IEAGHG Information Paper; 2014-IP10: Looking Beyond Demonstration for Oxyfuel Combustion Coal Fired Power Plant

Feedback from the 4th Oxy-CORR Working Group Meeting

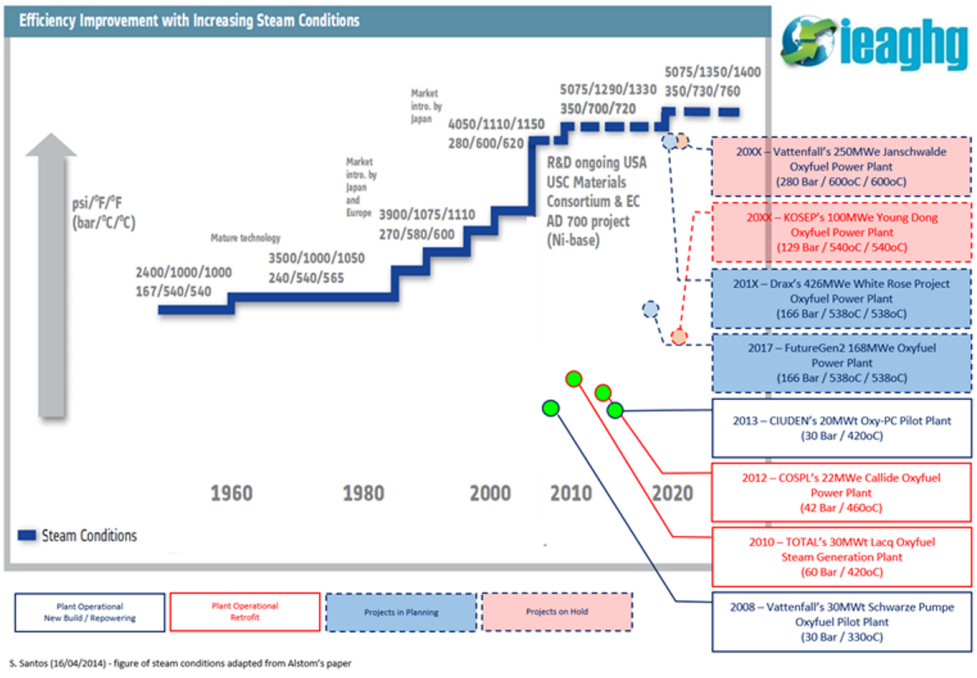
Last week, the IEA Greenhouse Gas R&D Programme organised the 4th Oxy-Corrosion Working Group Meeting. We gathered 25 experts from the US and Europe to review the current state of the art technology and identify the remaining issues.

The topic on Corrosion under Oxyfuel Combustion is a very specialised area that provides the much needed information to utilities and boiler manufacturers. Work under this area could be notoriously difficult such that some laboratory results may not necessarily translate to and/or relevant to practical boiler design and operation.

To recall, the first informal gathering of this group started in 2009, organised by IEAGHG under the Oxy-SOx Project funded by the UK TSB Programme. This is then followed up by a workshop organised by IFK under the FP7 funded Oxy-CORR project. Last year, the 3rd Oxyfuel Combustion Conference emphasised again its importance and organised a special session on this topic.

What makes this topic important…

The development in Oxyfuel Combustion for Coal Fired Power Plant will evolve and follow the footstep of the Conventional Air Fired Coal Power Plant. It is important to highlight the development curve of oxyfuel combustion will be steeper than its air fired counterpart.



In the past 10 years – various issues related to materials have been of immediate concern. This includes the potential for increased fireside corrosion and possible carburisation of waterwall and superheater tubing as indicated from early samples collected in various laboratory and large scale pilot testing.

The higher concentration of SOx, CO2 and water could have the potential to amplify the damaging effects of these species as the flue gas are recycled. Clearly, during the early days of development in 2000, we did not sufficiently understand the corrosion and carburisation mechanisms under oxyfuel combustion conditions.

We all know that SOx species are involved in several high-temperature corrosion mechanisms. Additionally, the higher concentration of CO2 and water vapour inherent to oxyfuel combustion process could make complex mechanisms more complicated.

It should be noted that the level of SOx and water vapour during oxyfuel combustion could depend greatly on the type of coal used and the extent on how the recycled flue gas are cleaned.

Here are some of the points regarding what we have learned…

1. The workshop participants have clearly noted and agreed the importance of standardising metal corrosion tests in both laboratory and field test environment to obtain comparable and meaningful results from various studies.
2. A common gas species environment for laboratory testing has been agreed. The use of the gas species with high level of SOx (i.e. 0.45%) has been agreed as one of the scenarios to evaluate the most aggressive operating conditions. Nonetheless, cases where SOx are removed in the flue gas prior to recycling should be evaluated – as these are the most likely conditions that we expect in early demonstration projects.
3. Mechanism for ash deposition and its effect to corrosion are to be re-visited. The understanding on ash deposition mechanisms is essential to understand a more realistic

corrosion mechanisms. It was concluded that SOx level in ash is higher as compared to air fired case.

4. Test on current materials used in sub-critical units (i.e. ferritic) to ultra-supercritical units (i.e. martensitic and austenitic) have been completed in various research institutes. They have concluded that high-temperature corrosion in oxyfuel is actually very similar to under air-firing conditions, and at worst, appears equivalent to conventional combustion of higher sulphur coals.
5. Test on future materials used in advance ultra-supercritical units (i.e. Ni alloys et. al.) should be pursued during the demonstration of oxyfuel combustion. Some participants have noted a possible minor divergence of corrosion mechanisms under oxyfuel combustion condition may occur once temperature reached greater than 700oC.

One of the important insights from this meeting is the talks from both Babcock and Wilcox and Alstom. Particularly from B&W, an insight to the material selection for the FutureGen 2.0 boiler was completed with favourable results based on conventional materials such as T91 are considered suitable for superheaters. It should be noted that FutureGen 2.0 will be using 60/40 blend of Illinois and PRB coal respectively – resulting to around 2.1% sulphur content. Semi-dry FGD will be installed within the recycle loop to control the SOx species. On the other hand, it could be noted that FEED study for White Rose project is on-going. Nonetheless, Alstom have positively indicated that corrosion will not be the main issue in the material selection with current state of the art ultra-supercritical conditions (at 280 Bar, 600/620oC)

Looking beyond demonstration…

Everyone agreed that fireside corrosion database (i.e. lab & steam loop) is small for higher temperatures (T > 650°C) and longer times (> 3000h) for both, air-and oxy-firing.

The current on-going testing involving the detailed investigation of Barry steam loop that will start in Autumn 2014 for high alloyed materials at higher temperatures (T= 650-815°C, Steam) n is expected is expected to reach >15000h. This will provide a very good insight to better understanding of mechanism over temperature (bell-shaped curve, temperature with maximum corrosion attack) under air fired conditions.

For oxyfuel combustion conditions, all the participants greatly wished to have a long term operation and evaluation of material performance in large scale plant. Hopefully, the early demonstration project could provide such opportunity to evaluate and collect samples to confirm current laboratory and pilot plant results.

As a general conclusion to this meeting – I was very pleased to see an upbeat perspective with a high level of confidence that high temperature corrosion will not be a barrier to development of oxyfuel combustion power plant. There will be no fundamentally different corrosion mechanisms as compared to air fired cases for the current state of the art sub-critical or ultra-supercritical units.

It was suggested that at this meeting that work should now focus on the following areas:

- Material performance testing at advanced ultra-supercritical conditions (i.e. greater than 700oC steam conditions)
- Co-firing of biomass and other opportunity fuels
- Conditions posed by load following power plant

Finally, all the participants are anticipating the forthcoming investment decision of the Futuregen 2.0 project which is expected at the end of this year, and that of White Rose expected a year later. The success of one of these projects could put oxyfuel combustion technology as one of possible options for CO2 capture in a coal fired power plant.

NOTE to the Readers:

All the presentations from the 4th Oxy-CORR Working Group Meeting will be uploaded by next week.

Stanley Santos
27/06/14