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CFD modelling of biomass fast pyrolysis in a solar trough receiver/reactor

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Concentrated solar thermal energy is capable of providing zero emission when used for biomass thermochemical conversion to fuels and chemicals. Fast pyrolysis of biomass is a highly endothermic process that takes place in the absence of oxygen at a fast heating rates (>300 ^{o}C/second) and a high heat flux to maintain the reactor temperature in the range of 400-550 ^{o}C. The solar thermal heat produced in a solar trough receiver/reactor is ideal for such operating conditions.

This study presents a three-dimensional computational fluid dynamic (CFD) to simulate fast pyrolysis of biomass in a solar trough receiver/reactor equipped with a novel gas solid separation system. The separator allows for better control of undesirable secondary vapour cracking reactions by reducing its residence time as well as achieving more than 99% gas-solid separation efficiency for solid particles greater than 45µm. Two-fluid (Eulerian-Eulerian) model, solved using ANSYS Fluent CFD software, was used by representing both the gas and solid as continuum phases under intense thermochemical decomposition. The biomass conversion reaction was assumed to be driven by concentrated solar radiation, received at a constant heat flux on the receiver/reactor outer surface. The pyrolysis reaction was represented as a first-order global reaction to produce solid carbon (bio-char), condensable (bio-oil) and non-condensable gases. The results demonstrate the great potentials of this concept for thermo-solar systems in general, and for biomass fast pyrolysis in particular. This study also demonstrates the CFD modelling capability for future development and optimization of solar reactors.

Keywords: biomass pyrolysis; CFD; concentrated solar energy; parabolic trough