devices to measure rate, temperature, and pressure.

4. Features of the experimental unit

Heat capacity	50 kW	
Gasifier chamber:		
height	1,500 mm	
diameter	300 mm	
Combustion chamber:		
height	3,800 mm	
diameter	70 mm	
Work temperature:		
камера газификации	800°C	
камера сжигания	900°C	
Bed material	Silica sand	
Bed weight	20 kg	
Mean diameter of bed solid particles	0.3–0.7 mm	
Fuel	biomass, model fuel, separated MSW	
Fuel input	19 kg/h	
Air input in combustion chamber	35 m^3/h	
Steam input in gasification chamber	12 kg/h	
Expected product gas composition:	Dry	Wet
H_2	37.7%	25.7%
CO	29.1%	19.8%
CO_2	25.3%	17.2%
CH_4	6.9%	4.7%
Cl	1%	0.8%
H_2O		31.8%

5. Information about project

Authors: Institute of Engineering Thermophysics, SEC “Biomass”.
Patent: under preparation.
Present status: detail design is developed.
Support of Science and Technology Centre in Ukraine (Project Agreement N 3036, $118,830).
October 2004–September 2006
Collaborators: Pacific Northwest National Laboratory (USA); Biomass Technology Group BV (The Netherlands).
Field of application: utilization of MSW in urban and rural areas.
Further steps: manufacture of production prototype; scaling-up.