2nd Oxyfuel Combustion Conference

Corrosion of candidate superheater materials during oxyfuel conditions

-Pilot plant and laboratory investigations

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high temperature corrosion; oxyfuel combustion; superheater

Introduction

Oxyfuel combustion process necessarily implies a new combustion atmosphere and since all the oxyfuel processes require the replacement of nitrogen with re-circulated flue gas, this results in higher concentrations of SO2/SO3, CO2, H2O and O2, and as a consequence in a potentially more aggressive environment. A crucial issue is to find suitable and cost-efficient alloy solutions in this new type of environment.

In order to acquire knowledge on material design, selection and application in USC oxy-coal fired boilers some candidate materials (one ferritic steel, two austenitic stainless steels and a Ni-based alloy) were exposed in a 3 MW Oxycoal Facility burning an Indonesian bituminous coal. The alloys were exposed at two different metal temperatures using two air-cooled temperature controlled corrosion probes. After the short-term exposure in the facility (~50 hr) the deposit formation as well as the type and extent of corrosion attack was analysed. Long-term corrosion testing (1000 hr) was performed in laboratory furnaces with both duplicate samples from the corrosion probe covered with real deposits, and coupons that had not been pre-exposed in the facility. During the short-term test in the facility ash was collected and the gas composition and temperature was monitored such that similar conditions could be acquired also during the laboratory tests.

1. Experimental Procedure

The combustion test was a joint measuring campaign of Enel, IFRF and IFK run at the 3 MW Enel's Oxycoal facility (FOSPER) with an Indonesian medium sulfur coal. Two air-cooled corrosion probes were inserted in port number 11 and 13 of the Furnace as illustrated in *Figure 1*. The temperature and gas composition inside the furnace (window number 10 and 14) were measured at intervals during the test and the medium values are reported in *Table 2*. Moreover in order to fully investigate the corrosion potential of the oxyfuel environment when burning a medium

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sulfur coal also HCl/SO3 measurements were performed during the test and several ash samples coming from different points in the facility were collected and characterized.

Proximate Analysis	Mass Fraction (% dry)	Ultimate Analysis	Mass Fraction (% dry)	Size distribution	Diameter (μm)
Moisture	6,3	C	69,5	$D_{10\%}$	9
Fixed carbon	49,9	H	5,5	$D_{50\%}$	47
Volatile matter	39,2	N	1,4	$D_{90\%}$	112
Ash	10,9	S	0,4		
		O (by difference)	12,3		
HHV	6432 kcal/kg				
LHV	6129 kcal/kg				

Table 1- Composition of the Indonesian Sebuku Coal used during the test

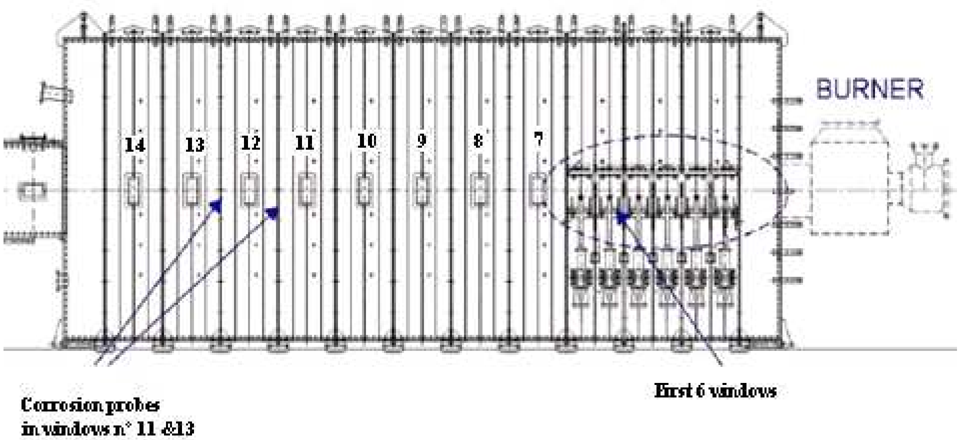

Figure 1 – The 3 MW Oxyfuel furnace used during the test

Window n°	H2O % mol	O2 % mol. wet	CO2 % mol. wet	CO ppm wet	NO ppm wet	SO2 ppm wet	N2 % mol. wet	Gas T °C
10	**12.7**	**7.9**	**65.2**	**<12000**	**325**	**928**	**14.2**	**934**
14	**14.0**	**3.2**	**67.5**	**93**	**247**	**1039**	**14.4**	**864**

Table 2 – Temperature and Gas composition close to the two corrosion probes during the short term test

	Fe	Ni	Cr	Mn	Mo	W	V	Si	N	C	Others
Ferritic steels:											
Steel A	Bal.	-	9.5	0.6	0.6	2	0.25		-	0.13	
Austenitic steels:											
Steel B	Bal.	8	18	0-2	-	-	-		0.06	0.04	
Steel C	Bal.	20	25	0-2	-	-	-	<0.75		~0.05	
Steel D	Bal.	11	21	0.5	-	-	-	1.6	0.17	0.09	Ce
Nickel-base alloys:											
Alloy A	<3	Bal.	22	0.5	9		-	<0.5		0.1	10-15Co, 0.8-1.5 Al

Table 3 – Materials used during the short and long term corrosion test

A total of 14 specimens were exposed on the two temperature controlled probes and almost each material was tested at two different temperatures (approximately 580 °C and 650 °C). Some selected specimens were duplicated in order to allow for material analysis after only 50 hours exposure time, and after further exposure in laboratory furnaces for 1000 hours. The materials for both short and long term test are reported in *Table 3*.

Long-term tests are ongoing at the IFK Laboratories in Stuttgart and at Swerea KIMAB in Stockholm. For each material, both specimens coming from the 3 MW Facility and ground surface specimens without prior exposure will be tested at 580°C and 650 °C.

For the short-term test, the post exposure evaluation will include: visual examination, microscopic examination of the oxide scale composition and thickness and SEM/EDS analysis of the deposits. For the long-term tests also metal loss and/or mass change measures will be performed in addition to the previous analyses.

The results of the above mentioned measures and analyses are expected to be available in early Spring 2011.

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