Design of a fountain confined conical spouted bed reactor for biomass torrefaction

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Highlights

- New alternatives are required for continuous torrefaction of biomass.
- The performance of a conical spouted beds has been evaluated.
- The configurations leading to stable operation were identified.
- A battery of reactors is required to increase torrefaction performance.

1. Introduction

Torrefaction of biomass is commonly carried out in a great variety of reactors, such as rotary drums and fluidised beds. Nevertheless, spouted beds are a promising alternative, as they allow operating with large particle size materials, such as those of biomass. Furthermore, continuous torrefaction of biomass in spouted beds is commonly conducted using beds of inert materials. Thus, biomass is fed into the upper surface of the bed and the torrefied biomass is entrained through a top outlet pipe on the other side from the inlet. Nevertheless, this configuration leads to a continuous steady state operation with a high fraction of coarse particles in the bed. Accordingly, new alternatives are required for continuous operation, preferably those involving beds made up of only biomass and high solid circulation.

2. Methods

Therefore, this study deals with the performance of a fountain confined conical spouted bed, in which hydrodynamics was evaluated using different biomasses (rice husk, almond shell and olive stone). Moreover, the effect of the draft tube and the fountain confiner was analysed and the configurations leading to stable operation were identified. Furthermore, the minimum spouting velocity and operating pressure drop were measured.

3. Results and discussion

The hydrodynamic behaviour of beds made up of almond shells has clear similarities with those of olive stones, which is explained by the common features of these solids. Furthermore, use of a draft tube, especially an open-sided one, reduces the minimum spouting velocity, but increase the solid residence time in the annulus. Accordingly, beds with draft tubes are suitable for increasing the torrefaction performance in conical spouted beds. Moreover, the presence of a fountain confiner avoids solid entrainment and allows increasing the gas-solid contact, which also leads to better torrefaction performance.

4. Conclusions

Overall, the results allow delimiting the operating conditions for biomass torrefaction in fountain confined conical spouted beds. Nevertheless, since torrefaction of biomass requires long solid residence times, a battery of reactors in series (or a multi-spout) is required in order to increase the gas-solid contact, especially in industrial scale fountain confined conical spouted bed reactors.

Keywords

Spouted bed, torrefaction, fountain confiner, reactor design.