Educational laboratorial facility for researching the technology of plasma gasification of production and consumption wastes including medical wastes

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Abstract. The article deals with the problems of waste management methods, which do not cope with the task of ecological utilization of solid waste. Based on the analysis of literature data, the following is presented: the morphological composition of solid waste, the block diagram of a laboratory waste gasification plant. And also a set of equipment characteristics for the modernization of a laboratory installation of plasma gasification.

The usual scheme for handling solid domestic waste for Russia is the collection of solid household waste without separation and burial (> 90%) leading to land degradation (employing over 50 thousand hectares of those present).

That allows increasing the migration in the siege space (the amount of solid waste exceeds the capacity of natural ecosystems). Burning was quite able to cope with the mission. But due to increased incomes and their variety, the disposal of old methods inevitably carries a serious threat to the environment.

In (Table 1), comparison of the methods of thermal destruction of solid waste.

Table 1. Comparison of methods of thermal destruction

\begin{tabular}{|c|c|c|c|}
\hline
 & Plazma gazification & Usual gazification & Burning \\
\hline
Destruction & 99 \% & 90 \% & 70\% \\
\hline
Temperature & \geq 1200^\circ C & \leq 1200^\circ C & \leq 1000^\circ C \\
\hline
The presence of resins and furans at the outlet & No & Yes & A lot \\
\hline
Ash & 1\% & 10\% & 30\%, toxic \\
\hline
Type of waste & any & Besides of individual inorganic materials & Besides of individual inorganic materials \\
\hline
\end{tabular}
| Sorting                  | Not required | required | required |
|-------------------------|--------------|----------|----------|
| Emissions of flue gases | low          | average  | high     |

Plasma gasification has limitations:
1) Power consumption.  
Because there are many costly and energy-consuming steps in the purification of exhaust gases, in addition to supplying plasmatrons, in order to comply with environmental standards.
2) In most cases, accurate calculation of plaschemical reactions in the reactor is not possible. Because SDW has a different morphological composition and a high temperature in the reactor, which makes it difficult to control the reactions to the reactor and simulate the ongoing reactions.
Therefore, we consider (in Table 2) the elemental morphological composition of various fractions of solid domestic waste, including medical ones.

Table 2. The content of individual elements in the composition of solid waste

| Component | Element content, % | Specific heat of combustion (lowest), MJ / kg |
|-----------|--------------------|----------------------------------------------|
|           | C  | H  | O  | N  | S  |                          |
| Textile   | 56,1 | 6,8 | 32,2 | 4,8 | 0,1 | 22,6                      |
| Wood      | 51  | 6,1 | 42,6 | 0,2 | 0,1 | 20,4                      |
| Paper     | 46,2 | 6,2 | 47,1 | 0,3 | 0,23 | 16,9                     |
| Leather   | 77,9 | 6,0 | 15,1 | 0,3 | 0,7  | 31,2                     |
| Rubber    | 77,9 | 6,0 | 15,1 | 0,3 | 0,7  | 31,2                     |
| Plastic   | 67,7 | 9,3 | 21,5 | 1,1 | 0,4  | 30,3                     |
| On average, for all waste materials | 50,5 | 6  | 31  | 2,5 | 0,2  | 20,2                     |

On Fig. 1 the block diagram of a laboratory installation of plasma gasification is presented.

![Figure 1. Block diagram of a laboratory waste gasification plant](image-url)
Modernization of the laboratory installation (Figure 1) is due to a change in the working gas in the gasifier chamber. Air is replaced by a more active oxidant (oxygen) or a gas mixture (oxygen with steam). A mixture of oxygen with water vapor is used because hydroxyl radicals (OH •) are formed (which is the strongest known oxidant). In the gasifier, the mixture decomposes to form hydroxyl radicals. The lifetime of the hydroxyl radical in the biological medium is approximately 10-9 sec, and the diffusion radius 10^-8 m. The main types of damage to biomolecules by hydroxyl radicals are: the detachment of the hydrogen atom (rupture any CH bond).

In chemistry, the main source of hydroxyl radical formation is the Fenton reaction (1) and the Haber-Weiss reaction (2) [1, 2].

\[ \text{Fe}^{2+} + \text{H}_2\text{O}_2 \rightarrow \text{OH}^- + \text{OH}^+ + \text{Fe}^{3+} \]  
\[ \text{O}_2^- + \text{H}_2\text{O}_2 \rightarrow \text{OH}^- + \text{OH}^+ + \text{O}_2 \]  

And instead of thermal drying, we use thermochemical ozonization.

Ozonization is used to reduce the organic mass of solid waste. For example, as a result of the oxidation of oil products by ozone in water, 48 elements of 51 organics are removed (mainly alkanes, olefins, esters, ethers, etc.) [3,4,5,6,7,8].

Ozone is toxic and decomposes at high temperatures instantaneously, which excludes the possibility of getting into the atmosphere. For example, the ozone half-life in air (Table 3) depends mainly on the air temperature.

Table 3. Ozone half-life in air

| Air temperature, C | -50 | -35 | -25 | 20  | 120 | 250 |
|-------------------|-----|-----|-----|-----|-----|-----|
| Half life         | 3 months | 18 days | 8 days | 3 days | 1.5 hours | 1.5 seconds |
Figure 2. Diagram of a laboratory installation of plasma gasification of medical waste of classes A, B, and B.

Upgrade the chamber of the gasifier by adding a layer of carbonized graphite. Since the temperature in the chamber, when the working gas changes, reaches up to 3500 °C.

Upgrade the drying chamber with an ozonator built in, with a range of characteristics (Table 4).

| Table 4. Range of technical characteristics of the ozonizer |
|-------------------------------------------------------------|
| **Ozone productivity, g / h** | 20 - 100 |
| **Fan capacity, m³ / h** | 360 - 750 |
| **Supply voltage** | 220 В |
| **Power, W** | 250 – 1040 |
| **Price, rubles** | 39 000 – 92 000 |

**Conclusions.**

Lack of plasma gasification, energy consumption, can be solved by selecting the working gas in the gasifier and reducing the mass of solid waste at the preparation / drying stage. This was revealed during the literary review of the chemical component of processes in the gasifier and in the stages of plasma gasification. The main difficulties in studying the chemical component of the processes - the lack of reliable data on the mechanism of the chemical process, the parameters of its individual stages and kinetic transport coefficients, etc. Ozonization was chosen as the preparation of solid waste (the stage of grinding, drying, etc.). Ozone destruction of various materials is a new direction and only developing, there are studies and installations for the destruction of tires for example. But because of the uncertain composition of solid waste, ozone depletion requires research. Since ozone is toxic and explosive with certain components, which requires experiments and the development of technology / mode of ozonation of solid waste. And also when analyzing the chemical component of the processes in the gasifier, a decision was taken to select and study the working gas in the gasifier. As there are foreign studies of increasing the efficiency of processes in the gasifier due to changes in the working gas (a mixture of oxygen and water vapor). A study will be made of the change in efficiency from changes in the composition of the working gas and the development of a technology / operating mode of the gasifier with various gas mixtures. The development of a model for the installation of a laboratory for the study of thermochemical destruction of production and consumption wastes, including medical ones. The choice of the design of the ozonizer is made and the range of required characteristics is determined.

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