SUMMARY

Presented doctoral dissertation, entitled „*Research on the combustion process and co-combustion of biomass fuels and alternative fuels in a fluidized bed in different process conditions",* has an experimental character.

The thesis that biomass fuels and RDF can be a relevant complement to fuels used in fluidized bed boilers, and the type of biomass fuels and composition of RDF are crucial in the selection of operating parameters of a fluidized bed boiler, i.e., temperature, inert material stream, and oxidizing atmosphere, was presented in the paper. In addition, proper preparation of alternative fuels at the production stage may improve their combustion/co-combustion process and increase the use of agro-biomass fuels.

Experimental research was preceded by a literature review and analysis. The literature review began with a discussion of global energy trends. The following subsections present the properties of biomass and alternative fuels, focusing on their various physicochemical properties. Then, the technical, environmental and economic aspects of combustion and co-combustion of biomass and alternative fuels were discussed. Fluidized bed combustion technology was also indicated as the leading technology that allows the use of various fuels. In addition, it enables the implementation of the oxy-combustion technology. Based on the analysis of the literature, it was found that the issues related to the thermal conversion of biomass fuels, fuels from waste, as well as modified alternative fuels was studied by a great group of researchers for a long time. The literature lacked detailed information on the analysis of the combustion of commercially available alternative fuels, such as pellets, produced from biomass and waste (RDF) in a fluidized bed. Of particular importance was the determination of the combustion kinetics of these fuels for different temperatures and different O_2 concentrations.

To confirm the papers' theses, selected alternative fuels detailed analysis of the combustion process of fluidized bed conditions was undertaken. The research material consisted of commercial pellet fuels, produced from forest and agro biomass and waste (RDF - Refuse Derived Fuel). Before conducting experimental studies of fuel combustion under various conditions in the fluidized bed, preliminary tests were carried out to determine the physicochemical properties of the fuels selected for analysis. Initial tests of fuels included technical analysis, i.e., determination of the content of volatiles,

moisture, ash, calorific value, and elemental analysis in the scope of the content of elements N, C, H, S determination.

In the first stage of experimental research, the chamber temperature and inert material influence on the combustion rate of the tested biomass fuels was analyzed. Initially, particles of selected fuels were combusted in an air atmosphere without inert material (Gs=0 kg/m2s) at three different temperatures of the combustion chamber: 850°C, 750°C, and 650°C. Then, the particles mass loss of all fuels was measured during combustion in a two-phase flow with the inert material at Gs=2.5 and 5 kg/m^{2}s.

In the second stage of experimental research, the effect of the share of oxygen in the mixture with carbon dioxide during the combustion process was analyzed. As in the first stage, the initial tests were carried out at Gs=0 kg/m^{2}s, and then in a stream of inert material modeling the conditions of the fluidized bed at Gs=2.5 and 5 kg/m^{2}s The tests were carried out at 850°C in the following concentrations of the oxygen/carbon dioxide gas mixture: 21%/79%, 25%/75%, 30%/70%. The same set of experimental tests was also applied to experimental tests on the combustion of selected RDF pellets.

The carried out and described tests of biomass fuels and RDF fuels made it possible to compile and compare their results. During the combustion of fuels in the fluidized bed, differences in the combustion process were observed, visible at the temperature of 850°C. The presence of the fluidized bed accelerated the combustion process of fuels from forest biomass and RDF due to the removal of ash formed on the particle surface, improvement of the diffusion process within the burned particle, and the process of mechanical particle destruction. On the other hand, the combustion of agro biomass fuels in a fluidized bed at 850°C led to the formation of sinters threatening the hydrodynamics of the fluidized bed.

To explain the reasons for the ash softening and the formation of sinters, the ash of the tested fuels analysis was performed. A high content of alkali metal oxides in both cases of agro biomass fuels, a high content of potassium oxide in the sunflower husk pellet, and sodium oxide in the straw pellet was shown. During the combustion of biomass and RDF fuels in oxidizing atmospheres, the acceleration the fuel combustion process with the increase in the amount of oxidant was notice. The change in the oxidant concentration caused a very similar increase in the mass loss rate of the tested fuel types. It was found that the tested fuels can be used in the oxy-combustion technology. An

increase in the oxidant in the range of 21-30% is only dangerous in the case of agro biomass fuels due to the increase in temperature on the surface of the burned particle.

In the next part of the research, it was decided to prepare a mixed secondary fuel from sunflower husk pellet and RDF pellet. These studies were aimed at analyzing the combustion process of fuel with a modified composition in the conditions of a fluidized bed. During the research, the influence of the inert material on the process of mixed secondary fuel combustion in fluidized bed at a constant temperature of 850°C was analyzed. The tests were carried out at Gs=0 kg/m^{2}s, and then in a stream of inert material at Gs=2.5 and 5 kg/m^{2}s.

In the last part of the doctoral thesis, it was decided to compare the results obtained during experimental research with the literature data for solid fuels. For the comparison, the testing results of hard coal from the Sobieski mine and brown coal from the Bełchatów mine were selected.

The research and analyses carried out in the work allowed us to prove the theses set out in the work. All biomass and RDF fuels selected for analysis can be combusted or co-combusted with coal fuels in fluidized bed boilers. Based on the carried out analyses, it was found that despite the fundamental differences related to the origin, chemical composition, and the method of preparation of biomass and alternative fuels, the combustion process can be fully controlled and highly effective. The necessary condition is the optimization of the combustion process consisting of the selection of process parameters, i.e., temperature, the concentration of the oxidant, and the intensity of the stream of inert material. The process of sinter formation can be eliminated at the stage of fuel preparation by lowering the concentration of alkaline elements inthe mineral substance by mixing agrofuel with RDF fuels.