



Oxidative torrefaction of biomass residues and densification of torrefied sawdust to pellets

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HIGHLIGHTS

- ▶ An oxidation torrefaction kinetics model was developed based on TGA data.
- ▶ Sawdust was torrefied in a fluidized bed reactor using oxygen-laden combustion flue gases.
- ▶ Torrefied sawdust was compressed into pellets of properties similar to regular pellets.

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ABSTRACT

Oxidative torrefaction of sawdust with a carrier gas containing 3–6% O₂ was investigated in a TG and a fluidized bed reactor, with the properties of the torrefied sawdust and pellets compared with traditional torrefaction without any O₂, as well as the dry raw material. It is found that the oxidative torrefaction process produced torrefied sawdust and pellets of similar properties as normally torrefied sawdust and corresponding pellets, especially on the density, energy consumption for pelletization, higher heating value and energy yield. For moisture absorption and hardness of the torrefied pellets, the oxidative torrefaction process showed slightly poor but negligible performance. Therefore, it is feasible to use oxygen laden combustion flue gases as the carrier gas for torrefaction of biomass. Besides, torrefied sawdust can be made into dense and strong pellets of high hydrophobicity at a higher die temperature than normally used in the production of traditional control pellets.

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1. Introduction

Currently, the interest in developing renewable energy has received considerable attention. Among these renewable energies, the unique position of biomass as the only renewable source as a sustainable carbon carrier makes biomass an attractive energy source (Pa et al., 2011). However, structural heterogeneity, non-uniform physical properties, low energy density, high moisture content and a hydrophilic nature of biomass have become major problems in its efficient and economic transport, handling, storage and conversion into bioenergy products (Lam et al., 2012). In order to address the above problems, biomass needs to be pretreated or upgraded in order to improve its quality for efficient energy conversion (Stelt et al., 2011; Uslu et al., 2008).

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Torrefaction is a mild pyrolysis of biomass at temperatures between 200 and 300 °C, normally in the absence of oxygen (Chen et al., 2011b; Medic et al., 2012). During torrefaction of biomass, considerable increase in energy density is achieved, whilst its fuel properties are improved to yield a fuel of much better quality for combustion and gasification applications (Chen et al., 2011a; Prins et al., 2006). The grindability is also improved by torrefaction to enable more efficient co-firing in existing pulverized coal power plants or entrained-flow gasifiers for the syngas production (Bergman et al., 2005b; Phanphanich and Mani, 2011). In combination with pelletization, torrefaction also aids in addressing the logistic issues for untreated biomass pellets, such as low energy density and low hydrophobicity. Torrefied pellets can potentially reduce the handling costs and result in a solid fuel of standardized shape and size that can be fed automatically to solids-fuel boilers for heat and power generation (Bergman, 2005a). As a result, there