THE MATHEMATICAL MODEL OF OXY-FUEL COMBUSTION OF MUNICIPAL SOLID WASTE ON THE GRATE FURNACE INTEGRATED WITH CO_2 CAPTURE

by Paulina Copik

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Silesian University of Technology Gliwice

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Author:

Paulina Copik, MSc

Joint Doctoral School at Silesian University of Technology

e-mail: paulina.wienchol@polsl.pl

Supervisor:

Andrzej Szlęk, Professor

Department of Thermal Technology

Silesian University of Technology

Konarskiego 22, 44-100 Gliwice, Poland

e-mail: andrzej.szlek@polsl.pl

Co-Supervisor:

Mario Ditaranto, PhD

SINTEF Energy Research

Sem Sælands vei 11, 7034 Trondheim, Norway

e-mail: marioditaranto@sintef.no

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Opracowanie modelu matematycznego spalania tlenowego stałych odpadów komunalnych na palenisku rusztowym zintegrowanym z wychwytem dwutlenku węgla

Abstract

Greenhouse gas (GHG) emissions are a serious environmental issue that humankind must face soon. Bio-energy carbon capture technology (BioCCS or BECCS) that results in negative-CO_2 power generation will be a vital in the transition toward a sustainable economy. Due to the biogenic origin of a considerable part of carbon contained in municipal solid waste (MSW), implementing carbon capture in waste incineration plants can be classified as BioCCS. Nowadays, there are four incinerators, in which CO_2 capture is applied; however, they use the post-combustion technique since it is the most mature method and does not require many changes in the system. Nevertheless, the separation of CO_2 from the flue gas stream, which contains mostly nitrogen, is expensive and causes a large drop in the system's total performance.

A more superior solution is oxy-fuel combustion technology. OFC involves the replacement of air as an oxidizer with oxygen and recirculated exhaust gas. As a result, the produced gas is composed mainly of CO_2 and H_2O, which makes its sequestration more cost-effective. Nevertheless, changing the atmosphere from N_2 to CO_2 affects combustion behaviour. To study the impact of atmosphere on the thermal degradation process, evaluate the quantitative differences between air and oxy-waste combustion, and to better understand the process principles, the mathematical model of waste combustion under different atmospheres was developed. The model included all important stages of waste decomposition taking place within the chamber, such as moisture evaporation, pyrolysis, char burnout, and gas combustion over the grate. The individual processes were described using chemical data determined based on experimental results obtained through an experimental campaign on a thermogravimetric (TG) instrument and a lab-scale experimental rig. Isoconversional methods were employed to determine kinetic data.

The results of the work will contribute to the development of waste incineration plants integrated with carbon capture, expanding knowledge about the thermal degradation of waste in various conditions and will be useful for the design of oxy-waste combustion chambers.