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Preliminary results on the ash behavior of peach stones during fluidized bed gasification: evaluation of fractionation and leaching as pre-treatments

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Abstract

Peach stones comprise a valuable agroindustrial by-product that is available in many countries of the World and especially in the Mediterranean region. A number of important advantages such as its high energy value, the low ash content in combination with the absence of transportation costs due to the fact that is produced in agro-industries, make peach stones an ideal fuel for energy production via gasification.

Gasification tests were performed in a lab-scale fluidized bed gasifier in order to study the behavior of peach stones and especially its ash during the gasification process. Apart from the tests with the initial peach stone samples, gasification tests were performed using peach stones that had been pre-treated using two different methods fractionation and leaching. Pre-treatments used in order to study their effect on the beneficiation of the materials ash and on the avoidance of ash-related problems such as deposition, agglomeration and corrosion during the gasification process.

A water-cooled steel tube placed vertical to the flow of the gasification gases was used in order to collect samples of ash deposits that were analyzed using SEM-EDX analysis techniques in order to assess the effect of the pre-treatment techniques on the peach stones ash behavior.

The produced results showed that peach stones can be used as gasification feedstock without significant ash problems. Fractionation resulted in a deterioration of the ash behavior of the material, increasing the amounts of alkali metals and chlorine included in its ash, while leaching showed a positive effect but to a moderate extent.

Keywords: Peach stones; Ash; Gasification; Sintering; Deposition; Fractionation; Leaching; Prunus persica

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1. Introduction

Biomass fuels cover a wide range of materials such as wood, energy crops, energy plantations, agricultural and agro-industrial byproducts and wastes, i.e. straws, cobs, hulls and pits, that can be used for energy production using thermochemical conversion methods. Recently, the use of biomass fuels for energy production has gained increasing importance as a substitute for or being used in combination with fossil fuels.

This development is mainly caused by the international concern regarding carbon dioxide (CO_2) emissions. Biomass fuels are CO_2-neutral and their use for energy production could substantially decrease the greenhouse effect at a global level [1,2]. However, the use of biomass fuels for energy production is restricted by the fact that they contain a large amount of elements with very reactive and problematic behavior.

The ash-forming elements, Al, Ca, Fe, K, Mg, Na, and Si, occur in the biofuels as internal or external mineral grains, simple salts such as KCl and $CaSO_4$ or associated with the organic parts of the fuel. Depending on the gas/particle temperature and the redox conditions during the reaction process, these elements may vaporize if they are in the forms of simple salts, while the mineral grains will approach each other and undergo phase transformations, forming fly ash particles. In specific, alkalis and alkali earth metals tend to react with silicon in the form of silica (SiO_2), and create low melting point silicates. The reactions can take place either in the solid phase during the burn-out of the biomass particles char or most commonly in the gas phase where the fly ash particles have been formed [3–5].

Chlorine acts as a facilitator increasing the mobility of potassium since most of it is present as KCl. Potassium chloride is among the most stable high-temperature gas-phase alkali-containing species, while the amount of chlorine in the fuel often dictates the amount of the alkali that can be vaporized during combustion or gasification. Calcium also appears to react with sulfur to form sulfates, but the lower mobility of calcium in combination with the low amounts of sulfur in these biofuels does not make it a significant problem. The produced alkali silicates and/or mixed alkali and/or calcium salts (chlorides/sulfates) have very low melting points that may reach $T < 700\,^{\circ}C$ and tend to deposit on the reactor walls or on the heat exchange surfaces in the case of the conventional grate-fired systems, increasing the deposition and corrosion problems observed. In the case of the fluidized bed reactors, they contribute significantly, especially KCl, to bed sintering and defluidization through the development of a sticky deposit layer on the surface of the bed particles [6–9].

The aim of this work is to study the effect of leaching, and fractionation pre-treatment techniques on the ash behavior of the peach stone material during gasification in a lab-scale gasifier. Leaching has been seen to beneficiate the ash of the treated materials by decreasing the amounts of alkali metals, chlorine, sulfur and also the total ash amount in variable levels depending on the material and the applied leaching conditions [10–12]. The results from various experimental trials varying from lab-to-commercial scale [13–16] clearly demonstrate that the combustion properties and the ash behavior of the leached biomass can be improved to an extent. On the other hand, fractionation affects positively mainly the total ash content of the treated material, while its effect on the chemical composition of the ash depends mainly on the specific characteristics of the material [10]. The produced results showed that there was a clear improvement regarding both the chemical composition and the amounts of ash in the case of leaching, while in the case of fractionation the results appeared to be encouraging regarding only the reduction of the ash amount contained in the material.

2. Experimental

Greek peach stones (*Prunus persica*), were used as feedstock material during the gasification tests. Peach stones consist of kernels and pulp and they are produced as by-product from the production of stewed fruits and/or natural juices in agro-industrial factories. The material was supplied by a local juice company situated at the area of Argos,