

Combustion Efficiency of Various Forms of Solid Biofuels in Terms of Changes in the Method of Fuel Feeding into the Combustion Chamber

Małgorzata Dula^{1, *}, Artur Kraszkiewicz², Stanisław Parafiniuk²

¹University of Life Sciences in Lublin, Lublin, Poland

²Department of Machine Operation and Production Processes Management, University of Life Sciences in Lublin, Lublin, Poland

Email address:

malgorzata.dula@up.edu.pl (Małgorzata Dula), artur.kraszkiewicz@up.edu.pl (Artur Kraszkiewicz), stanislaw.parafiniuk@up.edu.pl (Stanisław Parafiniuk)

*Corresponding author

Abstract

This article presents research in which four types of herbaceous waste biomass (wheat straw, rye straw, oat straw and hay) and one type of woody waste biomass (birch sawdust) were used. The basic chemical characteristics were determined for the raw materials. After appropriate preparation, the selected starting materials were subjected to briquetting and pelleting processes. Selected physical properties were also determined for the obtained biofuels. Biofuels made from birch sawdust had the lowest heat value ($16.34 \text{ MJ} \cdot \text{kg}^{-1}$), although biofuels made from wheat, rye and hay straw had a slightly lower calorific value, respectively: 16.29 ; 16.28 and $16.26 \text{ MJ} \cdot \text{kg}^{-1}$. However, the calorific value of oat straw biofuels was only $15.47 \text{ MJ} \cdot \text{kg}^{-1}$. Moreover, the ash content for herbaceous biomass was 2–4 times higher than for woody biomass. Similar differences between herbaceous and woody biomass were also observed for the nitrogen and sulfur content. To burn the prepared biofuels, a domestic grate-fired biomass boiler was used, periodically fed with portions of fuel in the form of pellets or briquettes (type A tests), which was then modified with a gutter burner enabling the automatic feeding of fuel in the form of pellets (type B tests). During the combustion tests with simultaneous timing, the concentration of CO_2 , CO , NO and SO_2 in the exhaust gases was examined and the temperature of the supplied air and exhaust gases was measured. The stack loss (q_A), combustion efficiency index (CEI) and toxicity index (TI) were also calculated. The research shows that the use of automatic fuel feeding stabilizes the combustion process. The combustion process is balanced between herbaceous and woody biomass biofuels. Disparities in CO_2 , CO and T_{gas} emissions are decreasing. However, during type B tests, an increase in NO emissions is observed. At the same time, the research conducted indicates that the combustion of herbaceous biomass pellets with their automatic feeding into the combustion chamber is characterized by an increase in combustion efficiency, indicating that when the combustion process is automated, they are a good replacement for wood biofuels—both pellets and briquettes.

Keywords

Pellets, Briquette, Combustion, Emission