2nd Oxyfuel Combustion Conference

Design of 300kW Oxy-CFB Test Rig

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1. Introduction

Combustion process under the atmosphere of flue gasses and oxygen (Oxyfuel-Process) was mostly researched, while combusting a pulverized, pneumatically conveyed fuel. Compared to the pulverized fuel combustion, combustion in circulating Fluidized Bed offers many advantages, such as lower reaction temperatures and better temperature distribution and lower recirculation rates. On the other hand, compared to the conventional air combustion, the Oxyfuel process shows many technical difficulties, such as the expected presence of local hot spots, safety of Oxygen handling issue and the problematic cooling of a combustion chamber to maintain the thermal balance. Therefore, design and build-up of a test rig on the TU –Dresden has been started.
Equipped with the experiences of the Oxyfuel pulverized combustion tests (www.adecos.de) and the knowledge of conventional fluidized bed operation a new test rig is being developed as a flexible modular system with a variety of operation regimes, such as:

- Combustion with air,
- Combustion with oxygen (Oxyfuel),
- Gasification,

One of the subproblems to solve is the cooling of bed material. A novel design of a CFB siphon with integrated cooling system is presented. This new design enables easy switch-on and switch-off of a cooling loop during operation, while avoiding any moving parts in the hot area.
The whole design has been proved at first on a 2 m tall cold CFB model and afterwards on the real 14 m CFB boiler test rig with a performance of 300 kW. The cold test rig has been built as a scaled model of real CFB loop with a siphon enabling a various geometry modifications. This procedure makes the comparison of calculations, scale-up methods and real operation experiences possible. Results of the research are giving an insight into siphon geometry problems and reports the design and scaling-up calculations.

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2. Extended Inhalt

2.1 Previous Research on the TU Dresden

There are about 5-years long experiences with oxyfuel combustion systems on the TU Dresden and even longer continuous work with CFB systems. Oxyfuel combustion processes are being studied since XXXX, when the ADECOS project (www.adecos.de) started ([1],[2]). From the recent research works with Oxyfuel-Pulverised Fuel Boiler came clear, that the limiting concentration of oxygen in oxidation mixture is approximately 33-35%. Above this limit are the temperatures too high (above 2000°C), which results in ash sintering and agglomeration, excessive NO_x production and material issues. Therefore the attention was moved from PC-Boiler to the CFB-Boiler with all its advantages, where the oxidation mixture consisting of 70% Oxygen and only 30 % of recycled flue gasses should be possible. Advantage of such ratio will be a compact unit with relatively low power consumption for flue gas recirculation. Therefore, a decision to construct a small scale pilot test rig for Oxy-CFB has been done.

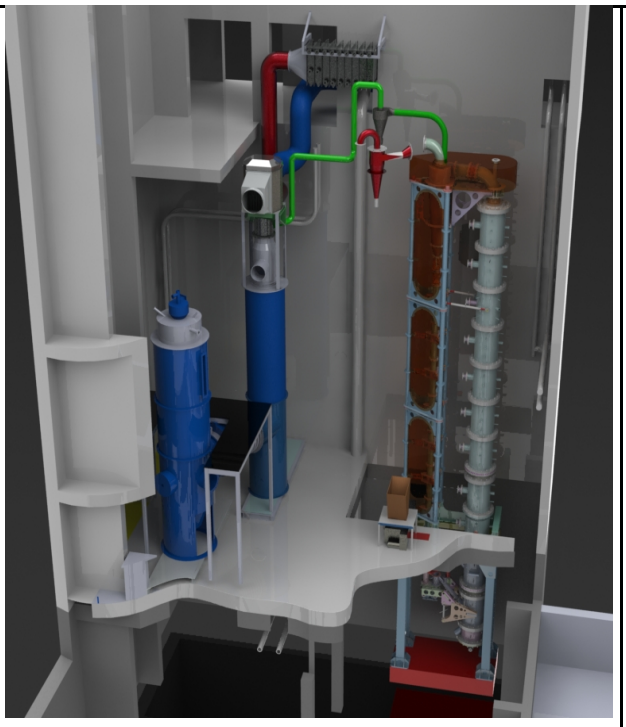
2.2 The 300kW Test Rig

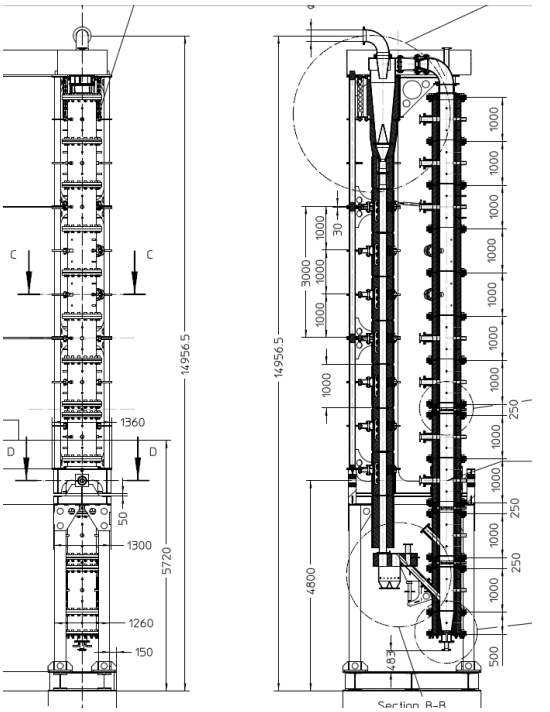
The test rig on TU Dresden is going to be commissioned in April 2011. It consist of adiabatic combustion chamber with internal diameter of 320mm (equivalently 200mm). Entrained solids are captured in hot adiabatic cyclone and transported to the siphon-valve. Directly in the siphon with integrated solids cooler are the particles cooled and returned back to the combustion chamber. The whole construction is modular, which enables us to reach the height of a combustion chamber up to 12 m (with 1m step).

For the experiments with air (Luftstufung) is the rig equipped with three modules for air injection into the combustion chamber, whose could be arbitrarily placed. Primary gas can be mixed from saturated steam, recycled flue gas, oxygen, CO2 or air, secondary gas from air, oxygen and flue gas only.

The test rig is able to operate under following conditions:

-Standard combustion with air
-Oxfuel combustion
-Gasification (burning of product gas is done in a second combustion chamber)

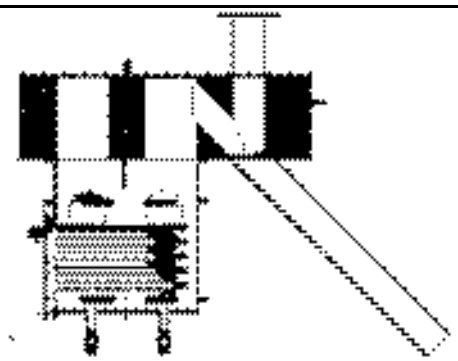


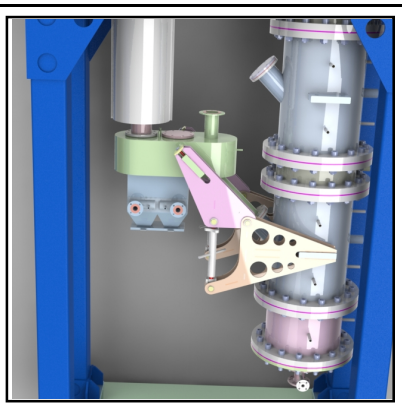


2.3 Heat Balance

Maintaining the heat balance is crucial problem even in case of air-fired CFB boilers, where any temperature rise above the 900°C poses a great danger for the whole facility. Oxy-CFB with high oxygen ratio in oxidation mixture will be facing a problem with maintaining the uniform temperature profile. Moreover, the test rig in Dresden has got adiabatic combustion chamber, which can absorb only a negligible amount of heat. Solution for maintaining the heat balance is the novel, in siphon integrated fluidized bed cooler, which can be easily regulated and spread the cooled particles evenly across the whole combustion chamber. Integrated cooler has been successfully tested in the cold test rig.

Mathematical modeling of the facility has shown that there are two power output borders, within whose the facility should be kept. Going with the power input too high means to big heat loading of the cooler. On the other hand, going with the power input too low means too small amount of solids being entrained to the cyclone, passing through the cooler and keeping the heat balance within the defined range. Therefore an external, independent fluidized bed cooler is being designed and will be tested according to usual scheme (design – cold model – real facility).





2.4 Measurement

For the control of the facility and validation of the results is the test rig equipped with following equipment:

-jacketed thermocouples Ni-CrNi in each module for measurement of temperature profiles

-jacketed thermocouples Ni-CrNi in each module for measurement of wall temperature

-Pressure Sensors +-200 mbar for measurement of pressure profiles and solids loading

All gas inlets are provided with usual temperature and mass flow sensors. Stoichiometry of combustion is controlled with O2-CO and CO2 sensors on the flue gas exit. Another device for measurement of flue gas composition will be used together with cooled suction probe for measurements of gas composition in combustion chamber. Heat transfer probes could be installed as well. So ist the facility equipped for any test to prove the oxyfuel regime.

[1] Wilhelm,R.: Bildung und Reduktion von Stickoxiden bei Braunkohlefeuerung im Luft- und Oxyfuel-Betrieb, Dissertation, TU Dresden, 2010

[2]Weigl,S.: Modellierung und experimentelle Untersuchungen zum Oxyfuel-Prozess an einer 50kW Staubfeuerung-Versuchsanlage, Dissertation, TU-Dresden, 2009