Performance of biomass pyrolysis products MILD combustion in a cyclonic burner

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Abstract
Energy vectors play a key role in supporting the integration of alternative and renewable energy sources in the fast evolving concept of smart energy grid. They include many fuels, among which bio- or deriving from thermochemical conversion of biomass unquestionably occupies a relevant role. On the other hand, due to the high content of diluent, which varies case by case and depends on the conversion process from biomass and on the biomass itself, the direct utilization of these low-grade fuels requires combustion technologies able to ensure high combustion efficiency, fuel and thermal load flexibility. In this respect, MILD combustion [1] is one of the most attractive. In fact, MILD combustion is suitable for the direct conversion of low calorific values, as gases deriving from bio- or thermochemical degradation of biomass are. With this background, in this work combustion performances of several model gas surrogates were experimentally investigated in a cyclonic burner under MILD conditions. These fuels were identified as gaseous fraction of biomass pyrolysis products, obtained from different feedstocks and condition ($43<\%CO_2<71$, $16<\%CO<39$, $6<\%CH_4<9$, $2<\%C_2-<4$, $0<\%H_2<3$). In particular, combustion stability and pollutant emissions were analyzed with respect to fuel composition, preheating level, equivalence ratio and thermal power. In this respect, experimental results showed that the oxidation process can be stabilized in a wide range of equivalence ratios by means of an effective preheating strategy, due to the high CO_2 dilution characterizing the gas surrogates. In fact, operational temperatures decrease by increasing the CO_2 amount in the fuel mixtures, being always lower than 1400K for all the investigated conditions. With respect to the speciation, the mixture composition and considered operational parameters slightly affect NO_x emissions, that always keep lower than 10 ppm, whereas CO emissions depend on both CO-CO_2 ratio in the fuel mixture. In particular, lower CO emissions have been detected for the fuel mixture with the lowest $\%CO_2$, despite the highest %CO. This behavior is due to the slightly higher operative temperature detected for the identified case, that allow to stabilize the oxidation process in a wider range of equivalence ratios, thus converting all the CO to CO_2.

Reference
[1] Sabia P, Sorrentino G, Ariemma GB, Manna M V., Ragucci R, de Joannon M. MILD Combustion and Biofuels: A Minireview. Energy and Fuels 2021;35:19901–19.