MODELLING OF FURNACES AND COMBUSTION SYSTEMS

(625) - (*) - ACCURATE THERMAL ANALYSIS OF OIL/GAS BOILERS BY INTEGRATED USE OF CFD AND FIELD DATA

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In the context of the ongoing energy transition from fossil to renewable energy sources, it is essential for steam boiler designers to improve and refine simulation capabilities to properly manage and fully exploit a wide range of liquid and gaseous fuels with extremely variable characteristics, going from bio-oils to low calorific value waste gases, taking up the challenge to combine the best performances – efficiency/emissions – reached with traditional fossil fuels, with the upcoming market demand for maximum flexibility and for conversion to cleaner fuels or for energy recover.

Indeed, affordable and reasonably fast CFD simulations make estimation of boiler performance possible in several completely different operating conditions, thus allowing optimal integration into the furnace of burners as well as additional features like over-fire-air, flue-gas-recirculation, gas mixing, required to achieve restrictive emission regulations minimizing costly post-treatment of flues.

The present paper summarizes the results obtained in a study – carried out within the "BE4GreenS" R&D project supported by *Regione Puglia* – in which accurate CFD prediction of thermal fluxes and temperature field are validated by means of experimental data. Indeed, CFD is a precious tool providing insight into local effects, but often lacks affordable input data to obtain accurate quantitative estimations needed to address design, while site testing can supply few but highly dependable data.

Taking advantage of AC Boilers activity on boilers – starting from design and up to on-site testing and operation – plant data were selected to provide validation for CFD analysis. Two different kinds of boiler have been considered: a 6-burner steam generator – two units in a refinery fed by process-gas or fuel-oil – and a 32-burner boiler – 4 units generating steam in power plant for an advanced super-critical Rankine cycle – fuelled by natural gas or fuel-oil. The field "master" data are essentially steam output, fuel input and its properties, and oxygen in the flue gases exiting the furnace: by these data and mass/energy balances the furnace exit temperature is obtained.

In particular for the 6-burner boiler both gas and oil feeding are considered at full and partial loads. First gas data allowed to set up correctly the mean heat-exchange parameters for membrane walls to be used in CFD – emissivity and heat-transfer coefficient dependent on *fouling* – then oil testing data were used to tune soot modelling, i.e oil flame emissivity crucial to properly catch radiation inside the furnace. The 32-burner boiler data, then, worked like validation test, using the same modelling and heat exchange parameters tuned in the previous step, on a significantly different case with flue-gas-recirculation and over-fire-air, excellent agreement is found between CFD and field data, both for natural gas and heavy-fuel-oil operation.

The results confirm that using physically meaningful validated parameters and models exempt by tuning even in quite different cases. In perspective, experienced use of CFD, together with reliable collection of site data, put boiler designers a step ahead in the present outlook of new and varied fuels applications and for cutting-edge optimization of systems and performance.

Palavras-chave : Multi-Fuel steam generator, Validation by DCS data, Combustion optimization, Soot modelling, Membrane walls heat exchange