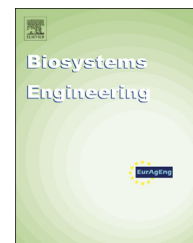


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Research Paper

Effects of mineral contamination on the ash content of olive tree residual biomass

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The rise in energy consumption has made the use of alternative fuels a priority. Residual biomass is an abundant renewable energy resource whose use can lead to significant socioeconomic and environmental benefits. This biomass is destined to play an important role in the new energy model since agricultural residues are produced in huge amounts throughout the world. Consequently, converting this residue into an energy product increases the value of these waste materials and reduces the environmental impact of waste disposal. The generation of agricultural residues from the olive sector in the Mediterranean area is an important source of residual biomass highly suitable for thermal energy generation. This biomass comes from olive groves and olive oil production plants that generate by-products with high energy content. However, since the properties of biomass are dependent on a wide range of factors, the focus of our research was to analyse all of its forms (leaves, branches, bark and wood) separately in order to better understand their thermal behaviour and assure the quality of the final energy product. The determination of the ash content for each type of olive tree residual biomass indicated that olive leaves were responsible for the high ash content of this biomass. As a result, various cleaning methods were used to study the effect of the mineral contamination from leaves on the final ash content. The ashes were also analysed with a microscope to ascertain their composition.

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1. Introduction

In recent years, there has been increasing interest in sustainable energy production in countries throughout the world. A major contribution to sustainable energy is expected to come from biomass as a renewable and CO₂-neutral energy source. Residues from agricultural production and processing industries are readily available in large quantities. Solid wastes are generated by a wide range of activities in modern

society, the disposal of which is no longer viable due to high costs and stricter environmental regulations. Furthermore, the conversion of this residue into energy increases the value of waste materials, mitigates the environmental impacts of waste disposal, and reduces waste mass and volume (Vamvuka & Kakaras, 2011).

The combustion of biomass is assumed to be a CO₂ neutral process if its consumption rate is not greater than its growth rate. Since this source of energy is regarded as environmentally friendly, it has become a focus of interest in many

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countries. New and upgraded solid biomass fuels (i.e. pellets, briquettes and powder) are now widely available. In fact, fuel pellets are particularly well-suited for the residential market (Öhman, Boman, Hedman, Nordin, & Boström, 2004) because of their high energy content and minimal need for ash removal (Rhén, Gref, Sjöström, & Wästerlund, 2005).

Nevertheless, one of the problems associated with biomass combustion is related to the ash content of the material. The quantity and quality of ash produced during the biomass combustion process are strongly influenced by the properties of the biomass and the combustion technology, including the characteristics of the furnace, temperature of the process, and ash extraction systems. Inorganic species in biomass fuels, such as alkali oxides and salts, can intensify agglomeration, deposition, and corrosion problems on the heat transfer surfaces of boilers (Tortosa Masiá, Buhre, Gupta, & Wall, 2007). Therefore, despite the obvious benefits of using biomass as a fuel source, technical difficulties related to the inorganic part of biomass fuels can lead to the reduced accessibility of biomass combustion systems. It goes without saying that this is also bad publicity for the residential pellet market (Öhman, Nordin, Hedman, & Jirjis, 2004; Rhén et al., 2005). The quality of pellets is determined by the end-user's requirements for the heating system and for handling properties. Higher ash content lowers the heating value of the pellets and increases the risk of sintering. Since this also negatively affects milling and pelleting equipment (Lehtikangas, 2001), the calculation and subsequent reduction of the ash content in biofuels is crucial to enhance their quality.

In the Mediterranean areas of southwest Europe, agricultural activities are very important, but they produce large quantities

of residue. This is the case of olive tree residues, which have traditionally been used for domestic heating in rural areas and which are an important source of residual biomass. One hectare of olive trees generates approximately three tons of different types of residual biomass (i.e. 0.7 t of wood, 1.5 t of branches, and 0.8 t of leaves) per year (AAE, 2008), most of which are now illegally burnt or left on the ground (Junta de Andalucía, 2009). Exploitation of the energy in this biomass would allow the sustainable replacement of fossil fuels. Furthermore, it would increase self-sufficiency and energy diversification, besides contributing to the development of rural areas. Nevertheless, certain characteristics, such as the higher ash content of pellets from olive trees (Ollero, Serrera, Arjona, & Alcantarilla, 2003; Zamorano, Popov, Rodriguez, & Garcia-Maraver, 2011) in comparison to other European pellets (Lehtikangas, 2001) have raised doubts concerning the viability of their use in thermal applications, especially in domestic heating systems.

During the harvesting of olive tree residues, mobile and mechanical equipment adapted to the conditions of the grove are used to improve their processing and transport (Fig. 1). According to previous research, the mechanized harvesting of this residue requires that the dimensions of the residue between the tree rows be 1.5 m in width and at least 1 m in height (IDAE, 2008). However, during this collection, soil is also picked up along with the biomass, which reduces its final quality and increases the ash content, primarily because of the sand contamination of the raw material during storage and handling (Öhman, Nordin et al., 2004).

In this research, fresh and stored materials from different olive tree residues were separated to determine their ash



Fig. 1 – Collection equipment of olive tree pruning residues (IDAE, 2008).

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