The relevance of re-equipment of thermal power plants under solid waste fuel

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Abstract. The use of thermal power plants (TPPs) as energy facilities in world practice is the most popular way to generate electricity. Traditional fuel for these objects is used in the form of coal and gas. Also, in world practice, other types of fuel are used for TPPs, namely, municipal solid waste (MSW). The relevance of the research is the proposal for reliable and technological re-equipment of thermal power plants, thereby solving the problem of the environmental situation in the near radius of the construction of thermal power plants for the disposal of solid waste. The object of research is thermal power plants and their ability to re-equip. The main purpose of the research is to analyze the world and domestic experience in the implementation of solid waste as a fuel for thermal power plants and to offer current technological solutions.

1. Introduction
Given the large number of existing thermal power plants in the world, which currently operate on traditional fuel in the form of coal and gas, as well as a limited supply of these resources, it is necessary to note the relevance in choosing another type of fuel for these facilities that could meet the increased safety requirements for the environment. This type of fuel is municipal solid waste, the disposal of which in this way will help solve the problem of landfill reloading. It should be noted that the importance of processing these wastes on a global scale is increasing every year. Every year, only in Russia produces more than 60 million MSW, which, in terms of one person, is about 400 kg [1, 2]. Only about 7–8% of collected MSW is drawn into economic circulation, and only 2% is burned. The low percentage of recycling (use) of solid waste in Russia is associated with insufficient infrastructure development: currently, there are 243 waste disposal complexes, 53 waste sorting complexes, and about 40 incineration plants [3].

Consequently, the object of study is the power stations and their ability to re-equip. The main tasks solved in the study are:

- to analyze the world and domestic experience in the implementation of solid waste as a fuel for thermal power plants;
- propose current technological solutions in terms of re-equipment of TPPs;
- develop a system of reliable, safe and technological re-equipment of thermal power plants.

On the other hand, the task of developing technical re-equipment and reconstruction of existing thermal generation power plants with the transition to municipal solid waste is to increase the level of environmental protection the environment in terms of waste management.
2. Scientific work

Considering the re-equipment of TPPs for fuel from MSW, first of all, it is necessary to consider MSW as a new type of fuel.

MSW is a waste from human life, namely food and vegetable waste, paper, magazines, wood, plastics, textiles, glass and various metals. Separate collection, burial and incineration of waste is applied to successfully combat household waste. Today in Russia the vast majority of waste is not sorted. Waste after entering the garbage containers are sent to specially designated landfills, landfills, where they are stored [4]. For example in Russian Federation, Moscow and the Moscow Region, there are more than 50 polygons, 27 of which have exhausted their capacity, and the other 19 are filled to 90%. Dumps of the same garbage more than 1000. Further development of this problem can lead to catastrophic consequences, because the disposal of solid waste causes pollution of the land, pollution of the upper aquifers with toxic substances contained in the filtrate generated at landfills. The release of large volumes of biogas, mainly methane and carbon dioxide, which leads to climate change, as well as to spontaneous combustion and combustion of landfills with garbage [5]. All of that has a negative impact on the environmental situation and the health of the population in nearby communities. In addition, in accordance with the draft federal law No 584399-5 “On Amendments to the Federal Law “On Production and Consumption Wastes”, waste reception at landfills will be limited [6]. As a result, it is worth reviewing this technology of waste disposal in favor of more environmentally friendly and innovative methods. One such method is incineration. Accordingly, the most acceptable option may be a thermal power plant for municipal solid waste [7].

Thermal power station (TPP) - a station, a set of installations and equipment necessary for the production of heat and electricity. Subdivided by type of energy produced at condensing power plants. (electrical energy), thermal power plants (both electrical and thermal), CHP (mainly thermal energy). Currently, power plants operate on two types of fuel: coal and gas. In densely populated areas, far from coal deposits, most power plants switched to gas. This is due to the cost of transporting coal and the non-environmentally friendly generation of energy for this type of fuel. Gas power plants are eco-friendly and compact. Fuel flows continuously and in all weather conditions. In this situation - this is the best solution for large cities [8]. But using traditional fuels does not solve urgent environmental problems, because there is a tendency to increase the amount of household waste. In world practice, more than ten technologies of incineration are implemented [9-14]. Important factors when choosing a particular technology is the station’s self-sufficiency and the ability to supply electricity and heat to consumers, as well as the fuel itself. For Russian conditions (high humidity of MSW, high content of inert and environmentally hazardous components in MSW), it is preferable to use the technology of layered burning on an inclined-pushing grate.

![Figure 1. Schematic diagram of layered burning on an oblique-pushing grate.](image)

Unsorted municipal solid waste is delivered to the receiving compartment using garbage trucks, then they are discharged into a temporary storage facility — an in-depth bunker served by a grapple crane.
(several cranes are usually installed depending on the needs of the units). With the help of a grab crane, waste is moved from the bunker to incineration. At this stage, all oversized garbage is also removed. From the bunker MSW is fed into the feed hopper, which separates the combustion chamber from the environment and prevents unorganized air flow into the furnace. A locking device is installed on the lower part of the receiving funnel - a valve that performs protective functions in the event of an accident. From the receiving funnel, MSW is sent to the firebox to the grate, usually using a hydraulic pusher. The waste incineration temperature is 850 °C. In the combustion process, slags are formed, which through cooled water fall into a hydraulic slag remover with a pusher device. Under the grate along its entire length, a scraper device is installed to collect spills between the grates. It is important that gas purification and waste incineration technologies are observed, as a result of which they reach the limiting concentrations of organic carbon, carbon oxides, and also perform the process of thermal decomposition of furans and dioxides [15].

Due to the reduced rates of electricity generation during the burning of solid waste, waste sorting and pre-crushing is used to increase the efficiency of fuel of a thermal power plant. Under such conditions, the calorific value (heat engineering indicators of fuel) increases. In addition, it becomes possible to select valuable raw materials for its recycling or composting. A significant increase in the efficiency of using MSW as a fuel for TPPs is achieved by only partial replacement of traditional fuel (coal, gas) with alternative (MSW) [16].

![Figure 2. Scheme of re-equipment of the station for fuel from MSW.](image)

Accordingly, in order to effectively implement the re-equipment of TPPs for fuel from MSW, it is necessary to develop a combined layout of TPPs for incineration of both traditional (coal, gas) and MSW, and to have an established waste sorting system [17]. In the Russian Federation, the process of sorting garbage is poorly developed, it is advisable to build a sorting complex directly next to the station. In addition, there must be a waste reception complex. Depending on the type of fuel burned at the station being reconstructed, additional equipment should be used: front furnace for burning solid waste (fuel - coal); installation for gasification of MSW, treatment facilities obtained product gas for subsequent combustion in the boiler furnaces (fuel - natural gas). The refurbished station should include a multi-stage gas cleaning system, ash and slag removal system to prevent the harmful effects on the environment of harmful impurities.

When re-equipment an existing station, there is no need to replace power lines and steam power plants. In addition, unlike other types of fuel, MSW is accepted with a cash surcharge. When re-equipping, it is necessary to make examinations and diagnostics of structures, structures, equipment in order to obtain optimal conditions for generating energy and increasing the reliability of the plant as a whole. In case of detection of defects and damages, it is necessary to work to eliminate them; decommission obsolete and outdated equipment from service. The operating experience of numerous foreign waste recycling stations shows that thermal power plants equipped with modern equipment are environmentally safe, the concentration of emissions of harmful substances from the station itself does not exceed the standard values. For example, in Europe, 28 billion kW / h of electricity and about 70 billion kW / h of thermal energy is already being produced, which prevents emissions of harmful
substances that could be released during landfill, and also provides significant savings for other types of fuel [18].

In assessing the current situation, we will look at the solution of the key tasks of re-equipping thermal power plants for solid waste fuel. After analyzing the world and domestic experience in the implementation of solid waste as a fuel for thermal power plants, it was revealed that there are problems with the development of infrastructure for the collection and sorting of garbage. And because of this, we do not use this resource again. Based on the above conditions, the use of the combined energy generation scheme is the most rational and efficient. Also, based on the result of the study, a system of reliable, safe and technological re-equipment of TPPs has been developed:

![Diagram](image)

**Figure 3.** Scheme of the system of reliable, safe and technological re-equipment of TPPs

This scheme demonstrates the sequence of operations for the reconstruction of thermal power plants for fuel from MSW, and also helps to retool effectively and safely, which is the main task of developing thermal generation.

3. Conclusion

The existing waste management system not only in Russia but throughout the world, focused on their disposal, is imperfect and requires modernization, as it leads to environmental pollution. Use of sorted MSW as fuel for TPPs with a combined plant layout is extremely efficient. Incineration of waste will reduce their volume, and, accordingly, their impact on the environment. In addition, MSW is an economically beneficial renewable fuel for thermal power plants, and with an increase in the number of sorting complexes, the relevance of re-equipment of thermal power plants will increase. Stations on this type of fuel have advantages over other technologies for waste disposal: environmental friendliness and efficiency. An analysis of the situation suggests that such stations will become real in Russia in the near future, but they are connected with the adoption of laws aimed at reducing landfill sites.

The tasks we set were completed. An analysis of world and domestic experience in the implementation of solid waste was carried out, and a scheme of reliable technological re-equipment of thermal power plants for Russian conditions was proposed.

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