

Efficient Fuel Pretreatment: Simultaneous Torrefaction and Grinding of Biomass

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ABSTRACT

Combining torrefaction and grinding of biomass in one reactor may be an attractive fuel pretreatment process. A combined laboratory torrefaction and ball mill reactor has been constructed for studies of the influence of temperature and residence time on the product yields and particle size reductions of Danish wheat straw, spruce chips, and pine chips. On the basis of initial experiments, which evaluated the influence of reactor mass loading, gas flow, and grinding ball size and material, a standard experimental procedure was developed. The particle size reduction capability of the torrefaction process has been evaluated by the relative change in d_{50} , and this method was compared to the Hardgrove grindability index (HGI), showing reasonably similar results. Significant differences in torrefaction behavior have been observed for straw and spruce chips torrefied at 270–330 °C. Torrefaction of straw for 90 min yielded a higher mass loss (27–60 wt %) and relative size reduction (59–95%) compared with spruce (mass loss of 10–56 wt % and size reduction of 20–60%). The two types of biomass investigated differ with respect to hemicellulose type, lignocellulosic composition, particle morphology, and ash composition, where straw has a higher alkali content. This and other studies indicate that the large difference in the alkali contents of the biomasses is the main cause for the observed difference in torrefaction characteristics. Experiments with separate particle heating and grinding showed a swift grinding of the torrefied biomass. This implies that the rate-limiting step in the laboratory reactor is the heat transfer and not the grinding process. Large pine particles (8–16 mm) showed a slightly higher mass loss than 4–8 and <4 mm particles. This could be the consequence of exothermic reactions in the particle core, which locally increase the temperature and conversion.

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