

# Energy-Technological Complex, Functioning On the Basis Of Waste Processing Technologies

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**Abstract.** In article mobile autonomous power complexes on utilization of liquid and solid organic waste by method of hydrothermal destruction and household waste by a pyrolysis method are described. The creation of these complexes is directed to elimination of city dumps and storages of garbage. As a part of complexes there are steam microturbines with power from 5 to 250 kW for own needs of installations in electric and thermal energy. The consortium of domestic manufacturing enterprises and research institutes works on creation of complexes. Project management is performed by LLC NPP «Donskiye tekhnologii».

## 1. Introduction

Analysis of current trends in the development of the waste processing industry shows that new technological solutions are needed in the field of waste processing. The volume of municipal waste is increasing, and the territorial possibilities for burial are decreasing. Current trends in the development of the waste recycling industry show that new technological solutions are needed in this area. One of the possible solutions is the development and design of a waste recycling complex that has mobility, autonomy, and high efficiency.

## 2. The scientific importance of waste utilization with a brief review of literature

The general scientific and technical state of the waste processing industry is characterized by an insufficient level of technological equipment. A low percentage of solid municipal waste utilization is associated with inadequate infrastructure development. At present, there are 243 waste disposal facilities in Russia, 53 sorting complexes, about 40 incineration plants. The predominance of the disposal of solid municipal waste by disposal leads to a number of problems. According to the Ministry of Nature of the Russian Federation, the country (with a population of 146.5 million people) annually produces about 4.5 billion tons of industrial, communal and agricultural waste. While in the EU countries - 1.3 billion tons, with a population of 510.2 million people. The main principles of the EU's waste management policy are as follows: waste should be placed as close as possible to their



source; consistent implementation of the principle of producer responsibility for waste generated; use for processing of the best available technologies.

### 3. Methods of utilization of heat generated by the energy technology complex

Complex processing of solid communal waste provides small losses in production, its maximum ecological and economic feasibility. With the "sorting + burning" technology, the amount of slag is reduced to 15% of the original waste, and ash - up to 1%, and the slag can be involved in industrial processing. However, at the present time, there are no autonomous recycling complexes that not only do not need to be connected to an external network but are also able to give surplus heat and electricity to consumers.

### 4. Setting the task of waste treatment plants research

When choosing the basic concept of the scheme of operation of the experimental energy complex, two variants were considered:

- the traditional scheme of a steam-power cycle with a steam generator, the role of which is performed by a waste heat boiler operating on the outgoing gases of a pyrolysis unit;
- scheme with an ejector installation into which outgoing gases of the pyrolysis plant are fed and heated water under pressure (1.0-2.0 MPa). As a result, a vapor-gas mixture with a water vapor content of up to 40-50%. Removal from the condenser of non-condensable gases is carried out by means of a vacuum pump.

To ensure the trigeneration mode, an absorption heat pump with indirect hot water heating is used, which uses as cooling source the cooling water of the condenser of the steam-power part of the power complex. Such decision will make independent regulation of power complex cold generation from its electric power, and also fuller use of primary energy during the warm period of year.

### 5. Theoretical researches of a power technology complex the main nodes

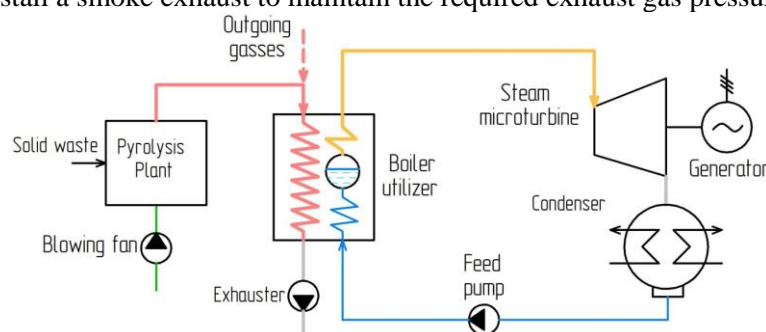
To generate electricity in the developed autonomous mobile micro-energy complex, the traditional Rankine steam-power cycle will be used. The main equipment of the steam-powered cycle (Figure 1) includes: steam generator, steam turbine, condenser, feed pump. Auxiliary equipment: a vacuum pump, a reserve water storage tank, a smoke exhauster, an armature, a workflow automation system, electrical converters, etc. As a steam generator we use a heat recovery boiler. The heat recovery boiler utilizes either the heat of the high-temperature secondary energy resources or the heat of the flue gases the pyrolysis plant recycling waste (Figure 1). When using a pyrolysis plant operating in a discrete mode, to ensure the uninterrupted operation of the steam turbine, a vapor battery.

The main advantages of the scheme with the heat recovery boiler:

- the ability to achieve more economical power generation with an efficiency of up to 30% at a steam pressure upstream of the turbine up to 4.0 MPa.

Disadvantages of the scheme with the heat recovery boiler:

- presence of large-sized elements (steam generator, condenser);
- the need to install a smoke exhaust to maintain the required exhaust gas pressure.

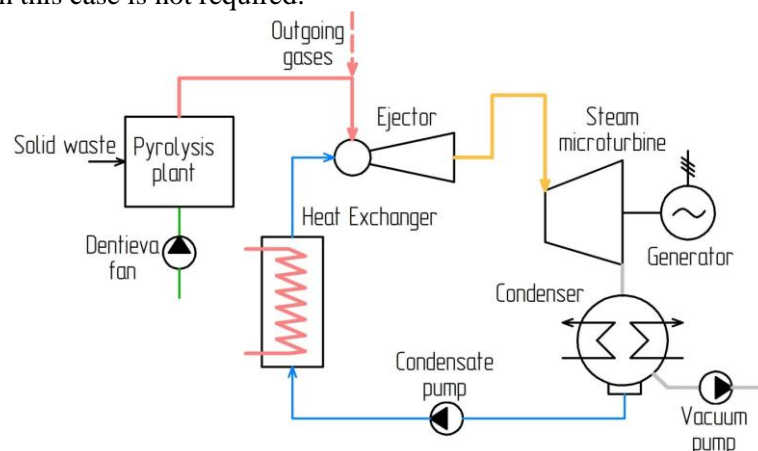


**Figure 1** - Schematic diagram of the steam-power part of the microenergy complex with the heat recovery boiler

To smooth out the possible uneven supply of secondary energy resources or solid municipal waste, it is necessary to use a vapor battery. It is also necessary to ensure the possibility of rebooting a pyrolysis installation operating in a discrete mode without stopping the micro-energy complex. Store vapor in a gaseous state under pressure is impractical, since steam will occupy a large volume. Therefore, it is advisable to use water stored at saturation and elevated pressure. This leads to the fact that when the pressure in the tank (valve opening) is lowered, an excess of energy is released in the water, which is used to convert part of the water to steam. This phenomenon is called instantaneous evaporation or effervescence. Equipment used to store pressurized water is called a steam accumulator. Earlier we performed calculations of a vapor battery. To accumulate steam, which ensures the uninterrupted operation of the complex in the nominal mode, it is necessary to provide one battery with a capacity of  $1.83 \text{ m}^3$ . The operating time is 30 minutes, with the steam temperature at the turbine inlet  $t_0 = t_{\text{nas}} = 180^\circ\text{C}$ . Place the battery in a mobile micro-energy complex is not advisable. Depending on the capabilities of the pyrolysis plant used, it is possible to shorten the time during which the operation of the microturbine will be provided by a vapor battery. This will lead to a decrease in the capacity of the battery and will favorably affect its mass dimensions.

The second option for implementing the steam-power part of the power complex is to use a circuit with an ejector installation instead of a steam generator (Figure 2).

The ejector unit is supplied with exhaust gases of pyrolysis plant or secondary energy resources and heated water under pressure (1.0-2.0 MPa). As a result, a vapor-gas mixture with a water vapor content of up to 40-50% and a pressure of about 0.25 MPa. The ejector is more compact in comparison with the steam generator, and the working medium in the case of using an ejector installation by half will consist of non-condensable (within the considered thermodynamic cycle) flue gases. Removal from the condenser of non-condensable gases will be carried out using a vacuum pump, the use of a smoke exhauster in this case is not required.



**Figure 2** - Schematic diagram of the steam flow Rankine cycle with an ejector installation

Advantages of the circuit with ejector installation:

- small-sized ejector in comparison with a large-sized steam generator;
- the dimensions of the condenser in the ejector circuit will decrease in comparison with the capacitor in the conventional circuit;
- no need to use a smoke exhaust fan.

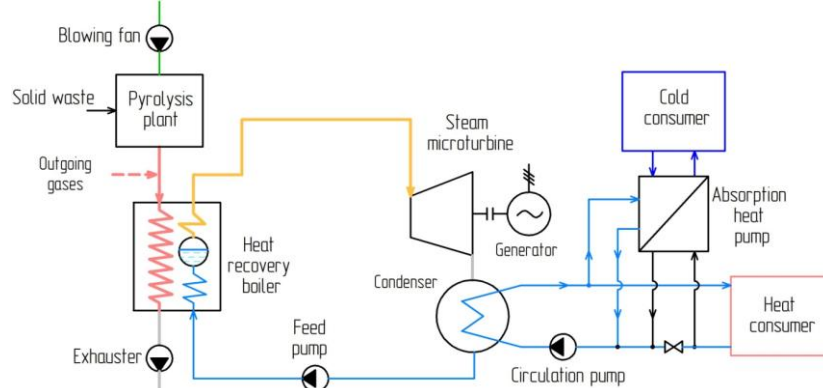
Disadvantages of the circuit with an ejector installation:

- low efficiency of the cycle - less than 5-8% due to the fact that the pressure of the vapor-gas mixture will be reduced, approximately 0.25 MPa;
- it will be necessary to create a deeper vacuum to about 0.05-0.06 MPa.

Cleaning of exhaust gases before release into the atmosphere is carried out in an additional installation, not shown in the diagram.

## 6. Results of the development the energy complex scheme

The main area of application of the developed energy complex is the utilization of solid municipal waste in the territory of landfills located far from the city infrastructure. Figure 3 shows the principal thermal scheme of the energy complex.



**Figure 3** – The principal thermal scheme of the energy complex

The choice of the basic scheme the energy complex was reduced to two options: a scheme with a heat recovery boiler and a scheme with an ejector installation. Using a circuit with an ejector will achieve the best mass-dimensions, but it will provide a lower efficiency in comparison with the traditional steam-power scheme. In addition, this will require constant recharge of additional water, which will be difficult to ensure under the expected operating conditions of the energy complex. Therefore, a more practical solution will be the use of the concept of an energy complex with the heat recovery boiler.

## 7. Conclusion

In the article various variants of the basic scheme of operation of the experimental energy complex:

- the traditional scheme of a steam-power cycle with a steam generator, the role of which is performed by a waste heat boiler operating on the outgoing gases of a pyrolysis unit;
- scheme with an ejector installation into which flue gases from the pyrolysis plant and heated water are fed, as a result, a vapor-gas mixture with a water vapor content of up to 40-50%. Removal from the condenser of non-condensable gases is carried out by means of a vacuum pump.

The ejector circuit is more compact but less efficient than the conventional one. The operating conditions of the energy complex imply the use of a closed cycle. Thus, as the final version, a scheme was chosen with a recovery boiler.

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