Corrosion of steels in H_2O-CO_2 atmospheres at temperatures between 500°C and 700°C

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The introduction of carbon capture technology into thermal power plants benefits from combustion of fuel and pure oxygen due to high partial pressures of CO_2 in the flue gas. The consumption of energy for carbon capture devices and oxygen production plants has to be compensated by higher efficiencies of the power plant. Consequently IGCC plants with 80 bar reactors and high temperature turbine equipment, boilers with 700 °C steam raising units will be the next generation power plants. All plants have in common locally in the process gas compositions with high CO_2 partial pressure and steam.

In our test we applied a gas composition with 30% H_2O and 70% CO_2 an composition in between the water content of coal burned in pure oxygen and Methane-oxygen combustion. Additional gas fractions such as SO_2 will be added in coming experiments.

In this paper we discuss the attack of our model gas composition on different typical power plant construction steels with chromium contents in the range of 1 to 24%. The test conditions were annealing time up to 1000 h, 80 bar pressure, fast flowing gas and temperatures between 500 and 700°C depending on the maximum working temperature of the individual steel.

Dependent on the test parameters and in particular the chromium content the oxide scale growth mechanism, the scale thickness, the scale microstructure and phase sequences differed. In particular we observe the growth of FeO at temperatures lower than 570°C which is the eutectic decomposition temperature in the Oxygen-iron phase diagram. Iron carbides are primarily formed in low alloyed steels near the oxide steel interface.

The steels studied containing more then 9% chromium the growth of Fe_3O_4 and Fe-Cr-Spinel was typical. Co and W influenced the reaction in 9 – 12% Cr-steel. The attrition of Mn and other alloying additions was monitored. In no case a dense and protective Cr_2O_3 or an other Metal-Cr-oxide layer was observed.

The oxide scale thickness increases strongly with temperature and decrease with raising chromium content. Data of oxide scale thickness up to corrosion time of 1000 h will be presented. A model will be presented, which deals with possible reactions paths during the corrosion processes in flowing CO_2 and water. The steels can be arranged according the reaction with gas and their alloying elements such as Mn, Co and W. In the test environment the maximum working temperature of the steels decreased 50K compared to working temperature in current power plant environment.

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