



Detection of incipient self-ignition process in solid fuels through gas emissions methodology



Nieves Fernandez Anez^{a, *}, Javier Garcia Torrent^{a, b}, Ljiljana Medic Pejic^a, Carlos Grima Olmedo^c

^a Department of Energy and Fuels (UPM Technical University of Madrid, Spain), C/ Alenza 4, 28003 Madrid, Spain

^b Laboratorio Oficial Madariaga, LOM (UPM Technical University of Madrid, Spain), C/ Eric Kandel, 1 – (TECNOGETAFE), Parque Científico y Tecnológico de la UPM, 28906 Getafe, Madrid, Spain

^c Department of Geological and Mining Engineering (UPM Technical University of Madrid, Spain), C/ Alenza 4, 28003 Madrid, Spain

ARTICLE INFO

Article history:

Received 9 September 2014

Received in revised form

19 February 2015

Accepted 19 February 2015

Available online 21 February 2015

Keywords:

Self-ignition

Spontaneous combustion

Gas emission

Solid fuels

ABSTRACT

The aim of this study is to propose an experimental methodology to detect incipient self-ignition processes in solid fuels. This methodology is based on the gases emissions of different solid fuels, varying the degree of compaction and the grain size of the materials. To achieve this goal, a procedure for the collection and analysis of the gases emitted by samples of various fuels has been developed, analysing the temperatures at which these emissions begin. The results obtained for different materials show that it is possible to detect incipient spontaneous combustion processes using measurements of CO and CO₂ emissions during heating process, and then to set alarm thresholds based on the concentrations of these gases. Those results have been compared with results from conventional thermogravimetry and differential scanning calorimetry tests and it is shown that the proposed methodology detect the self-ignition process start point in advance.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

Currently over 80% of the energy source used in the world comes from the combustion of fossil fuels (International Energy Agency, 2013). Historically, coal is the fossil fuel most used to produce energy and nowadays it is still one of the most used fuels all over the world, with a total world consumption of 8,123,601 thousand tons in 2011 (U.S. Energy Information Administration). Thus, coal storage is a common practice and the associated hazards, its harmful effects to the environment and human health (Fabiano et al., 2013) and its self-ignition and spontaneous combustion risks are commonly studied (Sipilä et al., 2012). But coal production is gently being reduced (World coal association, 2013) and replaced by other products, such as biomass.

The United Nations Framework Convention on Climate Change ((UNFCCC)) defines biomass as the “non-fossilized and biodegradable organic material originating from plants, animals and micro-organisms. This shall also include products, by-products, residues

and waste from agriculture, forestry and related industries as well as the non-fossilized and biodegradable organic fractions of industrial and municipal wastes. Biomass also includes gases and liquids recovered from the decomposition of non-fossilized and biodegradable organic material”. One of the most used biomass is the one derived from wood, as pellets or chips, but new biomasses from waste are being developed also nowadays (Kothari et al., 2010).

Benefits of substituting coal by biomass are well studied and known (Heller et al., 2004), but other options, as using trees for carbon sequestration, are also possible to achieve the objectives (Baral and Guha, 2004). Existing beliefs about the no-gas emissions of biomass are not exactly true (Wibe, 2012) (Kallio et al., 2013), and the use of biomass generate several hazards. Two of the main hazards of this kind of substances are highly related. Those are the gas emissions associated to the heating and oxidation of the biomass (Goode and Yokelson, 1999) (Hegg et al., 1990), and the heating and oxidation their selves, which are the cause of the self-ignition of these storages (García-Torrent et al., 2012) (Veznikova et al., 2014).

Thermogravimetric and differential scanning calorimetric analyses are useful tools for a first and fast assessment of the

* Corresponding author.

E-mail address: nieves.fernandez@upm.es (N. Fernandez Anez).

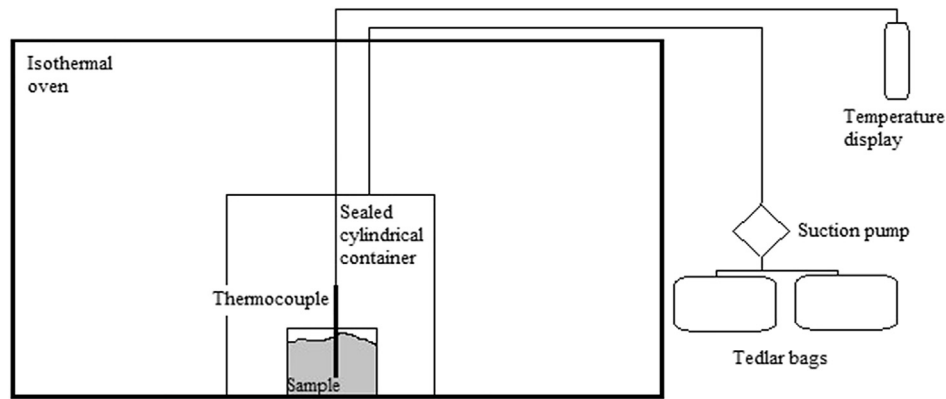


Fig. 1. Equipment for gas emissions test.

combustion properties of fuels (Magdziarz and Wilk, 2013) (Montenegro Mateos et al., 2013) and they are also used to initially evaluate the behaviour of the combustion on larger scale. But these techniques have a main disadvantage that is the difficulty of testing different parameters of the samples and different operating conditions, such as particle porosity, gas velocity magnitude and direction or oxygen concentration, that condition the smouldering and flaming combustion of the samples (Aldushin et al., 2006) (Bakhman et al., 2002).

A number of studies has been developed to determine the main parameters obtained from thermogravimetric and differential scanning calorimetric analyses, but this is not the only way to predict the combustion properties of materials (Everard et al., 2014). The combustion process of a sample starts even before the point at which is determined by these analyses, and the first indicator of this combustion is the gas emissions associated.

Adding this conviction with the necessity of studying several different parameters, a new test for the detection of the incipient self-ignition process in solid fuels has been developed and tested with coal and biomass samples (Fernandez-Anez et al., 2014) (Laboratorio Oficial Madariaga (LOM), 2013).

2. Experiments

2.1. Gas emissions tests

The equipment used to carry out these experiments is detailed below (Fig. 1):

- 10 L sealed cylindrical container.
- Isothermal oven P-Selecta.
- Type K thermocouple.
- Digital temperature display Testo 925.
- 1 L Tedlar sampling bags Sigma–Aldrich.
- Gas analyser Rosemount Analytical NGA-2000.

The sample is introduced inside a 1000 cm³ cubical wired basket according to different arrangements (compacted and non-compacted) and this basket is introduced inside the sealed container. The container is closed and connected with the temperature display through a K-thermocouple that is placed inside the sample, approximately at its centre. Before introducing the container, the oven is preheated at the tested temperature.

The sealed container is situated inside the oven to carry out the sample heating. The container has a narrow fitting 3 mm diameter on top where it connects to a plastic tube closed with a Mohr wrench.

Once the desired temperature inside the sample is reached, the plastic tube is connected with the sampling bags by opening the Mohr wrench and they are filled with the gas driven by a suction pump. Due to the small volume of the samples tested, temperature quickly stabilizes and it is considered constant during the sampling time. When the bags are full, they are disconnected from the plastic tube and connected to the analysers. Gases emitted during combustion are measured, starting at the connection between bag and analyser, until gas emission is zero.

The gas analyser Rosemount Analytical NGA-2000 measured emission data of CO and CO₂. Also some H₂O has been observed to condensate inside the tube, but it is not measured because it is not significant for the present research.

To determine the point at which emissions started, the relative percentage of emissions have been determined for each 20 K – interval. These relative percentages have been calculated according to the following procedure.

First of all, relative differences (RD) for each 20 K – interval have been calculated as shown in Equation (1).

$$RD = \frac{e_{T2} - e_{T1}}{e_{T1}} \quad (1)$$

Where e_{T1} means the emissions at the lowest temperature of the interval and e_{T2} are the emissions at the highest temperature of the interval.

After that, relative percentages (RP) are determined by Equation (2) as the division between the relative difference of the interval and the sum of all the relative differences of the experiment, multiplied by 100.

$$RP = \frac{RD}{\sum RD_i} \cdot 100 \quad (2)$$

2.2. Thermogravimetry and differential scanning calorimetry analyses

In Thermogravimetric analysis (TG) the weight loss of a sample is measured when the sample is heated at a constant rate in air as

Table 1
Moisture and granulometry of studied samples.

Sample	Moisture (%)	d10 (μm)	d50 (μm)	d90 (μm)
Wood chips (fine)	6.9	43	153	379
Wood chips (coarse)	7.2	115	600	1150
Sewage sludge	7.2	290	638	1210
Coal	4.0	8	46	166

Download English Version:

<https://daneshyari.com/en/article/6973204>

Download Persian Version:

<https://daneshyari.com/article/6973204>

[Daneshyari.com](https://daneshyari.com)