Lab-scale experimental characterization of oxy-coal combustion with steam moderation

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Oxy-fuel combustion with steam moderation has been proposed as a way to improve the operability and efficiency of oxy-combustion power plants. By this alternative, oxygen is mixed with steam that plays the role of the recycled CO2 in original oxy-fuel utility boilers. Thus, the flue gas is mainly constituted by CO2 and H2O, which can be mostly condensed resulting in an almost pure CO2 stream for transport and sequestration. A fraction of the condensed water can be re-boiled using available heat in the flue gases and redirected to the furnace. In comparison to O2/CO2 recycled combustion, this novel process gathers some advantages: a simpler plant layout, lower operational costs, lower volumetric flow rates through the boiler, fewer air in-leakages, and no need for the filtration stage of recirculated gases.

So far, few and limited studies have addressed the research of the effects of large steam concentrations on coal ignition, combustion efficiency (unburned carbon rates) and pollutants emissions (SO2 and NOx). To this purpose, a new lab-scale entrained flow reactor has been erected and started-up at the University of Zaragoza (Spain). The facility is designed to fire pulverized fuels, with the capability of feeding multiple gas atmospheres (O2/N2, O2/CO2, O2/CO2/H2O) with steam concentrations up to 50% vol.

An experimental campaign is being executed, focused on two of the coals fired in Spanish power plants: a high rank anthracite and a blend of imported sub-bituminous with domestic high-sulphur lignite. Both samples were previously milled and sieved to provide a 75-150 µm feed sample. Gas flow through the reactor is set to ensure particle residence times in the range 2-3 s at operational temperatures in the range 1000-1150ºC. Gas mixtures fed to the reactor include O2/CO2 environments that cover O2 concentrations from 20 to 40 % vol., with oxygen excess from 15 to 30%. To study the effect of steam addition, replacement of CO2 by steam is carried out up to 40 % vol. H2O. In a further stage, the effect of re-injecting pollutants in the reactor will be also sought.

On-line measurements are continuously recorded during the trials to seek the effect of the operating conditions on the pollutant formation and the combustion efficiency. On-load samples are also

taken from the dust separator to after determine the unburned carbon rates as well as to proceed with a morphological and chemical characterization of the ashes. The obtained results during these campaigns will allow to assess the effects of large addition of steam and to ascertain the feasibility for a future scale-up of this technology.