2nd Oxyfuel Combustion Conference

Corrosion processes and carbonisation of boiler materials under air and Oxyfuel process conditions

Dipl.-Ing. Alexander Findeisen[a]*, Prof. Dr.-Ing. Hans Joachim Krautz[a], Dipl.-Ing. Thomas Hauke[b]; Prof. Dr. Axel Kranzmann[c]

[a] Brandenburg University of Technology Cottbus, Universitaetsstraße 22, 03046 Cottbus / Germany
[b] Vattenfall Europe Generation AG, Vom-Stein-Straße 39, 03050 Cottbus / Germany
[c] Federal Institut for Materials Research and Testing, Unter den Eichen 87, 12205 Berlin / Germany

CCS technology; Oxyfuel process; corrosion; materials; power plant

1. Introduction

To reduce the production of anthropogenic CO_2 emissions from fossil fuel-fired power plants currently two objectives push the development of new cycles. One route concentrates on increasing efficiency in conventional power plant units (e.g. 700°C technology, coal drying) and the other direction focusses on the implementation of CO_2-reducing technologies including pre-combustion, post-combustion and Oxyfuel technology. For capture processes numerous pilot and demonstration plant projects in various stages of development including planning, construction and operation /1/ - /5/.

The standard low NO_x -producing operation of large and modern lignite-fired power plants results in combustion states that cause damage to components. Damage can also be caused by the altered process conditions that occur when Oxyfuel technology is implemented. The corrosion of plant components as a result of contact with flue gas and ash is a significant issue that must be examined.

2. Basic principles of corrosion

Corrosion is generally present in all interactions between a material and its environment. Corrosion and the accompanying diffusion of impurities induces measurable changes in the properties of the material and the deterioration of the function of the technical systems /6/. Gas corrosion occurs at temperatures above 200°C and has to be considered in all high temperature technology. The first high temperature corrosion problems were detected in the 1940s in coal dust-fired boilers in the USA and are described in /7/. In Germany problems were first noticed in the superheater tubes in the boiler of the Emil Adolf paper mill, which was documented by Geiger und Huber /8/; /9/.

In lignite-fired power plants severe corrosion can be caused by sulphur. Additional dissolution of material slag, carburization, oxidation and hydrogen may damage the material. The corrosion process depends on the humidity of the gas and fugazities of gas species like SO_2, gaseous S, H_2O, CO_2, CO and very important O_2 /10/; /11/. These parameters change the picture of corrosion when they act in combination. Even blocking of one mechanism by competing mechanisms is possible. Oxygen-deficient corrosion with fuels containing sulphur as the main corrosion mechanism in lignite-fired power plant units is discussed /9/; /13/.

The intensity of corrosion is dependent on different influencing parameters. These can be divided into fuel-related, equipment-related and operation-related factors. The principle effect of fuel on the risk of corrosion becomes clear when comparing combustion plants that are fired using low load, homogeneous fuels (e.g. gas or oil) with those that use chlorine and sulphur loaded, homogeneous and heterogeneous fuels (e.g. coal, waste). In practice the latter are often corroded following soiling and slagging in steam generators. In contrast there are plants that use unfavourable fuels but operate without corrosion and slagging problems. However steam generators in the same location with different fuel and boiler technologies but similar fuel sources do not exhibit identical corrosion behaviour. Correspondingly corrosion is also influenced and driven by plant construction and process technology as well as operating conditions.

3. Investigations

For the investigations the evaporator materials 16Mo3, 13CrMo4-5, 7CrVTiB10-10 as well as the superheater materials 10CrMo9-10, VM12 SHC were selected. The analysis of the probes for the selected materials was conducted at the Federal Institute for Materials Research and Testing, Department V, Division V.1 Composition and Microstructure of Engineering Materials. For further classification of the composition of the materials a Schaeffler diagram was used to display the limits of the austenitic, ferrite and martensitic phases in relation to the chromium and nickel equivalents.

The layout of the test facility and the laboratory test rig, which will be used for the investigations, is described. These investigations were carried out in the test facility over a timeframe of 110 hours to allow initial corrosion to occur. The corroded probes were then placed for a further 1,000 hours in a laboratory test rig. Subsequently the probes were assessed using light and scanning electron microscopy. The results of the analysis will be described and conclusions illustrated.

4. References

/1/ Bundesministerium für Wirtschaft und Technologie. Leuchtturm COORETEC – Der Weg zum zukunftsfähigen Kraftwerk mit fossilen Brennstoffen, Forschungsbericht Nr. 566, Berlin 2007.

/2/ Bundesministerium für Wirtschaft und Technologie: “Forschungs- und Entwicklungskonzept für emissionsarme fossil befeuerte Kraftwerke”, Forschungsbericht Nr. 527, Berlin 2003.

/3/ Zentrum für Energieforschung: Endbericht „Neubau fossil gefeuerter Kraftwerke -Versorgungssicherheit, Wirtschaftlichkeit, CO_2-Reduzierung“, Stuttgart 2006.

/4/ International Energy Agency: http://www.iea.org/ccs/technology_status.asp

/5/ Global CCS-Institute: http://www.globalccsinstitute.com/resources
/6/ Normenausschuss Materialprüfung (NMP) im Deutschen Institut für Normung e.V.: DIN EN ISO 8044 Korrosion von Metallen und Legierungen – Grundbegriffe und Definition, Beuth Verlag, Berlin 1999.
/7/ Corey, R. C., Reid, W. T., Cross, B. J.: External Corrosion of Furnace-Wall Tubes – History and Occurrence, Transactions of the ASME 67, p. 279-302, 1945.
/8/ Geiger, T.: Metallographische Untersuchungen an den Überhitzerrohren des Kessels Reutlingen nach verschiedenen Betriebszeiten, Vortragsveranstaltung der Mannesmann Röhrenwerke AG, Düsseldorf 1958.
/9/ Huber, H., 1958. Abzunderungsschäden im Kessel Reutlingen, Vortragsveranstaltung der Mannesmann Röhrenwerke AG, Düsseldorf 1958.
/10/ N. Birks, G. H. Meier, F. S. Petit: Introduction to the Hight-Temperature Oxidation of Metals, Second Edition, Cambridge press, 2006.
/11/ Bürgel, R.: Handbuch Hochtemperaturwerkstofftechnik, Vieweg-Verlag Wiesbaden, ISBN: 978-3-528-23107-1, 2006.
/12/ Born, M.: Dampferzeugerkorrosion, Verlag SAXONIA Standortentwicklungs- und Verwaltungsgesellschaft mbH, Freiberg 2005, ISBN 3-934409-27-X.
/13/ Schütze, M.: Ergebnisse des Forschungs- und Entwicklungsprogramms „Korrosion und Korrosionsschutz“. In: Proceedings of the Materials and Corrosion Conference, Jahrgang 1996, p. 103-105.