Oxy-flame combustion at IFRF, past, present and future

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The presentation reviews the activities on oxy-flame combustion carried out at IFRF in the last ten years and the tests currently carried out with ENEL at Livorno experimental facilities.
In particular, the oxy-combustion campaign objectives and programme are the following.

1) Study the feasibility of the conversion of the FOSPER plant (IFRF furnace #1) from conventional combustion to oxy-combustion with recycled flue gas.
2) Study the retrofitting issues to identify the ones that can arise in industrial scale plants, with particular scope of maximizing the CO_2 contents in the flue gases.
3) Study the influence of different burners and their settings and of the recycle ratio on the burner stability, flame radiation and NO_X emission.
4) Perform in-flame measurements both in conventional air combustion, to be used as baseline, and in oxy-combustion to develop a better understanding of the process of combustion with pure oxygen and recycled flue gas.
5) Characterise the solid fuels used in the semi-industrial tests in terms of devolatilisation and oxidation/gasification behaviour in condition typical of flue gas recirculation and pure oxygen. These tests are performed by means of the IFRF Isothermal Plug Flow Reactor (IPFR) operating in oxy-fuel conditions
6) Develop sub-models for oxy-fuel conditions to be used in comprehensive code for industrial furnace simulation. The data sets collected in all the trials are also intended to provide validation cases for CFD.

Retrofitting and plant modification: the activity going on
Retrofitting a plant means modifying an existing conventional plant in order to burn fuel with a mixture of O_2 and recycled flue gas.
The main achievements of initial trials were to assess FOSPER rig modification from a conventional air combustion plant to a facility capable to perform oxy-combustion with recycled flue gas.
The plant modification were thought to make it as much flexible as possible in order to have a large number of experimental configurations available. Being so, it is possible to set the following parameters during experimental tests in FOSPER facility:

1. Wet/Dry recycle – a condenser is been installed in the flue gas recycle line, in order to enable both dry recycle and wet recycle.
2. Ljungström mode – the Ljungström can be by-passed, both in comburent and in the flue gas sides, in order to study the influence of this equipment in the air-in leakage into the system.
3. Oxygen injection – there is the possibility of having oxygen in the primary gas, injecting it in primary duct of the burner. It was chosen not to mix it with the transport flue gas before the transport of the coal for safety reasons.

Downstream the plant, it had been installed a condensing heat exchanger. Its purpose is to capture the water vapour produced in the combustion before the flue gases are sent back into the furnace. In this unit there is a system to neutralize the pH of the condensate, which is expected to be very low due to the solubilisation of the SO_2 present in the flue gas that in water transforms in H_2SO_4.
In particular the problem of the air in-leakage is resulted the major cause of the level of the CO_2 in the flue gases lower than expected. In industrial scale plants, especially in the older ones, this might be a critical point from the economic point of view and can determine the feasibility of the retrofitting.

The in-flame data collected during the campaigns are to be published in an IFRF report and may be used to develop a better understanding of the changes in the chemical and physical processes involved in this kind of combustion. They can also provide modelers with a starting hint for the development of oxy-combustion flame mathematical simulation.