EXPERIMENTAL AND NUMERICAL INVESTIGATION OF FLAMELESS COMBUSTION OF LOW CALORIFIC VALUE GASES FOR THE IRON AND STEEL INDUSTRY

A. Gambale, D. Lupant, B. Pesenti, P. Lybaert
alessandro.gambale@umons.ac.be
Université de Mons - Service de Thermique et Combustion
Rue de l'Epargne, 56 - B-7000 MONS

Within the iron and steel industry, waste gases such as blast furnace gas (BFG) and Coal Oven Gas (COG) are produced and can be used to fuel gas turbines and generate power. These gases are mainly composed of CH4, CO and H2 in variable proportions. While generation of a stable flame is difficult because of the variable calorific value and ignition characteristics of these gases, diluted flameless combustion can simultaneously be stable and produce low emissions [1] [2].
Flameless, or diluted, combustion is achieved by preheating the combustion air and fuel above the auto-ignition temperature of the mixture and by creating a strong recirculation of burnt gases inside the combustion chamber, which leads to a dilution of the fuel-oxidizer mixture. This causes the combustion region to be extended in the whole furnace, rather than concentrated on a flame front as in common burners. Dilution avoids the formation of thermal hot spots, significantly reducing nitrogen oxides and carbon emissions without compromising the efficiency [3] [4].
The aim of this work is to characterize the combustion features of low calorific fuels (blends of CO, CH4, H2 and N2) in diluted combustion conditions, with focus on the effects of fuel composition on thermal efficiency and pollutants production. This study is based on both numerical simulations and experiments on a 30 kW combustion chamber. Combustion regimes [5] and properties are characterized by means of measurements of gas composition inside the combustion chamber, flue gas temperature and composition (including NOx) and intensity of the chemiluminescence emission of OH radicals in the reaction zone.

References

[1] Parente, A., C. Galletti, and L. Tognotti, Effect of the combustion model and kinetic mechanism on the MILD combustion in an industrial burner fed with hydrogen enriched fuels, International Journal of Hydrogen Energy 33, no. 24
[2] Derudi, M., VillaniA., and Rota, R., Sustainability of mild combustion of hydrogen-containing hybrid fuels, Proceedings of the Combustion Institute 31, no. 2 (January 2007): 3393-3400.
[3] Wunning, J. A., and J. G. Wunning, Flameless oxidation to reduce thermal no-formation, Progress in Energy and Combustion Science 23, no. 1 (1997): 81-94.
[4] Lupant, D., Pesenti, B. and Lybaert, P., Characterization of flameless combustion of natural gas in a laboratory scale furnace, Proceedings of the "European Combustion Meeting ECM 2007", Chania, Crete, avril 2007
[5] Sezgin, E, Pesenti, B., Lupant, D. and Lybaert, P., Development of stability diagrams of flame in diluted combustion, Proceedings of the "European Combustion Meeting ECM 2009", Vienne, Avril 2009