POLLUTION ASPECTS

(600) - DESIGN AND TESTING OF A MULTI-FUEL INDUSTRIAL BURNER SUITABLE FOR SYN-GASES, FLARE GAS AND PURE HYDROGEN

Gianluca Rossiello (Italy)[1]; Lorenzo Morandi (Italy)[2]; Diego Maggiolini (Italy)[2]; Marzio Ferrara (Italy)[2]; Marco Torresi (Italy)[3]; Seyed Behzad Ahmadpanah (Iran)[3]; Giuseppe Blasi (Italy)[3]; Giuseppe Molfetta (Italy)[4]; Gabriele Domenico Rago (Italy)[4]; Alessandro Saponaro (Italy)[4]

1 - Itea SpA (Sofinter group), Largo Buffoni n.3, 21013 Gallarate (VA), ITALY; 2 - Macchi (division of Sofinter SpA), Largo Buffoni n.3, 21013 Gallarate (VA), ITALY; 3 - Department of Mechanics, Mathematics and Management, Polytechnic University of Bari, Via Re David, 200 – 70125 Bari, ITALY; 4 - Centro Combustione Ambiente SpA (CCA, Sofinter group), via Milano km 1,600, 70023 Gioia del Colle (BA), ITALY

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The need to reduce Greenhouse Gases (GHG) emissions in a context of increasing steam demand for process/industrial applications is leading the development of a new generation of heavy-duty burners able to accompany and promote energy transition from fossil to renewable fuels. The capability to burn with high efficiency and low emissions a wide range of fuels going from natural gas to flare gases with different compositions and even low heating values, up to pure hydrogen is already strategical in the current quickly evolving scenario, and motivated the team of Macchi in cooperation with CCA to design, engineer and test an innovative Low-NOx Multi-Fuel heavy-duty gas burner. The present paper gives an insight into the design process, starting from the conceptual definition of the operating principles, and going through CFD analyses and prototype experimental testing, which represent the steps taken in the framework of the R&D project named “BE4GreenS” supported by *Regione Puglia*.

First of all, the burner was designed on a 2.5 MW prototype scale, taking into account the main targets of flame stability, variable capacity, low NOx emissions and possibility to be fed by extremely different gaseous fuel streams, *even simultaneously*: each feature was pursued by specific components or operating characteristics. With CFD analysis on the 2.5 MW prototype, the operating principles have been verified and analysed in much detail, with a deep insight into both cold and hot aerodynamics. Then a 1.5 MW prototype was designed and tested with natural gas – either pure or diluted with nitrogen to mimic a low heating value flare gas – and with increasing percentage of hydrogen up to 100%. Finally a 35 MW prototype has been designed and tested providing full-scale data and validating the design.

The CFD simulations – carried out with natural gas as fuel on 2.5 MW scale – clearly show all the operating principles and the peculiarities of the Multi-Fuel burner, including the stabilization recirculation region and the external low temperature combustion zone with relevant entrainment of exhausts, which shifts the conventional diffusive combustion process toward the “MILD” regime. Moreover different fuel injection configurations were studied to define a suitable orientation for nozzles.

Experimental testing on 1.5 MW prototype in a refractory lined furnace confirmed the good performance of the burner with all the fuel streams, showing excellent flame stability even without central stabilization gas feed. As expected, increasing the fuel heating values, increasing NOx emissions have been registered. Keeping a very low excess of air and almost no carbon monoxide in the exit flue gases, the absolute NOx levels compare well with state of the art Low-NOx industrial burners developed for standard fossil fuels.

The complete development process from conceptual design to full-scale testing has been carried out and described, leading to the definition and analysis of a Multi-Fuel burner suitable for extremely different gaseous streams. Further work will compare full scale and prototype testing on one side, and carry on a CFD analysis to shed light on the NOx formation mechanism in different operating conditions.

Palavras-chave : MILD combustion, CFD analysis, Fuel flexibility, Low-NOx hydrogen burner, Biogas