Combustion properties and environmental performance during small scale combustion of pelletized hardwood raw material of aspen

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ABSTRACT

The over all objective of the project was to study the combustion properties and emission performance during combustion of pelletized hardwood raw material in typical residential appliances. Unbarked aspen trees including branches and twigs were used in this project with the specific objectives to determine; ***i)*** combustion performance (ash formation, accessibility and slagging tendencies), ***ii)*** environmental performance (emissions of gases and particles) in present residential appliances and ***iii)*** combustion characteristics (total conversion time/reactivity) of single pellets. The project was a pilot study that enables a first evaluation of the potential of pelletized hardwood (deciduous) raw material to be used in residential combustion appliances. The aspen raw material showed fully acceptable pelletizing properties and the produced pellets was comparable with present softwood pellets with respect to bulk density, length and fraction of fine material. The inclusion of bark increased the concentrations of some major ash forming elements (K, Ca and Mg) as well as some trace metals (Zn, Cu and Pb) compared to chips (low-bark) of the aspen material and reference wood pellets. No operation problems (e.g. ash related) were seen during the 24 h combustion tests that were performed in two typical pellet burners. The low slagging tendency was probably related to the low content of silicon and high content of calcium in the aspen fuel. Somewhat higher emissions of CO, NO and PM_{tot} was determined for the aspen fuel compared to reference values for residential wood pellet combustion at nominal load. The PM was totally dominated (95%) by fine submicron particles consisting mainly of potassium, carbon and sulfur, presumably as potassium carbonates and sulfates. The increased PM emissions are most certainly caused by the relatively high concentrations of potassium in the aspen fuel used. Further, the combustion characteristics/char reactivity and char yield for single pellets of aspen and reference pellets were performed in an electrically heated laboratory heated furnace. Also, char density and pellets shrinkage and weight reduction after pyrolysis were determined. In principal, very similar combustion behavior were seen for the aspen pellets compared to reference wood pellets. On conclusion, this relatively small study, illustrate that aspen raw material seem to have a good potential to be used for production of fuel pellets regarding aspects of pelletizing process, pellets quality and combustion properties. However, one must consider the fact that this kind of whole tree assortments will increase the content of ash forming elements and trace metals in the fuel (and therefore also in the ash and emissions) as well as potentially increased emissions of both gases and particles compared to present stemwood based fuel pellets. These aspects are, however, related to the presence of bark and other non-stemwood fractions in the fuel, and therefore coincide with the general issues (fuel- , technical- and environmental orientated) to consider if/when the fuel feedstock for pellets production is to be expanded with new forest and agricultural based raw materials.

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