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論　　文　　要　　旨
Thesis Abstract

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主論文題名　（Title）

An analysis of drying characteristics of Polish lignite in superheated steam atmosphere

内容の要旨　（Abstract）

Among countries in possession of lignite (also known as low-rank coal), Poland's position has been remaining in top ten regarding both reserves and resources of this fossil fuel. Lignite is characterized with relatively high water content, often exceeding 50%. Thus, due to low thermal efficiency of plants operating on lignite and high average age of Polish power generation units, the development of efficient fuel utilization technologies is highly desirable.

One of the approaches focused on achieving that goal is drying of lignite which can be performed applying various methods. Superheated steam drying is a technique that recently has been gaining popularity in the industry. Its advantages may include prevention of spontaneous combustion, high heat transfer rate and potential for recovering the heat of moisture evaporation.

Still, in order to design a drying system utilizing superheated steam, a thorough research on drying kinetics of prospective fuel is demanded in order to gain knowledge required for adjusting the optimal mode of operation for this device. To meet that goal, the experimental research was performed on lignite samples from two Polish lignite mines: Belchatow and Turow. They were formed into spheres of four diameters (2.5, 5, 10 and 30 mm) and exposed one after another to superheated steam heated to one of four temperatures (110, 130, 150 and 170 ^{o}C). Relying on temperature and weight measurement, the drying characteristics curves against time, consisting moisture content, drying rate and temperature profile, were prepared. Four major stages of drying were distinguished, with specific features related to each of them: pre-heating, constant drying rate period, decreasing drying rate period and final drying. It was concluded that raising the temperature of drying medium or decreasing the sample size entails increase in the drying rate and reduction in time required for the completion of the process.

The influence of geological origin on the drying behavior was also discussed, producing observations correlating features related with internal structure and properties such as

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density or moisture content. The thermodynamic deliberation led to linearization of formula describing heat transfer coefficient during constant drying rate period. Along with the function for this coefficient derived from the experimental drying kinetics, it was used to examine the consistency of drying parameters for lignite batches mined in different locations of Belchatow and Turow coal complexes.

For the sake of gaining the wider perspective on the drying process, the experimental trials were video recorded. The footage was used to discuss the phenomena of shrinkage, droplet formation and cracking of the surface.

The values of lignite properties obtained experimentally, supplemented by those acquired in additional studies, were adapted as parameters of the mathematical model of drying. It was constructed on the assumption of isotropy of the properties within lignite sphere, thus the one-dimensional model could be applied. The unsteady state equations formulating mechanisms of heat and mass transfer were discretized using the control-volume method and the explicit method of computation was applied.

The simulation attempts came out with the predicted values of drying indicators, including temperature difference within a sphere, time of drying, peak drying rate etc.

The changes in those quantities were also taken into consideration in sensitivity analysis of the numerical model with regard to material properties and other process parameters.

Multiple-particle simulations were also performed using the numerical model to reflect more precisely the scheme of operation of actual dryer. They were conducted with reference to lignite assortments applied in Polish lignite industry.

In order to assess the impact of lignite drying on enhancement of its calorific value, the formula for lower heating value was worked out as a function of water share. Inclusion of this equation into results of numerical simulation allowed for prediction of calorific value at a certain instance of the process, with regard to coals of various assortments or material parameters.

The results of this work may be used in the further research. These might include either investigation of lignite porosity with the application of microstructural tomography or research related to optimization of grinder/dryer system in relation to power input required for fragmentation of coal.

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