H_2O EFFECT ON PROPANE AUTOIGNITION DELAY TIMES UNDER MILD COMBUSTION OPERATIVE CONDITIONS

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MILD combustion is an innovative technology for energy production in an efficient and eco-friendly way. It takes place when reactants are diluted outside flammability limits and pre-heated up to temperatures higher than autoignition mixture temperature. Moderate working temperatures, due to high dilution levels, are below critical conditions for main pollutants formation (NOx, soot). Furthermore it represents the most effective way to burn low-calorific value fuels without drastic changes of the combustion unit.
Fuel oxidation under MILD conditions is totally different with respect to traditional flames thus, because of the lack of knowledge of basic aspects of the process, a fundamental analysis of phenomena promoted by these novel operative conditions along with the identification of optimal range of parameters in which plants should be exercised are mandatory in order to promote its spreading as leader technology in the framework of low carbon energy and energy efficiency outlined by European Community.
The aim of the work was to characterize combustion regimes and to evaluate autoignition delay times of hydrocarbons in MILD conditions. Attention was devoted to H2O effects on the ignition process because, in practice, dilution and preheating are generally obtained through high levels of exhaust gas recirculation (high percentages of CO2 and H2O) in the reaction volume.
Experimental tests were carried out at atmospheric pressure in a tubular flow reactor. Propane/oxygen mixtures diluted in H2O at 90% were used. Propane was chosen as reference fuel because it is the simplest hydrocarbon with oxidation kinetics similar to those of heavier paraffins. Carbon/Oxygen ratio (0.035-1) and inlet temperatures (900-1240 K) were changed.
A richness of phenomenologies (ignition, no combustion, pyrolysis, low reactivity, dynamic, transient) was experimentally observed and characterized. In fact high dilution levels significantly slow down oxidation routes, while high preheating temperatures promote fuel pyrolytic reactions, thus changing their relative weight and promoting the onset of several regimes not recognizable in traditional systems, where the typical high temperature gradient implies a fast transition among them.
Moreover, experimental results showed that H2O inhibits ignition process in the analyzed temperature range compared to mixtures diluted in N2 or CO2, tested in previous works.
In parallel, numerical simulations were performed by means of software CHEMKIN and Cantera and the comparison with experimental results showed the need to optimize detailed kinetic mechanisms to MILD conditions. Numerical analysis showed the main reactions constrained by the presence of H2O, which requires action for the updating of kinetic mechanisms. In this perspective, experimental results represent a rich database very useful to improve reliability and robustness of kinetic schemes which is a fundamental step in the implementation of reduced models in CFD codes for designing industrial systems.

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