

## Mobile Thermocatalytic Waste Processing Complex

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The design and functionality of basic units of a mobile waste processing complex is described. Experimental data on the catalytic purification of gases are presented. It is determined that concentrations of toxic compounds in waste incineration flue gas of a mobile waste processing complex are much smaller than the values allowed by regulations for emissions.

### 1. Introduction

The world practice of elimination of municipal waste and industrial combustible waste in the most industrialized countries, Germany, United States, Austria, France, Sweden, Italy, and others, showed that the most acceptable methods of processing are thermal methods. Among them, thermocatalytic methods are the most effective, versatile, and environmentally friendly.

Using modern thermocatalytic methods makes it possible to solve two socioeconomic problems: Disposal of existing and continuously incoming waste and prevention of their further accumulation through the application of environmentally friendly technologies for processing; Renewal of the material and energy resource base of processing industries by means of sorting of commercial waste for recycling, as well as through the use of waste heat of exhaust gas.

Mobile waste processing installations make it possible to eliminate the negative impact of the accumulation of solid industrial and consumer waste in the human environment on relatively small sites, while they may provide service for a number of wastes over a considerable territorial space without damaging the environment by accumulation of debris.

The Technology Scientific Production Firm under the auspices of the Northeast Center of the Academy of Sciences of Ukraine and the Southern Railway and a number of institutes, universities and enterprises designed, produced, and put into operation the MPK series of complex mobile waste processing facilities with a capacity from 50 to 400 kg/h and stationary plants with a capacity of up to 5 t/h.

The developed installations are based on the environmentally friendly technologies of incineration of domestic municipal solid waste and industrial waste, fully corresponding to the requirements of European standards and superior to them for some indicators. These processing systems commenced solving the problem of the negative impact of accumulation of municipal solid waste (MSW) in the human environment on relatively small sites. In the designs of plants, the world experience in dealing with solid waste has been taken into account, and environmentally safe disposal of solid waste is fully implemented.

In the systems integrated approach to waste management, combining the sorting of solid waste with extraction of recyclable material and the burning of residue, which provides the maximum environmental and economic efficiency, is implemented. The developments are protected by patents of Ukraine and the Russian Federation. In this paper, we consider the effectiveness of the treatment system of the mobile complex for thermocatalytic disposal of waste.

### 2. Basic part

Ltd. "Lotta" together with NTU "KPI" have developed an environmentally safe technology of burning household and industrial waste, fully compliant with European standards. Individual quality indicators of

flue gas cleaning exceed European one. Technology is implemented in portable industrial waste incinerators.

The unit is equipped with four gas cleaning stages. The first stage is a post-combustion chamber (in Figure 1 is not shown), which provides three-dimensional post-combustion of organic compounds at 700 – 1000 °C.

The second stage is the catalytic purification unit - 19, providing the catalytic decomposition of organometallic compounds to HCl, HF, H<sub>2</sub>SO<sub>4</sub>, polycyclic aromatic hydrocarbons to CO<sub>2</sub>, the oxidation of CO to CO<sub>2</sub> reduction of nitrogen oxides to elemental nitrogen and partial combustion of soot.

Catalytic purification unit is a parallelepiped which is filled by four parallel rows of ceramic carriers which made in the form of gas turbine blades and located at a certain angle.

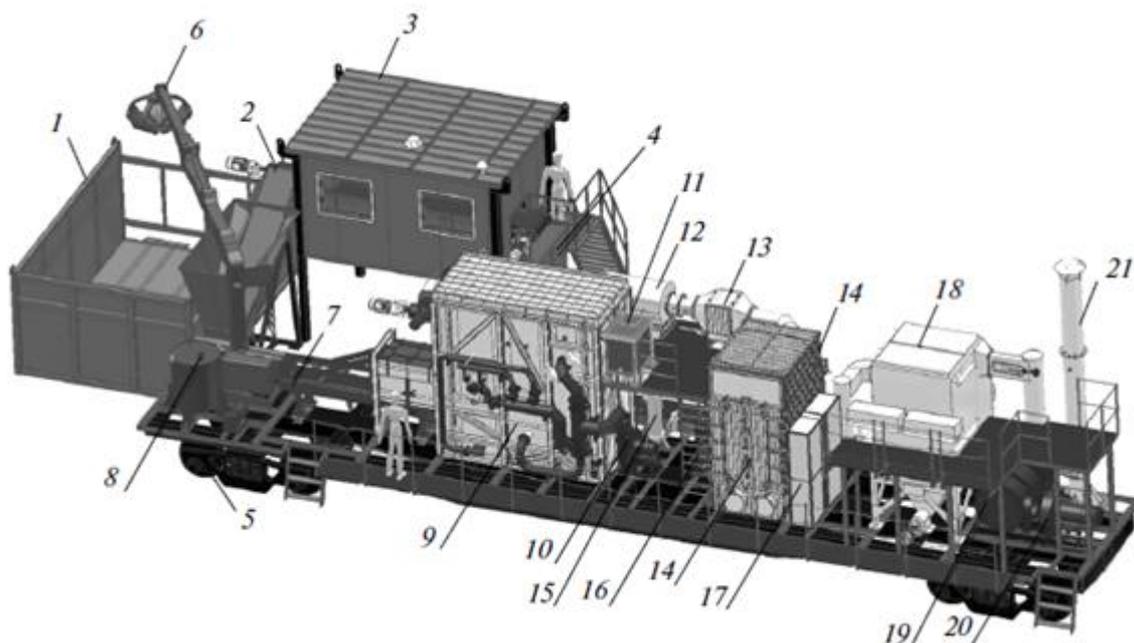


Figure 1. General drawing of a mobile waste processing complex. (1) Container for receiving MSW. (2) loading conveyor with hopper, (3) grading cabin, (4) unloading conveyor with hopper, (5) railway platform; (6) manipulator with oil-pumping station; (7) kiln feeder; (8) fuel tank with fuel supply system; (9) oven for thermocatalytic disposal of waste; (10) blower fan with air duct; (11) tank with system of supply of alkaline solution; (12) centrifugal vortex dust collector; (13) second-stage catalytic reactor, (14) second-stage fume cooler; (15) air drier; (16) compressor; (17) control box; (18) bag filter; (19) adsorption carbon fiber filter; (20) chimney

The third stage of the gases purification process provides adsorption products which formed during the conversion of harmful substances in gases - HCl, HF, H<sub>2</sub>SO<sub>4</sub> with an alkaline solution and the binding of toxic heavy metal oxides into harmless salt.

The final stage of treatment is the capturing process of dust, soot, products of acids neutralization, products of incomplete combustion of organic materials which takes place in bag filters.

Chromatogram of the chemical composition of organic substances which forms in secondary combustion chamber is shown in Figure 2. Figure 3 shows the composition of organic contaminants that have passed through the catalytic reactor and bag filters.

Analysis of the results which is shown in Figure 2 and 3 shows that after the post-combustion chamber concentration of organic substances varies from 150 to 750 mg/m<sup>3</sup>. It is also noted that compounds such as phenol, naphthalene, phenanthrene, anthracene, pyrene, chrysene, benzopyrene and perylene in the gases contained in an amount of 8-10 %, and the remaining 90 % were C<sub>20</sub>-C<sub>35</sub> hydrocarbons.

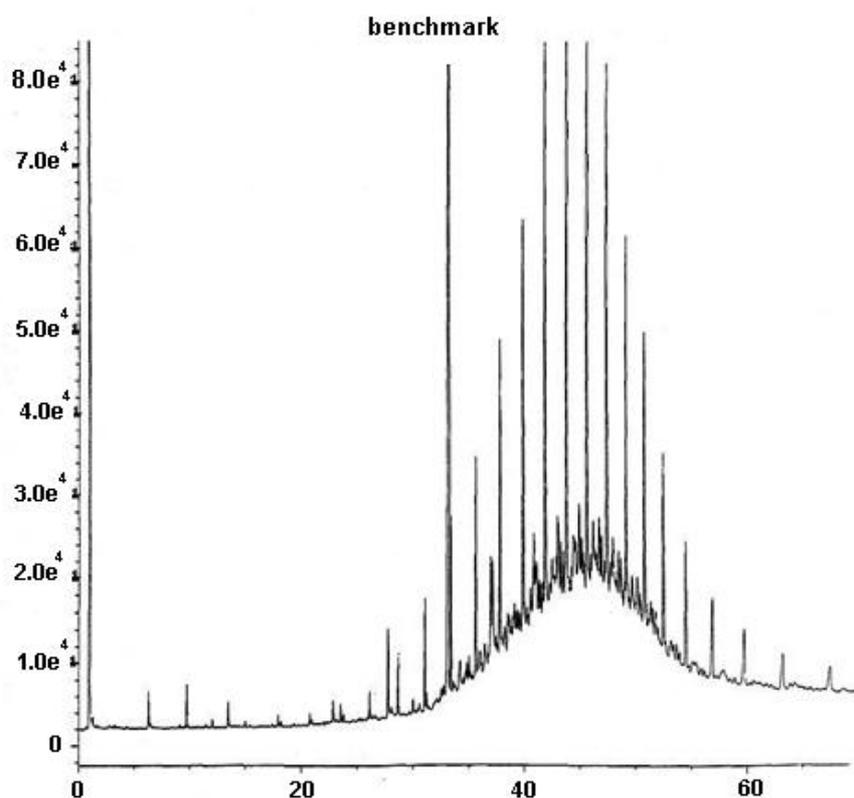


Figure 2. Chromatogram of the gas inlet of the catalytic converter

The data presented in the figures above also shows that on catalytic converter occurs neutralization of polycyclic aromatic hydrocarbons and  $C_{20}$ - $C_{35}$  hydrocarbons. The degree of purification of gases from harmful organic gas emissions is about 96 %. The residual total organic content after passing through a bag filter is defined as  $7.10 \text{ mg/m}^3$ . Benzopyrene content in the purification process has decreased from  $0.05 \text{ mg/m}^3$  to  $0.001 \text{ mg/m}^3$  and total concentration polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDF) is  $0.01 \text{ ng/m}^3$ .

The use of the catalytic purification block allows to reduce emissions to the environment of toxic substances by 11.944 t/y for  $C_3$ - $C_{20}$  hydrocarbons, 0.81 t/y for chlorinated hydrocarbons, 3.176 t/y for polyaromatic hydrocarbons. During the year the mobile incinerator prevents from entering the atmosphere about 188 t of toxic substances. Comparative data of the amount of substances emitted into the atmosphere before and after treatment are shown in Table 1.

The results of analyzes of halogenated substances determination in the mobile waste processing complex gas emissions are shown in Figure 4 and Figure 5. These data indicate that the concentrations of HCl and HF in the gas path after the main purification stages for several days vary little. Thus, concentration of HCl ranges from 20 to  $80 \text{ mg/m}^3$ , concentration of HF varies from 10 to  $50 \text{ mg/m}^3$ . It should be noted that at the outlet of the catalytic converter content of HCl and HF increased by 1.5-2 times. This is the result of the decomposition processes of organic halogenated compounds on the catalyst. However, after exposure to the gas flow of alkaline solution concentration of HCl and HF decreased sharply to  $0.01 \text{ mg/m}^3$ .

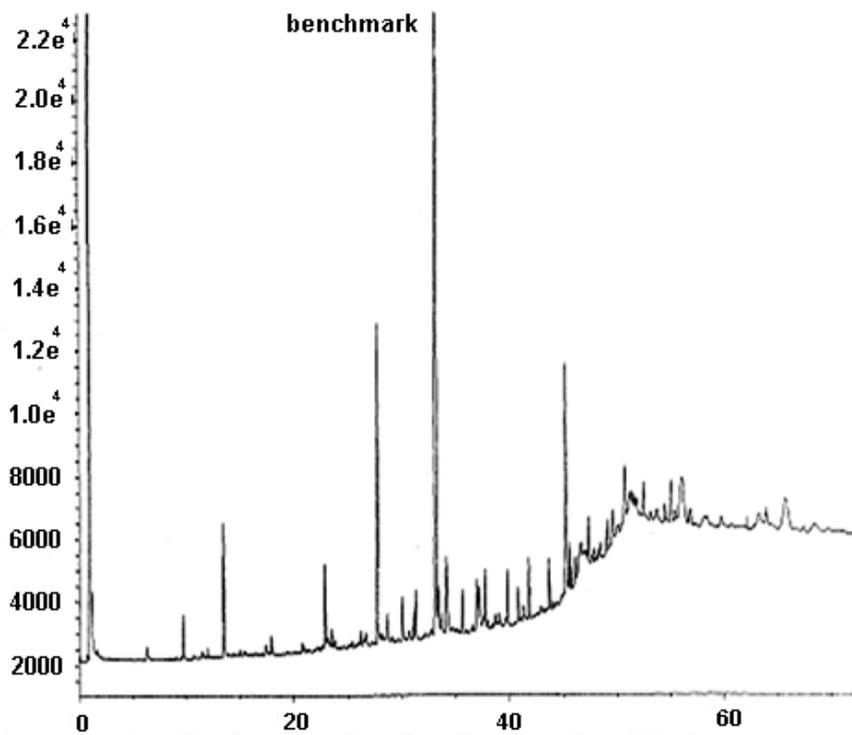


Figure 3. Chromatogram of the gas composition at the plant output

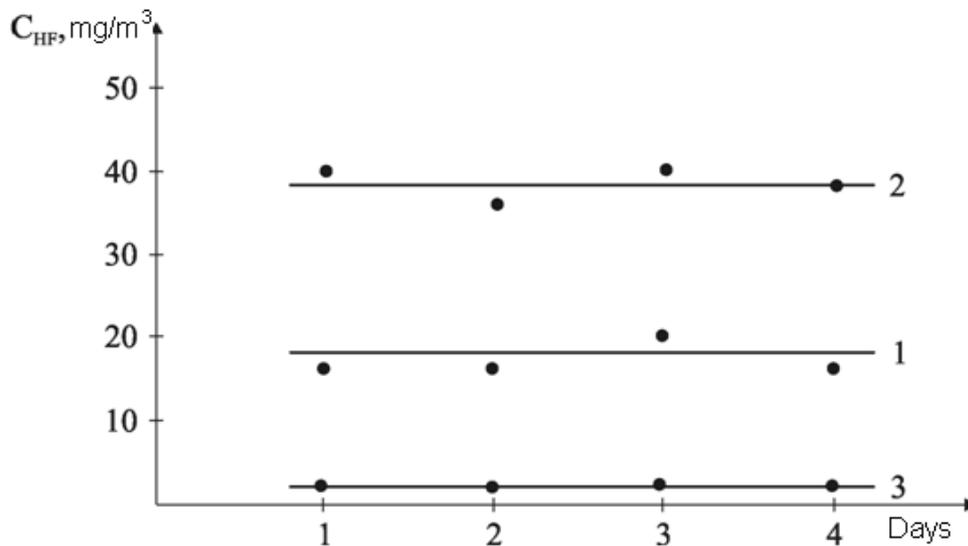


Figure 4. Change in concentration of HF in the gas path of the mobile waste processing complex: plots 1 and 2 - before and after the catalytic converter, respectively, 3 - after the bag filter

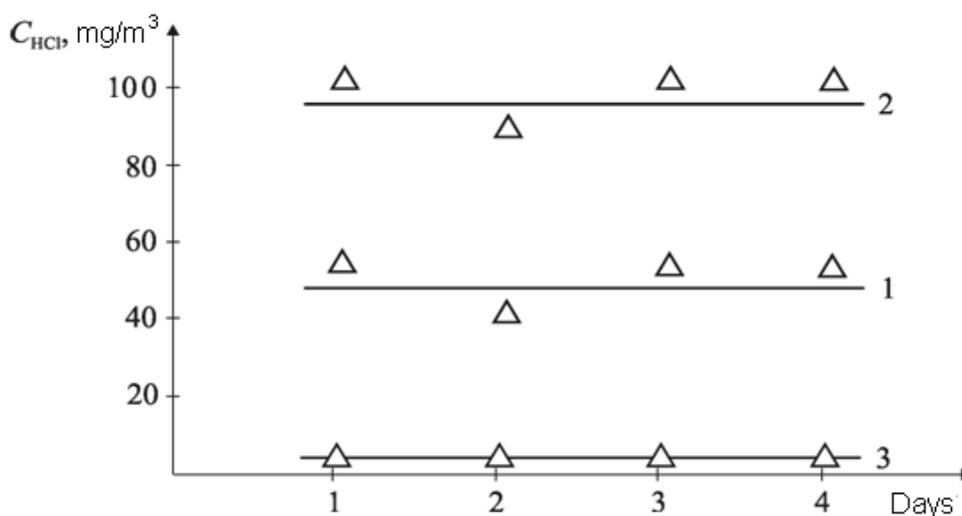


Figure 5. Change in concentration of HCl in the gas path of the mobile waste processing complex: plots 1 and 2 - before and after the catalytic converter, 3 - after the bag filter

Table 1: Emissions of toxic substances before and after treatment

Component	Emissions in kg per h		
	before treatment	after treatment	degree of purification
1. Nitrogen oxides	0.41	0.162	60.5
2. Carbon monoxide	15.2	1.54	99.0
3. Hydrogen chloride	0.216	0.012	95.0
4. Hydrogen fluoride	0.135	0.007	95.0
5. Polyaromatic hydrocarbons	0.402	0.005	98.5
6. Chlorinated hydrocarbons	0.101	0.0024	98.6
7. C <sub>3</sub> -C <sub>20</sub> hydrocarbons	1.514	0.021	98.6
8. Benzopyrene	0.135×10 <sup>-5</sup>	0.1×10 <sup>-9</sup>	99.92
9. Dioxins	0.081×10 <sup>-5</sup>	0.8×10 <sup>-9</sup>	99.9910
10. Furans	0.054×10 <sup>-5</sup>	0.5×10 <sup>-9</sup>	99.99
11. Dust	5.4	3×10 <sup>-4</sup>	99.9
12. Soot	1.0	0.09	91.0

During experimental studies it was found that nitric oxide reduces with organic matter and CO to nitrogen on the active surface of the catalyst, and their concentration decreases from 150 mg/m<sup>3</sup> to 70 mg/m<sup>3</sup>. Exothermic process of neutralization of harmful gases raises the gas flow temperature from 600 °C to 730-830 °C. This is accompanied with decrease of the dust particles content from 10 to 2 g/m<sup>3</sup>, which are soot, which delayed with bag filters. Design features of the catalytic converter unit enabled deposition of particles directly during catalytic process in a special receiver. The analysis of these particles showed that they consist of metal oxides.

### 3. Conclusions

The use of catalytic thermal technology in a mobile incinerator allows to reduce the content in the environment of toxic substances and to solve important environmental problem of carcinogens, dioxins and furans, which are the reasons of mutagenicity, cancer, etc.

The use of an incinerator allows more than in 10 times to reduce waste disposal to landfill and potentially eliminate it when solving the problem of disposing of the ash. Multi-stage flue gas cleaning system ensures the concentration of harmful substances in the surface layer not more than 12 % of the maximum allowable according to the standards of Ukraine and CIS countries.

Secondary energy resources are generated during incineration of solid waste and used in the technological process which significantly reduces the need for external fuel. The main part of secondary energy used to produce thermal energy which can be sold to consumers outside the enterprise.

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