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ABSTRACT OF THE DOCTORAL THESIS

Toluene decomposition as a model simulator of tar produced in the biomass gasification process, in plasma and plasma-catalytic system

In recent years, there has been an increase in the importance of biomass of both plant and animal origin as a renewable energy source. One of the ways to use biomass for energy production is to obtain gaseous fuels from it in the gasification and pyrolysis processes. These processes make it possible to manage the production and agricultural waste. Tar produced during the processes, consisting mainly of mono and polycyclic aromatic hydrocarbons, can deposit on the walls of the reactor and cause clogging and damage to engines and turbines. To enable the use of gas after gasification or pyrolysis of biomass in engines, turbines and further synthesis, it needs to be purified.

Plasma and plasma-catalytic systems with the use of a gliding arc discharge plasma and nickel catalysts were used to study the process of toluene decomposition as an imitator of tars. Industrial and self-prepared catalysts were used. Due to its durability and low toxicity, toluene was used in the research. The tests were carried out under atmospheric pressure, using gas with a composition similar to that produced by gasification of biomass. A mixture of CO, CO_2, H_2 and N_2 was used. The total gas flow rate was 1 and 1.5 Nm^3/h. The initial toluene concentrations were 2000-6000 ppm (8.8-22.6 g/Nm^3).

The results of the research showed that it is possible to almost completely (99%) decompose toluene, as a model substance, in plasma-catalytic system using the G-0117 nickel catalyst. The gas purified in this way can be used in internal combustion engines. In the tested systems, the degree of toluene conversion depended on both the discharge power and the catalyst temperature, and the reactions took place in the plasma and on the catalyst. Depending on the system used, the process could be more or less dependent on one of these processes. It was shown that the addition of calcium in the catalyst support had a positive effect on the

deactivation resistance of the catalyst. The calcium content in the carrier could not be too high because it adversely affected the toluene decomposition process.

On the basis of the obtained test results, it was shown that the increased hydrogen content in the starting gas had a positive effect on the decomposition of toluene in plasma-catalytic systems, in which large amounts of methane were generated or in which the catalyst had a large number of active sites where decomposition of toluene could take place.

The influence of the reactions taking place in plasma and plasma-catalytic systems on the calorific value of the obtained gas was also investigated. Gas composition and toluene decomposition products, such as benzene, 1-methylcyclohexa-1,3-diene, benzyl alcohol, 3-hexen-2-one and intermediate tar decomposition products such as diphenylmethane and 4-hydroxybenzophenone were determined using gas chromatographs and a mass spectrometer

Based on XRD analysis the form of the active phase of the catalysts before and after the process was determined. The changes on their surfaces were observed with the use of SEM and spectrometer EDS. Based on the results of these studies and the results of a detailed analysis of the gas composition after the process, a mechanism of toluene decomposition has been proposed. Under the conditions of the process, the catalysts could be reduced to the metallic form of nickel, and on the surface of some of them, the formation of carbon deposits and nanofibers was observed, which may cause their deactivation.

The tests carried out with the use of industrial and self-made catalysts made it possible to assess the influence of the content and form of the active phase of the catalyst as well as the composition and structure of the support on the process of decomposition of the model substance and the durability of the catalyst. The use of high gas flow rates and gas composition similar to that obtained during biomass gasification allowed to conduct research in conditions more similar to real ones than those used so far in research. The wide range of gliding arc discharge power and toluene concentrations allowed for the demonstration of the relationship between these parameters and toluene conversion rate.

Keywords: gliding arc discharge, plasma-catalytic system, tars decomposition, nickel catalysts