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Characteristics of the Solid Fuels for the Plasma Gasification

Aytac Sanlisoy*, Halil Melez, Melda Ozdinc Carpinlioglu

Gaziantep University, Mechanical Engineering Department, Gaziantep 27310 Turkey

Abstract

In this study, characteristics of 6 different fuels which are going to be gasified in a plasma reactor are analyzed. The types of fuels are Russian coal, South Africa coal, Sırnak-Turkey coal, hornbeam sawdust, pine tree sawdust and polyethylene. The characteristics of these fuels are examined by measuring heating values, densities and performing the proximate and ultimate analysis on their composition. The carbon and hydrogen content have a favorable influence on heating value meanwhile, moisture, ash, oxygen, nitrogen and sulphur have an adverse effect. This fact is also confirmed by proximate and ultimate analysis. According to the results it is observed that the Russian and South Africa coals have the higher heating values because of their high carbon and hydrogen content. Meanwhile the moisture and volatile matter which are high in sawdust is the cause of reduction in heating values. Polyethylene has the highest heating value in calculation, although it could not be measured directly by a bomb calorimeter.

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1. Introduction

In this study, the characteristics of the solid fuels are examined by proximate, ultimate analysis and evaluating heating values of the solid fuels. As an input to the system, the solid fuel characteristics especially the heating value have great importance for the thermochemical processes. The performance of the process depends on the input energy. In the thermochemical process the fuels are input energy in case of chemical form and the energy amount is indicated by the heating value. In the literature, the most common ways to calculate the heating value are the bomb

* Corresponding author. Tel.: +905349485684;
E-mail address: aytacsanlisoy@gantep.edu.tr

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calorimeter test or the empirical equations derived from the data of proximate and ultimate analysis [1]. There are numerous studies to find the heating value by using the proximate and ultimate analysis with the content restrictions [2-8]. For the solid fuels analyzed in this study, the equations derived by Channiwale & Parikh used to calculate the HHV [3] and Finet to calculate the LHV [4] by using the proximate and ultimate analysis data. Also, the heating value is measured by using the adiabatic bomb calorimeter.

This study aimed to investigate the solid fuels characteristics which are going to be gasified in a plasma gasification system; MCw Gasifier. The input energy amount should be evaluated to find out the performance. The energy content of these fuels were evaluated by both bomb calorimeter measurement and the empirical equation which gives the heating values by using the proximate and ultimate analysis.

2. Experimental procedure

The measurement procedure of density of solid fuels, proximate and ultimate analysis of solid fuels and higher heating value of them are presented in this section.

2.1. Density

Density of solid samples are measured by using Eltra 84 Analytical Balance. 100 mL measuring cylinder is filled for the each sample and the mass is measured. The density is determined by the ratio of mass to volume.

2.2. Proximate analysis

Proximate analysis indicate the contents of moisture, volatile matter, fixed carbon and ash in the fuels in percentage by weight. For the determination of contents of matter, the methodology is given below.

Moisture content: Moisture content is determined by removing water from the sample fuel by the specified method without causing any chemical change to the fuel. Approximately, 1 g of fine powdered coal is weighed in the crucible which is covered by the lid. The crucible-lid is placed inside the oven where the temperature is maintained at 105-110℃ for 1 hour. Then sample is taken out and weighed. The loss in weight is giving the moisture content in fuel. Moisture content is calculated by using equation 1.

$$\text{Moisture (\%)} = \frac{\text{Initial weight of the sample} - \text{final weight of the sample}}{\text{Initial weight of the sample}} \times 100 \quad (1)$$

Volatile Matter: Volatile matter is determined by holding the dried fuel sample in the oven where the temperature is maintained at $925\ ℃ \pm 25℃$ for 7 minute. Then the sample is weighted again. The losses in weight of dry fuel sample gives the volatile components. The percentage of the volatile matters can be calculated as equation 2.

$$\text{Volatile matter (\%)} = \frac{\text{Initial weight of the dry sample} - \text{final weight of the sample}}{\text{Initial weight of the sample}} \times 100 \quad (2)$$

Ash content: Rest of the fuel sample in the crucible after the volatile matter measurements is held in the oven without using the lid at 700℃ + 50℃ for half an hour. After the burning of the fuel, the residue in the crucible gives the ash content. The amount is measured and the percentage ash is determined as equation 3.

$$\text{Ash (\%)} = \frac{\text{Residual weight of the sample}}{\text{Initial weight of the sample}} \times 100 \quad (3)$$

Fixed carbon: The difference between the initial weight of the sample and the sum of the moisture, volatile matter and ash gives the fixed carbon content. The percentage of the fixed carbon can be determined as equation 4.