PRESSURIZED GASIFICATION OF COAL CHARS UNDER CO₂/CO ATMOSPHERES – A KINETIC STUDY

*G. Tomaszewicz, M. Tomaszewicz, P. Babiński, M. Sciażko
ICHPW, Institute for Chemical Processing of Coal, 41-803 Zabrze, 1 Zamkowa St., Poland

Abstract:
Due to concerns over environmental protection and therefore, to reduce the carbon emissions, clean coal technologies like IGCC are considered to be promising option worldwide. At the same time, the studies are oriented on increasing the gasification efficiency. In result, a novel method for gasification has been developed at the IChPW in which additional carbon dioxide is added to the process. The beneficial effect of the CO₂ addition is associated with a decrease in the demand for both carbon and oxygen while maintaining the syngas quality as in conventional air-blown systems through the increased influence of the char-CO₂ reaction. To optimize the process conditions, a thorough understanding of the char reaction kinetics is essential, especially those of the char-CO₂ reaction, which is among the slowest independent gasification reactions and simultaneously plays a critical role in the process. Additionally, the retarding effect of CO cannot be neglected when establishing the kinetic model for such a process.

Numerous models can sufficiently describe the CO₂-gasification rate variation, including models that either do or do not consider the structural changes in the coal char as the reaction proceeds. The models regarded as the most popular are as follows: the volumetric, the modified volumetric, the grain, the random pore, the unification theory model, and the Langmuir-Hinshelwood models. The latter incorporates the inhibiting effect of CO addition on the reaction rate, so it provides comprehensive information on reactivity of particular char valid under wide range of process conditions.

The main purpose of this study is to compare the results of fitting the aforementioned most-popular kinetic models to the experimental data. The gasification experiments were carried out using a pressurized thermogravimetric analyzer (TG-HP150s, TA Instruments, USA). During the studies, two char samples derived from Turów lignite B and Janina subbituminous B were subjected to gasification toward CO₂. The validation of all models was established for the processes performed at temperatures of 850, 950 and 1050°C, and CO₂ pressures of 0.4, 1, 10 and 20 bar. Additionally, experiments with mixtures comprising of 5% and 20% of CO in CO₂ were employed under the same temperature and pressure conditions. The effect of the process variables and the parent coal rank and characteristics on the chars reactivity has been established and thoroughly discussed.

Keywords: coal char, CO₂, gasification, kinetics, reactivity, elevated pressure, TGA

Acknowledgement: The research results presented herein were obtained during the course of the project "Development of coal gasification technology for high-efficiency production of fuels and energy", Task No. 3 of the Strategic Program for Research and Development: "Advanced energy generation technologies" funded by the Polish National Centre for Research and Development.

*Corresponding author:
e-mail: tomaszewicz@ichpw.zabrze.pl Tel: +48 32 271 0041 int. 211, fax. +48 32 271 0809