A REDUCED KINETIC MECHANISM FOR JET-A1 COMBUSTION IN VITIATED AIR

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Abstract
Understanding the fundamental oxidation properties of jet fuels is essential for the development of aircraft engines and the improvement of aeronautical propulsion systems, in particular for non-conventional applications, like vitiated air-conditions (i.e. afterburner chamber conditions). The presence of non-negligible concentrations of CO_2 and H_2O in the combustion chamber can affect the combustion properties, as largely demonstrated in literature for the oxidation of hydrogen and other hydrocarbons. However, few studies have been carried out to date to investigate the effects of vitiated air on aviation fuels. Given this framework, JetA1 oxidation experiments were carried out in a Jet Stirred Flow Reactor (JSFR) as a function of the inlet temperature, at fixed dilution level (in N_2 and N_2-CO_2 as diluent species), residence time and equivalence ratio, at nearly-atmospheric pressure. Temperature and species concentrations were collected for different operative conditions, to outline a reference database for a kinetic model reduction.
The experimental tests suggested that CO_2 can affect the oxidation behaviour of JetA1. In particular, due to its high specific heat capacity, it reduces the maximum temperature increment of the system. CO_2 concentration equal to 20% has a slight promoting effect on system reactivity in the low-temperature range (950-1030 K), while at CO_2=50, 70%, the oxidation process is delayed, thus a higher inlet temperature is required to ignite the mixture.
At T<1000 K, the unburnt species formation is slightly affected by CO_2, while for higher temperatures, the mixture with 50% CO_2 oxidizes with the highest CO formation whereas the mixture with 70% CO_2 produces the lowest concentrations of H_2 and CO_2.
A two component fuel surrogate (20% C_7H_8, 80% $nC_{12}H_{26}$) was identified for the numerical investigations, based on the chemical analysis on the JetA1. Different kinetic mechanisms were tested against the obtained data, observing in general a good agreement with the experimental results. The smallest-size model was selected for a further mechanism reduction. A reduced scheme, consisting of 59 species and 591 reactions was obtained by a sequential use of different Direct Relation Graph (DRG) techniques. The reduced model reproduces well the target temperature and species profiles; nevertheless a further optimization is necessary to reproduce better the CH_4 concentration in the temperature range 950-1050 K.