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ANALYSIS OF EMISSIONS OF MAJOR POLLUTANTS DURING BIOGAS COMBUSTION

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Abstract

Due to global climate change and the need to switch to renewable energy sources, the use of biogas as an alternative fuel is becoming increasingly important. Biogas, being a renewable energy source, can help reduce greenhouse gas emissions, reduce dependence on fossil energy sources and reduce the anthropogenic impact on the environment. However, when biogas is burned, in particular in steam boilers, significant emissions of pollutants occur, such as nitrogen oxides (NO_x), carbon monoxide (CO), carbon dioxide (CO_2), methane (CH_4) and nitrogen oxide (N_2O). Therefore, it is relevant to study the impact of biogas on atmospheric emissions when it is used in energy plants, in particular in steam boilers, as well as to find ways to reduce these emissions to improve the environmental situation.

Keywords: biogas, fuel, steam boiler, heat of combustion.

Introduction

In recent years, there has been significant progress in the study of the use of biogas as an energy source and its impact on the environment. The main areas of scientific research focus on aspects such as reducing greenhouse gas emissions, improving the efficiency of biogas use, and purifying this fuel to reduce its negative impact on the atmosphere.

The aim of the work is to determine the gross emissions of major pollutants (nitrogen oxides, carbon monoxide, carbon dioxide, methane, nitrogen oxide) during biogas combustion.

Research results

Biogas is identical in composition to natural gas, but it can be inferior or superior in calorific value - depending on the method of production and subsequent purification. The fundamental difference is in the method of production, because natural gas is extracted from the subsoil, and biogas is from biological waste or specially grown raw materials. Thus, biogas is a renewable energy source. According to experts, world reserves of natural gas at the current rate of consumption will last for another 50 years. Therefore, biogas can be an equivalent alternative. Especially if it is purified to the state of biomethane, with a methane concentration of 95-98% [1].

Modern energy needs are met mainly by three types of energy resources: organic fuel, water and nuclear energy. Water energy and nuclear energy are used by man after converting it into electrical energy. At the same time, a significant amount of energy placed in organic fuel is used in the form of heat and only a part of it is converted into electricity. However, in both cases, the release of energy from fossil fuels is linked to their combustion and, consequently, to the release of combustion products into the environment [2].

Biogas will play a key role in achieving Europe's long-term energy security and climate change mitigation goals within a promising and balanced renewable energy mix. Furthermore, its benefits extend far beyond reducing greenhouse gas emissions.

Biogas is the cheapest and most scalable form of renewable gas available today. It is a dispatchable energy carrier and as such can be used to balance intermittent renewable energy production. Furthermore, biomethane (improved biogas) can directly replace natural gas and can be stored and deployed across the energy system using existing gas infrastructure and end-use technologies.

Furthermore, biogas has a high potential to provide significant long-term socio-economic benefits, thus supporting the transition to a more sustainable closed-loop economy [3-4].

The main components of biogas are CH_4 and CO_2 , the ratio of which depends on the initial substrate and the characteristics of the fermentation process (temperature, residence time of the mixture in the reactor, loading of the working medium). Along with these important components, biogas contains minor amounts of H_2 and H_2S , as well as N_2 [5].

The use of biogas has advantages not only in terms of savings by replacing natural gas, but also as a method of improving the environmental situation, which will reduce the man-made load on the environment and reduce dependence on imported gas [5].

Traditionally, biogas has been used as a fuel for boilers during heat production or for cogeneration of heat and electricity in a combined heat and power plant (CHP) [6].

According to initiatives such as the Paris Climate Agreement, biomass energy is a reliable and sustainable source of base load for both industry and electricity suppliers. It also helps to achieve environmental goals by absorbing more CO_2 than it emits, and efficient equipment used for electricity generation leads to lower emissions at the plant [6].

The paper investigates the features of gross emissions into the atmosphere when operating the Invest steam boiler on biogas. The calculation is carried out for natural gas and biogas. The biogas used for the study has the following composition: CH_4 – 60%; H_2 – 0.02%; H_2S – 0.96%; CO – 0.02%; N_2 – 2%; CO_2 – 37%. Biogas density – $\rho = 1.196 \text{ kg/m}^3$; lower working heat of combustion of fuel is brought to normal conditions – $Q = 21.53 \text{ MJ/kg}$. Emission indicators of pollutants: $\text{kNO}_x = 67.41 \text{ g/GJ}$; $\text{kCO} = 20.94 \text{ g/GJ}$; $\text{kCO}_2 = 73767.9 \text{ g/GJ}$; $\text{kN}_2\text{O} = 0.1 \text{ g/GJ}$; $\text{kCH}_4 = 1.0 \text{ g/GJ}$.

In the equivalent of 1000 m^3 of natural gas is equal to 1500 m^3 of biogas [7].

For the operation of the Invest steam boiler, the enterprise needs 13306809 m^3 of biogas, so its mass consumption will be 15916.9 t/year. Then:

- gross emission of nitrogen oxide (in terms of nitrogen dioxide) $\text{ENO}_x = 23.1 \text{ t}$;
- gross emission of carbon monoxide $\text{ECO} = 7.176 \text{ t}$;
- gross emission of carbon dioxide $\text{ECO}_2 = 25278.6 \text{ t}$;
- gross methane emission $\text{EH}_4 = 0.3427 \text{ t}$;
- gross nitrogen oxide emission $\text{EN}_2\text{O} = 0.0343 \text{ t}$.

Conclusions

So, it is important to understand that methane (CH_4) is a potent greenhouse gas, 25 times more potent than CO_2 in terms of climate change impact. Also, when biogas is burned, methane is converted to CO_2 , which is less harmful to the atmosphere.

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