21/2019 January to December 2019

PPCHEM

The Journal of All Power & Plant Chemistry Areas

2019's Scientific and Technical Contributions

PowerPlant Chemistry, January/February 2019, 21(1), 8–20

CORROSION AND DEPOSITS IN WATER-COOLED GENERATOR STATOR WINDINGS: PART 3: REMOVAL OF FLOW RESTRICTIONS

Thomas Bauer, Matthias Svoboda, and Robert Svoboda

Flow restrictions in generator stator bar hollow conductors can be removed either mechanically or chemically. Both methods have their advantages and disadvantages and in certain cases only a combination of both leads to success.

Mechanical cleaning can open up completely plugged hollow conductors at the inlet or outlet of the bars, while chemical cleaning thoroughly removes all copper oxides, also within the bars. However, as with all chemical cleaning methods, there must be access for the chemicals to the copper oxide deposits so the chemicals can dissolve and remove the plugging.

To prevent metallic deposits, it is important that the chemical cleaning be performed under oxidizing conditions. Additionally, it might also be useful to apply a post-cleaning surface treatment under certain conditions.

It is recommended to take any kind of plugging seriously and to start reacting when first signs of plugging occur. Once severe conditions have developed, this might lead to power downrates, a decrease in insulation lifetime, forced outages or in the worst case even irreversible damage to the generator.

PowerPlant Chemistry, January/February 2019, 21(1), 26–39

ELECTROCHEMICAL CORROSION POTENTIAL MONITORING IN BWRS

Yoichi Wada, Kazushige Ishida, Masahiko Tachibana, Nobuyuki Ota, and Makoto Nagase

The status of Hitachi-GE Nuclear Energy's electrochemical corrosion potential (ECP) sensor development and ECP measurement in boiling water reactors (BWRs) is reviewed. Hitachi-GE Nuclear Energy (Hitachi-GE) has been dedicated to developing and providing ECP sensors and applied ECP monitoring to various BWRs since the ECP has been an index of stress corrosion cracking (SCC). Hitachi-GE considers simultaneous use of at least 2 types of ECP sensor and employment of a guard drive circuit for the ECP measuring system to be essential. Results of ECP measurement in hydrogen water chemistry (HWC) showed that the ECPs were above 0.1 V(SHE) before HWC and decreased with an increase in the hydrogen concentration in the feedwater. Compared to the bottom region, the ECP in the primary loop recirculation system decreased at lower hydrogen dosage. Hitachi-GE recommends long-term and in-situ ECP monitoring because the ECP is affected by core management and the direct measurement of the ECP is more meaningful for SCC evaluation.

PowerPlant Chemistry, January/February 2019, 21(1), 40–41

POWERPLANT CHEMISTRY® INTERVIEW

Tapio Werder

On January 1st, 2019, the publishing house Waesseri GmbH was transformed into the new company PPCHEM AG. To introduce this chan ge to our readers, Tapio Werder, Editor in Chief of the PowerPlant Chemistry® journal, talks to Michael Rziha, Chief Key Expert for Plant Chemistry at PPCHEM AG.

PowerPlant Chemistry, January/February 2019, 21(1), 42–49

2018'S SCIENTIFIC AND TECHNICAL CONTRIBUTIONS

PowerPlant Chemistry, March/April 2019, 21(2), 62–72

CORROSION AND DEPOSITS IN WATER-COOLED GENERATOR STATOR WINDINGS: PART 4: OPERATING EXPERIENCE WITH FLOW RESTRICTIONS IN STATOR COOLING WATER SYSTEMS

Matthias Svoboda and Thomas Bauer

A common problem with water-cooled generator stator windings is plugging of the hollow conductors that act as cooling channels. The causes are sometimes difficult to identify, but some common factors can be found. Insufficient layup during outages is a common one. The importance of good monitoring and maintenance practices is highlighted throughout the discussed examples.

The stator is the main concern, because of its vulnerability to oxide deposits in the hollow conductors and the fact that if it fails, the whole power plant has to be shut down. Strainers and filters can also plug up and act as early warning devices for stator plugging. If replacing them is not an option, chemical cleaning can help, but it usually only removes the symptoms.

Proactive treatment of these problems should be a priority, as damages can go into the millions. Even when cleaning is still possible, persistent deposits can often only be removed by more invasive treatments.

PowerPlant Chemistry, March/April 2019, 21(2), 78–83

A REVIEW OF IMPORTANT WET-LIMESTONE SCRUBBING DETAILS

Brad Buecker

Coal combustion releases a number of harmful compounds that need to be removed from the flue gas before discharge to the atmosphere. One of these compounds is sulfur dioxide (SO_2). The most common process to remove SO_2 is wet-limestone flue gas desulfurization (WFGD). This article examines the fundamentals of this process and discusses modern developments to maximize scrubbing efficiency in these systems.

PowerPlant Chemistry, March/April 2019, 21(2), 90–127

IAPWS TGD9-18: AIR IN-LEAKAGE IN STEAM–WATER CYCLES

The International Association for the Properties of Water and Steam

This Technical Guidance Document considers the phenomenon of air in-leakage (AIL) in fossil, combined cycle / HRSG, and biomass plants. It covers the importance of AIL to the performance and cycle chemistry control of generating plants. The sources of AIL are delineated as well as the background science. The monitoring equipment/techniques are provided in Section 4. Controlling guidance for AIL in the most common generating plants worldwide is covered in Section 6, as well the customization aspects for other plants with varying equipment in Section 7. The document represents the accumulated experience of the IAPWS Power Cycle Chemistry (PCC) Working Group with representation from 24 countries.

PowerPlant Chemistry, March/April 2019, 21(2), 130–131

FILM FORMING SUBSTANCES (FFS) CONFERENCE, FFS2019 – HIGHLIGHTS AND PRESS RELEASE

The third FFS International Conference was held on the 19th – 21st March 2019 in Heidelberg, Germany chaired by Barry Dooley of Structural Integrity. FFS2019 was a unique conference on a narrow topic in cycle chemistry control of power plants but attracted over 70 participants from 22 countries.

PowerPlant Chemistry, May/June 2019, 21(3), 142

OUTSTANDING MEETINGS OF TWO NATIONAL IAPWS COMMITTEES – PRESS RELEASE

The International Association for the Properties of Water and Steam (IAPWS) is the world's leading body for power station chemistry. With AGL's Principal Chemist Hayden Henderson being the Chairperson of the Australian branch (AUSAPWS), AGL hosted the first ever Australian AUSAPWS workshop for power station chemists in April 2019 in Melbourne.

PowerPlant Chemistry, May/June 2019, 21(3), 146–154

ADSORPTION OF OLEYL PROPYLENEDIAMINE ON METAL SURFACES

Duygu Disci-Zayed, Julia Jasper, and Wolfgang Hater

Operation of water/steam cycles is threatened by corrosion unless proper conditioning measures are taken. As an alternative to traditional cycle chemistry, film forming amines (FFAs) are becoming increasingly important.

It is essential to understand the adsorption behavior of FFAs. This paper presents the results of an extensive study on the adsorption characteristics of FFAs on metal surfaces: stainless steel, carbon steel, copper, and aluminum alloys. Moreover, to reflect the plant conditions in a more realistic way, experiments with an iron oxide ('magnetite') layer were performed.

Adsorption trials were carried out with different film former concentrations and at different temperatures in a custom-made polytetrafluoroethylene vessel. The focus of this research was mainly on the use of oleyl propylenediamine (OLDA), one important FFA, which is included in the Technical Guidance Document issued by the International Association for the Properties of Water and Steam [1]. Nevertheless, other FFAs (homologues of OLDA) were also tested for comparison.

The adsorption isotherms were described with the Henry adsorption model due to the limited number of experiments and for the sake of simplicity. Adsorption of FFA accelerates with temperature and follows first order kinetics. Moreover, surface coverage by FFA was determined by mass balance, which is influenced by the nature of the metal and the FFA used.

For selected metals the surface coverage data of FFAs were compared to polarization resistance data obtained from electrochemical impedance spectroscopy. These data showed that the same degree of corrosion protection is achieved with lower amounts of OLDA compared to oleylamine (OLA).

The time dependence of surface coverage by OLDA showed the same tendency as the polarization resistance data on steel and aluminum.

PowerPlant Chemistry, May/June 2019, 21(3), 158–188

TRENDS IN HRSG RELIABILITY – A 10-YEAR REVIEW

Barry Dooley and Bob Anderson

By 2008 the authors had conducted assessment surveys at a small number of combined cycle/heat recovery steam generator (HRSG) plants in the areas of cycle chemistry, flow-accelerated corrosion (FAC), and thermal transients. The results clearly showed some important trends on why the major failure/damage events occurred on these plants. In the interim period the authors have extended the number of plants worldwide to 90 to allow a ten-year review of combined cycle/HRSG reliability. There has been a remarkable increase in knowledge and understanding of the main drivers of damage/failure, and in combination with the tools developed for the assessments, this paper now includes clear direction on how to address the reliability issues retroactively and how to avoid them proactively. The major cycle chemistry influenced issues are: HRSG Tube Failures due to FAC, under-deposit corrosion, deposits in high pressure (HP) evaporators, and failure in the phase-transition zone of the steam turbine. The main thermal transient aspects of thermal and corrosion fatigue relate to inappropriate/inadequate operation and maintenance of attemperators, poor drain control of superheaters and reheaters, HP drum ramp rates, and forced cooling. Another emerging issue is severe erosion of bypass pressure control valves. The paper discusses each and provides directions by which plants can avoid the issues in the future.

PowerPlant Chemistry, May/June 2019, 21(3), 192–193

EUROPEAN HRSG FORUM (EHF2019) HIGHLIGHTS AND PRESS RELEASE

A hugely successful sixth annual meeting of EHF was held on the 14th – 16th May 2019 in Athens, Greece chaired by Barry Dooley of Structural Integrity. EHF2019 attracted 76 participants from 17 countries. EHF is supported by the International Association for the Properties of Water and Steam (IAPWS) and is held in association with the Australasian Boiler and HRSG Users Group (ABHUG) and the US HRSG Forum (HF).

PPCHEM® Journal, July/August 2019, 21(4), 218–229

AN INTERLABORATORY TEST OF ANALYSIS METHODS FOR CORROSION PRODUCTS

Karsten Thomsen and Maja Skou Jensen

This report describes the outcome of an interlaboratory comparison of analysis methods for iron among a group of laboratories in the power and heat industry. The samples sent out to the laboratories were real samples of feedwater and district heating water that had an inherent inhomogeneity due to the particulate nature of the corrosion products. The analysis methods compared were the standard methods based on spectrophotometry and inductively coupled plasma spectroscopy as well as analysis of filtered material on a 0.45 µm membrane filter. The filtered material from a 1 L sample was digested and dissolved to a 50 mL final sample volume, which gave a concentration factor of 20, enhancing the sensitivity of the method relative to the others. The purpose of the interlaboratory comparison was twofold: to qualify the filter method to be recommended for corrosion product analysis by the International Association for the Properties of Water and Steam in a Technical Guidance Document, and to give the laboratories an opportunity to test their methods on realistic samples against a group of other professional laboratories. For accredited laboratories, proficiency testing like this is a well-known and prescribed means of quality control and often supplements the internal quality control nicely.

Although measures had been taken to minimize the heterogeneity of the samples, the district heating samples turned out to be not even close to homogeneous. By assuming a log-normal distribution and independent results of the double determinations from each laboratory, the inhomogeneity of the samples could be handled, and the performance of the laboratories compared. The comparison shows that the reproducibility of the filter method matches the reference methods, and that both feedwater and district heating water samples fit nicely to the log-normal distribution. The results indicate that the filter method is reproducible when transferred from one laboratory to another.

PPCHEM® Journal, July/August 2019, 21(4), 232–241

THIRTY YEARS OF EXPERIENCE WITH FILM-FORMING AMINES AT A NORWEGIAN FERTILIZER PRODUCTION SITE

Roy van Lier, André de Smet, Lene-Marie Olsen, Matej Halasa, and Trond Arve Fjærem

In Glomfjord, Norway, above the Arctic Circle, Yara produces some 400 000 t (100 % equivalent) per year of nitric acid in two older units. All of the acid is used in downstream plants on site to produce a range of fertilizer grades.

The Glomfjord site has been of great importance both to the pioneering of ammonia and nitric acid synthesis technology and to the history of Norsk Hydro, which eventually divested its fertilizer activities as Yara International. It is also a location with some of the longest operational experience with film-forming amines for industrial steam system treatment, certainly in relation to nitric acid production.

The present paper first provides background information on the Glomfjord site. Steam generation in nitric acid plants in general is then succinctly explained. Yara's operational experience is subsequently elaborated in the context of the specificities of the Glomfjord application, and of filming amine and water chemistry in the Nordic countries. This includes analysis of a possibly unique case of fouling and damage that illustrates the importance of adequate boiler feedwater quality, regardless of the chemical treatment program in place.

PPCHEM® Journal, July/August 2019, 21(4), 242–249

CRITICAL CHEMICAL ISSUES DURING PRE-COMMISSIONING

Andrés Rodríguez Pérez

Most cases of severe corrosion and consequent failure in the commercial operation of water-steam cycle and boiler systems are initiated during the first stages of a project, frequently because of a lack of preservation, an absence of regular inspections, inadequate water quality for pressure tests and a lack of understanding of corrosion processes by many of the parties involved.

Selecting an appropriate pre-commissioning program control will mitigate the risk of corrosion during the progression of the project, and subsequently, minimize potential failures upon commissioning.

Putting together an effective pre-commissioning strategy requires a great deal of coordination among different departments, the integration of practical lessons learned and great common effort throughout the project. Even engineers involved in the first stages need to retain responsibility for keeping a long-term vision for the success of the final results.

PPCHEM® Journal, September/October 2019, 21(5), 270–285

COMPARISON OF TWO CORROSION PRODUCT SAMPLING METHODS AT ERARING POWER STATION

Mark Wyburn

Cycle chemical conditions have been modified several times over the last 20 plus years at Eraring Power Station (EPS) in Australia. The mixed metallurgy of the condensate system had proved difficult to manage with respect to minimising flow-accelerated corrosion (FAC) and copper transportation.

A project to convert all units from all-volatile treatment under reducing conditions (AVT(R)) to all-volatile treatment under oxidising conditions (AVT(O)) has been underway since 2016. Units 1, 2 and 4 have now had their 35-year-old brass-tubed low-pressure (LP) heaters replaced with stainless-steel-tubed heat exchangers, and Unit 3 will be converted in late 2019.

After each AVT(O) conversion, intensive corrosion product sampling and analysis has been undertaken over several months to measure the success of the project in reducing iron transportation. This has involved simultaneously using integrated sampling and an on-line voltammetric analyser, which was previously trialled in 2015. This analysis has revealed some interesting trends during the chemistry change.

This paper compares the results from integrated sampling and the voltammetric analyser and discusses the relative merits of each process under the constraints of major power plant operations in a competitive market.

PPCHEM® Journal, September/October 2019, 21(5), 290–292

INTERNATIONAL ASSOCIATION FOR THE PROPERTIES OF WATER AND STEAM (IAPWS)2019 EXECUTIVE COMMITTEE AND WORKING GROUP MEETINGS

PRESS RELEASE

Between September 29th – October 4th, 2019, 92 scientists, engineers and guests representing 16 countries descended on the Banff Centre for Arts and Creativity in Banff, Alberta, Canada for the annual meeting of the IAPWS Executive Committee and Working Groups. This continues a series that began in 1929 in London, UK with the purpose to connect researchers and scientists with the engineers who use their work providing the researchers with guidance on topical problems within industry and

providing the engineers with the latest research results. Areas of application include power cycle chemistry, high temperature aqueous technologies applicable to steam cycles and steam injection, the use of high temperature water and supercritical steam in chemical and metallurgical processes, supercritical synthesis of new materials and destruction of toxic wastes, hydrothermal geochemistry, hydrometallurgy, oceanography and global climate modelling, power cycles with CO_2 capture and storage systems and combined heat and power systems.

PPCHEM® Journal, September/October 2019, 21(5), 292–297

KNOWLEDGE TRANSFER AND SUCCESSION PLANNING FOR POWER PLANT CHEMISTRY

Bertil C. Valenkamph, Paul E. Schrock, Brian S. Snyder, and K. Anthony Selby

Electric utilities are faced with a shortage of skilled personnel in the coming years due to normal retirements, early retirements, and plant closings. This is true in chemistry departments as well as other departments.

There are many aspects to succession planning to successfully fill the upcoming vacancies. For chemistry departments one important tool is to develop comprehensive written plans for chemical control of the systems impacted by chemistry. These plans can be termed control plans or strategic plans. The chemistry plans should be developed for several individual plant systems, including boiler cycle chemistry, open cooling water, closed cooling water, makeup treatment systems, glycol systems, and wastewater treatment systems, among others.

Another very important tool is the comprehensive chemistry data acquisition system – a collection of supervisory control and data acquisition (SCADA) nodes at each generating station, accompanied by a combined web-based management system overview. These systems are vital in monitoring all the process chemistry systems explained in the aforementioned control/strategic plans.

This paper describes the development and content of control/strategic plans for chemistry control in these various systems as well as several other succession planning items.

PPCHEM® Journal, September/October 2019, 21(5), 302–359

IAPWS TGD11-19: APPLICATION OF FILM FORMING SUBSTANCES IN INDUSTRIAL STEAM GENERATORS

The International Association for the Properties of Water and Steam

This Technical Guidance Document addresses the use of film forming substances in the water/steam cycles of industrial steam generating plants.

In order to control corrosion throughout the water/steam circuits of industrial steam generating plants, it is essential for the operator of the plant to choose and optimize a chemical treatment scheme that is customized to that plant. IAPWS has provided guidance on the use of volatile treatments as well as for phosphate and caustic treatments; this document addresses the use and application for the range of chemicals referred to as film forming substances (FFS). As well as providing background information on FFS, the document includes guidance in Section 8 for determining if a FFS should be applied, the tests required before application, the locations for the addition, the optimum dosage level, and tests to determine the benefits of applying FFS. It is emphasized that this is an IAPWS guidance document and that, depending on local plant requirements, the application of FFS will need to be customized (Section 9) for each industrial plant depending on the actual conditions of operation, the equipment and materials installed, the condenser cooling media, and applicable regulations.

PPCHEM® Journal, November/December 2019, 21(6), 374–395

PRACTICAL OBSERVATIONS AND INTERPRETATION OF OXIDE GROWTH AND EXFOLIATION IN STEAM

Barry Dooley and Ian Wright

Over the last 40 years oxide growth and exfoliation (OGE) in superheater and reheater tubing have been responsible for a number of power plant problems which seriously have affected reliability. In the same time period, the authors have collected a data base of scale morphologies that has been used to describe in detail the progression of oxide scale development to the point where failure can occur. The concomitant evolution of knowledge of the factors that determine the mode of scale growth and failure in steam has provided the foundation for defining the specific stages in that progression, understanding differences among ferritic and austenitic alloys, and for categorizing the influence of plant operating characteristics. In particular, while tube/steam temperature and the maximum temperature drop at plant shutdown are major variables, the specific cycle chemistry used for the plant feedwater has very little influence. Key stages in the progression of scale growth to the point of failure are identified as OGE indices that are specific for ferritic and austenitic steels. These indices are intended to be used proactively to determine the current condition of a superheater or reheater on the path to exfoliation and possible plant damage. Also, by analyzing samples of exfoliant or oxide deposits responsible for damage, the origin of the oxide, and thus a possible superheater or reheater problem, can be identified retroactively

PPCHEM® Journal, November/December 2019, 21(6), 396–397

ABHUG 2019 HIGHLIGHTS AND PRESS RELEASE

Bertil C. Valenkamph, Paul E. Schrock, Brian S. Snyder, and K. Anthony Selby

The first annual meeting of ABHUG held on the 30th October to 1st November 2019 in Brisbane, Australia was chaired by Barry Dooley of Structural Integrity Associates. This first ABHUG conference followed 11 annual meetings of AHUG (Australasian HRSG Users Group) and included conventional fossil plant technology and issues closely related to those in HRSGs. ABHUG 2019 attracted 75 participants from Australia, Japan, New Zealand, Thailand, UK, and USA. About 50% of the participants were Users, which is the highest of the other HRSG forums worldwide.

PPCHEM® Journal, November/December 2019, 21(6), 400–439

IAPWS TGD10-19: CHEMISTRY MANAGEMENT IN GENERATOR WATER COOLING DURING OPERATION AND SHUTDOWN

The International Association for the Properties of Water and Steam

This Technical Guidance Document applies to all generators with water-cooled windings. From the operating side, adherence to a suitable water chemistry regimen as well as proper layup practices help to avoid or mitigate flow restrictions. Other influencing factors are design and materials. It is emphasized that this is an IAPWS Technical Guidance Document and that, depending on local requirements, the normal or target values will need to be customized for each case, depending on the actual conditions of operation and maintenance.

PPCHEM® Journal, Media Information: journal.ppchem.com