2005's Scientific and Technical Contributions

John Hickling
Hans-Peter Seifert
Stefan Ritter

PPChem 2005, 7(1), 4–15

Research and Service Experience with Environmentally Assisted Cracking of Low-Alloy Steel

Environmentally assisted cracking (EAC) of carbon and low-alloy steels has been identified as a possible degradation mechanism for pressure vessels and piping in nuclear power plants. Selected aspects of research and service experience with cracking of these materials in high-temperature water are reviewed, with special emphasis on the primary pressure boundary in boiling water reactors. The main factors controlling EAC susceptibility under reactor conditions are discussed with regard to both crack initiation and crack growth. The adequacy and conservatism of the relevant engineering criteria for component design and disposition of detected or postulated flaws are evaluated in the context of recent research results, e.g., on the effects of so-called "ripple loading" or of water chemistry transients. Finally, the relevant operating experience over the last 30 years is briefly summarized and compared with the background knowledge which has been accumulated in more recent laboratory experiments. Some of the insights gained in this work may also be of value in improving understanding and prediction of the EAC behavior of carbon and low-alloy steels in certain fossil plant components, if appropriate allowances are made for differences in temperature and water chemistry.

Masayoshi Hirano
Satoshi Itaba
Takao Minami
Li-Bin Niu
Hiroshi Takaku

PPChem 2005, 7(1), 16–20

Corrosion Behavior of Boiler Materials during Long-Term Layup of a Fossil Unit

The applicability of the electrochemical corrosion potential (ECP) method as an online corrosion monitoring technique for boiler equipment during long-term layup in fossil units was experimentally investigated for boiler equipment materials. It was found that the ECPs of all materials tested show stable values for a few hundred hours after the test, and that oxide films formed under AVT (all-volatile treatment) conditions show a good stability in the subsequent ECP measurements. Under conditions of the presence of hydrazine, the corrosion potential of STB410 carbon steel shifts to the noble side, showing high corrosion resistance. The results obtained by the ECP method are in good agreement with those of the corrosion immersion test. The temporary decrease in the corrosion potential due to the addition of hydrazine to the water may result from effects of both the reducing reaction of oxide films and the decomposition of hydrazine. The results in this work suggest that the ECP method may be effective for the corrosion monitoring of boiler equipment materials. Based on the fundamental results obtained, it is expected that the corrosion of boiler equipment during the layup period can be detected by the ECP method.

Siegfried Köhler
Mechthild Müller

PPChem 2005, 7(1), 25–30

Corrosion Behaviour of and Damage to Copper Alloy Power Cycle Components

At temperatures > 60 °C, the corrosion behaviour of copper alloys is determined above all by the oxygen content and the temperature of the medium. The prevailing corrosion mechanisms include dezincification, pitting corrosion, stress corrosion cracking, ammonia grooving, and sulphide-induced corrosion. In addition, intergranular corrosion may occur in aluminium brass.

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PPChem 2005, 7(1), 35–39

Modeling of Diffusion Phenomenon of Liquid Poison in Shutdown System #2 of PHWRs

The diffusion phenomenon of poison solution (gadolinium nitrate) in connection with the secondary shutdown system of pressurized heavy water reactors is studied with a simple approach of one-dimensional macro-modeling and application of the experimental results to arrive at actual power plant operational specifications. The results obtained by mass balance macro-dynamics and simple laboratory experiments tally with the power plant operational requirements. Obtaining Fick's constant from the results confirms the validity of the model. A new interpretation of Fick's constant is given for better understanding of the diffusion process.

Brad Buecker

PPChem 2005, 7(1), 40–43

Condenser Performance – A Critical Issue for Plant Chemists

Along with the boiler, the steam condenser is one of the two largest heat exchangers in a steam generating power plant. Waterside scaling or fouling, or excess air in-leakage on the steam side, will seriously impair heat transfer, which in turn increases fuel requirements and costs. Power plant chemists must keep track of condenser performance, especially as it relates to cooling water chemical treatment. Failure or poor operation of chemical feed systems will initiate fouling that often can only be removed by a unit shutdown and mechanical cleaning. Prompt detection of air in-leakage upsets is also important to maintain proper condenser efficiency. This article outlines a practical method for condenser performance monitoring that the author has used with excellent success.

PPChem 2005, 7(1), 44–62

2004' Scientific and Technical Contributions – Papers in English

As every year, the January issue closes with abstracts of all the articles published in this journal in the last year. Back issues of our journal are – with few exceptions – still available; interested parties can receive PDF files of all articles by e-mail. The order forms may be downloaded from our homepage.

R. Barry Dooley
Neville F. Rieger
Farhang Bakhtar

PPChem 2005, 7(2), 69–80

Studies of Electrostatic Charge Effects Relating to Power Output from Steam Turbines

This paper summarizes the work done in several recent studies concerning the effects of electrostatic charge imposed on the steam flow in a turbine exhaust environment. The purpose of these studies was to determine whether an electrostatic charge imposed on the turbine exhaust steam could increase turbine power output in a commercially useful manner.

Certain studies carried out in the Ukraine on this topic using a 50 MW utility turbine are considered first. The results of these studies indicated that electrostatic charging of steam could lead to a small but commercially useful increase in power output. Basic work was subsequently undertaken in the USA to study the influence of an electric field on wet steam in a laboratory chamber. A full-scale test program was also undertaken in the USA, in which electric charge was imposed on the steam flowing through the exhaust hood of a large (425 MW) utility turbine. Several grids of wire electrodes strung within the exhaust hood of the turbine were used in this test. These wires carried a high voltage of subcorona potential.

In a separate program the electrostatic effects associated with a nucleating flow of steam within a two-dimensional cascade were examined. The measurements are of the electrical charges generated on first nucleation and of the effect of electrical charge on nucleation of steam droplets.

The paper describes the work undertaken in these programs, and it summarizes the results achieved to date. Conclusions drawn from the results are presented, with discussion.

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James J. Dillon
Steef H. M. Vrijhoeven

PPChem 2005, 7(2), 82–94

Case Histories of Stress-Assisted Corrosion in Boilers

Stress-assisted corrosion refers to attack at locations where applied and/or residual stresses are imparted to the metal. Case histories are presented from a variety of different boiler systems that illustrate the effects of stress-assisted corrosion, including environmental conditions that may promote attack. Methods that may be used to control stress-assisted corrosion are also outlined.

Bernhard Stellwag
Ulrich Staudt

PPChem 2005, 7(2), 95–102

Water Chemistry Practice at German BWR Plants

As visual examinations carried out in 1994 detected cracks in a German boiling water reactor (BWR) plant due to intergranular stress corrosion cracking in core shroud components manufactured from Nb-stabilized CrNi steel 1.4550, safety-related assessments and in-service inspections were subsequently performed for the other six German BWRs. No cracks were found in the core shrouds of these plants.

The second major event in the early 1990s was the detection of cracks at various German BWRs in piping systems made of Ti-stabilized CrNi steel 1.4541 caused by thermal sen-

sitization in the heat-affected zone of welds. Comprehensive investigations resulted in a number of remedial measures (repair, replacement) implemented at piping in contact with reactor coolant of temperatures above 200 °C.

Thanks to the remedial measures and according to the analyses performed, cracking in the components in question due to the considered damage mechanisms need not be expected. German operators have therefore continued operating their BWR plants on normal water chemistry with an oxidizing environment. As a precaution, more stringent reactor coolant quality requirements have been specified and the limiting values of VGB Guideline R 401 J revised. This paper gives an overview of the trends in chemistry parameters at German BWR plants in the past 10 years. In addition, other relevant experience gained from the German BWR plants operating under normal water chemistry conditions is outlined: dose rates and collective doses, fuel performance, and results of periodic in-service inspections of major components of the reactor system. In the nearly 10 years of plant operation since implementation of the remedial measures, no cracks or other indications have been detected in any of the systems and components concerned.

Peter J. Millett

PPChem 2005, 7(2), 107–111

Advances in High Temperature Water Chemistry and Future Issues

This paper traces the development of advances in high temperature water chemistry with emphasis in the field of nuclear power. Many of the water chemistry technologies used in plants throughout the world today would not have been possible without the underlying scientific advances made in this field. In recent years, optimization of water chemistry has been accomplished by the availability of high temperature water chemistry codes such as MULTEQ. These tools have made the science of high temperature chemistry readily accessible for engineering purposes. The paper closes with a discussion of what additional scientific data and insights must be pursued in order to support the further development of water chemistry technologies for the nuclear industry.

Sung Chul Cha
Michael Spiegel

PPChem 2005, 7(2), 112–118

Studies on the Local Reactions of Alkali Chloride Particles on Metal Surfaces

During biomass combustion alkali chloride particles are formed, depositing on the metallic surface or on the already formed oxide layer. Subsequently, they react with the metal or the oxide layer and accelerate the oxidation process. To investigate these reactions equipment for particle deposition by impactor and thermophoresis was installed and optimized for homogeneous deposition. After deposition of KCl, iron samples were exposed to 800 $mL \cdot L^{-1}$ N_2-200 $mL \cdot L^{-1}$ O_2 and 799.5 $mL \cdot L^{-1}$ N_2-200 $mL \cdot L^{-1}$ O_2-0.5 $mL \cdot L^{-1}$ HCl atmospheres for short times at 300 °C. In 800 $mL \cdot L^{-1}$ N_2-200 $mL \cdot L^{-1}$ O_2, some deformation and local spreading of the particles were observed, probably by melt formation in contact with the metal. Oxidation with HCl addition led to a significant increase of chlorine and oxygen contents on the KCl deposited sample surfaces. Finally, thermogravimetric tests were conducted on deposits formed on iron at temperatures from 300 °C to 400 °C in 950 $mL \cdot L^{-1}$ Ar-50 $mL \cdot L^{-1}$ O_2 atmospheres with and without addition of 0.5 $mL \cdot L^{-1}$ HCl. In the case of HCl addition, mass gains increased rapidly in the beginning of oxidation. The iron chloride or chlorine-rich layer was formed directly at the metal scale and under the oxide layer.

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PPChem 2005, 7(2), 119–125

Online Monitoring of Steam/Water Chemistry of a Fast Breeder Test Reactor

Operating experience with the once-through steam generator of a fast breeder test reactor (FBTR) has shown that an efficient water chemistry control played a major role in minimizing corrosion related failures of steam generator tubes and ensuring steam generator tube integrity. In order to meet the stringent feedwater and steam quality specifications, use of fast and sensitive online monitors to detect impurity levels is highly desirable. Online monitoring techniques have helped in achieving feedwater of an exceptional degree of purity. Experience in operating the online monitors in the steam/water system of a FBTR is discussed in detail in this paper. In addition, the effect of excess hydrazine in the feedwater on the steam generator leak detection system and the need for a hydrazine online meter are also discussed.

Milan Zmítko
Jan Kysela

PPChem 2005, 7(3), 133–139

Coolant Technology and Experience in VVER Units

The primary coolant technology approaches currently used in VVER units are reviewed and compared with those used in PWR units. Standard and modified water chemistries differing in boron/potassium control are discussed. Preparation of the VVER Primary Water Chemistry Guidelines in the Czech Republic is noted. Operational experience of some VVER units operated in the Czech Republic and Slovakia in the areas of the primary water chemistry and radioactivity transport and build-up are presented. In the Mochovce and Temelín units, a surface preconditioning (passivation) procedure has been applied during hot functional tests. The main principles of the controlled primary water chemistry applied during the hot functional tests are reviewed and the importance of the water chemistry, technological and other relevant parameters is stressed in regard to the quality of the passive layer formed on the primary system surfaces. The first operational experience obtained in the course of the commissioning of these units is presented, mainly with respect to the corrosion product level in the coolant and surface activities of the corrosion products. The effect of the initial passivation performed during hot functional tests and the primary water chemistry on the radioactivity level and radiation situation of corrosion products is discussed.

Ewa M. Labuda
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PPChem 2005, 7(3), 145–153

Stress-Assisted Corrosion: Case Histories

Three case studies involving waterwall and economizer tubes from a conventional type boiler and a high pressure primary superheater header removed from a heat recovery steam generator are presented. In each case, results of visual examination, scanning electron microscopy/energy dispersive X-ray spectroscopy, and optical metallography are provided. Corrosive environments and possible stresses that led to failures are discussed.

Preet M. Singh
Jorge J. Perdomo
Jamshad Mahmood
Pablo Conde

PPChem 2005, 7(3), 155–161

Stress-Assisted Corrosion Simulation in the Laboratory

Stress-assisted corrosion (SAC) of boiler tubes and economizer tubes from the waterside is one of the major problems in availability loss and safety of power plants and industrial boilers. Use of carbon steel for the service of high temperature water applications strongly depends upon the formation and stability of the protective magnetite oxide film, Fe_3O_4, on the waterside surface of boiler tubes. Failure mechanisms involved in waterside SAC surely include film damage as an important step. To understand SAC, a recirculation-loop autoclave facility for high temperature water testing was set up. The autoclave is designed for tests under industrial boiling water conditions. The maximum operational temperature is 350 °C, with test pressures of up to 24.1 MPa (3 500 psi) and flow rates of up to 10 $L \cdot h^{-1}$. Boiler water chemistry can be changed during the tests and the dissolved oxygen can be controlled within the range of 10 $\mu g \cdot kg^{-1}$ to 32 $mg \cdot kg^{-1}$. Initial tests were conducted to develop magnetite film on carbon steel tube samples at different temperatures.

Keezhanatham S. Seshadri
Muthiah Pushpa
Pradeep Kumar Sinha
Kamal Behari Lal

PPChem 2005, 7(3), 163–167

Wet Oxidation of EDTA Using Metal-Doped MCM-41 as Catalyst

Decontaminants like ethylenediaminetetraacetic acid (EDTA), ascorbic acid, and citric acid are widely used in the radioactive decontamination of reactor components. The complexants interfere in the treatment of radioactive effluent and hence it is imperative to oxidatively destroy the complexant to enable easy treatment of radioactive effluent. An attempt has been made to oxidatively destroy EDTA using hydrogen peroxide as oxidant in the presence of metal-doped MCM-41 as catalyst. The reason for using metal-doped MCM-41 as catalyst for the oxidative degradation is because of its larger surface area (~ 1 000 $m^2 \cdot g^{-1}$) with small pore size (20–100 Å). Also the metal used has variable valency, which helps in undergoing electron transfer reactions. Metal-doped MCM-41 was synthesized. Results indicate that among the metals chosen for doping MCM-41, the catalytic efficiency in the oxidative degradation decreased in the following order: molybdenum > vanadium > titanium.

Albert Bursik

PPChem 2005, 7(3), 169–175

Power Plant Cycle Chemistry – A Currently Neglected Power Plant Chemistry Discipline

Power plant cycle chemistry seems to be a stepchild at both utilities and universities and research organizations. It is felt that other power plant chemistry disciplines are more important. The last International Power Cycle Chemistry Conference in Prague may be cited as an example. A critical reviewof the papers presented at this conference seems to confirm the abovementioned statements.

This situation is very unsatisfactory and has led to an increasing number of component failures and instances of damage to major cycle components. Optimization of cycle chemistry in fossil power plants undoubtedly results in clear benefits and savings with respect to operating costs. It should be kept in mind that many seemingly important chemistry-related issues lose their importance during forced outages of units practicing faulty plant cycle chemistry.

Eric V. Maughan

PPChem 2005, 7(3), 181–187

pH – A Simple Measurement Most Frequently Done Incorrectly

pH is the most popular analytical process measurement. Despite this, it is also very often misinterpreted. This paper will attempt to explain the measurement of pH, the pitfalls and the influences which other variables have on this analytical method.

Hans-Günter Seipp
Frank-Udo Leidich

PPChem 2005, 7(4), 197–207

Damage in Water/Steam Cycles – Often a Matter of Solubility

Water and steam, the working fluids in the water/steam cycles of power plants, nowadays are characterized by a high degree of purity. Nevertheless, from time to time, damage is detected on plant components that is attributable to a substantial localized accumulation of "contaminants." This report presents a number of examples where typical damage was found, but the effects of the process-dependent varying solubility of substances had not fully been taken into consideration.

David M. Gray

PPChem 2005, 7(4), 214–218

pH and CO_2 Determinations Based on Power Plant Conductivity Measurements

Previous work has focused on major improvements in the accuracy of conductivity measurements and on the development and benefit of multi-parameter on-line analytical instrumentation. This background as well as continuing work now provide additional parameters that can be derived from accurate specific, cation (acid) and degassed cation (acid) conductivity measurements.

Masahiko Kurashina
Hideo Uzawa
Koya Utagawa
Hiroshi Takaku

PPChem 2005, 7(4), 219–223

On-Line Analysis of ETA and Organic Acids in Secondary Systems of PWR Plants

To reduce the iron concentration in the secondary water of plants with pressurized water reactors (PWRs), ethanolamine (ETA) is used as an alkalizing agent in the secondary cycle. An on-line ion chromatography (IC) monitoring system for monitoring concentrations of ETA and anions of organic acids was developed, its performance was evaluated, and verification tests were conducted at an actual PWR plant. It was demonstrated that the concentration of both ETA and anions of organic acids may be successfully monitored by IC in PWR secondary cycle streams alkalized by ETA.

Albert Bursik

PPChem 2005, 7(4), 224–230

Is Pittsburgh (PA) Worth a Trip for a Power Plant Chemist?

In this paper, power plant chemistry-related papers presented at the 65th International Water Conference® held in Pittsburgh (PA) last year are reviewed. The review of these papers results in a recommendation to attend the conference this year again (Orlando, FL, October 9–13).

Pavel Kolat
Dagmar Juchelková
Anna Nezhodová

PPChem 2005, 7(4), 231–242

Energy Utilization of Biofuels Based on Sludge and Lignite

Energy utilization of alternative fuels is one of the main tasks in the development of renewable sources in the European Community and the Czech Republic. The topics of the research consist of combustion tests in an experimental pilot plant with an atmospheric fluidized bed located at the Technical University, Dresden, Germany, for the lignite and sewage sludge, and thermo-analytical studies of biofuels. Recommendations for the suitability of thermal disposal of wastes in the atmospheric fluidized bed are presented

with respect to minimizing the harmful emissions. It may be assumed from results that combustion with a content of 15 % biofuels is applicable in the large fluidized bed boilers installed in the Czech Republic.

Eric V. Maughan

PPChem 2005, 7(4), 247–251

The Conductivity Cell and the Determination of Cell Constant in Pure Water Systems

There are many manufacturers of conductivity measurement systems for pure water, all of which work on the same physical principles. However, what is often confusing is the range of conductivity measurement cells or sensors and how to select the most appropriate cell constant for a particular application. This paper covers the theory of conductivity measurement and the determination of cell constants.

Ulf Ilg

PPChem 2005, 7(5), 261–270

Failure Analysis of Austenitic Stainless Steel Piping in Boiling Water Reactors – Root Cause and Remedies

In stainless steel piping DN 150–250 mm (DN, diameter nominal, metric equivalent to NPS, nominal pipe size) of German boiling water reactors, intergranular cracks in the heat affected zones of titanium-stabilized material have been detected. The piping systems are connected with the reactor pressure vessel and characterized by permanent reactor water flow at 288 °C.

Crack susceptibility is based on local sensitization. The present sensitization mechanism is due to a sequence generating free carbon caused by dissolution of Ti carbides followed by precipitation of chromium-rich carbides at the grain boundaries. This occurred during formerly used manufacturing processes about 20 years ago.

All affected piping systems were replaced by an optimized niobium-stabilized austenitic steel with low-carbon content and a high niobium to carbon ratio. Well controlled manufacturing and welding procedures with a good root weld quality were realized. In addition to this, reactor water chemistry was improved.

In the measures above, the total number of stainless steel welds DN > 50 mm within the containment was drastically reduced from about 450 to about 100. All nondestructive tests performed with the piping lines under discussion confirmed a condition without indications.

Kevin J. Shields
Michael A. Sadler

PPChem 2005, 7(5), 271–277

Power Industry Application of Condensate Polishing Technology

Condensate polishing was originally valued in power cycles as it offered protection against the impurities that entered the steam/water circuits. Its use also shortened the time necessary to start up the units. In addition, polishing permits fossil units to use more effective methods of cycle chemistry treatment. This is now recognized as a very important advantage. There are now various condensate polishing plant configurations in use around the world, but these have not changed significantly for some time. EPRI has initiated an investigation of innovative polishing techniques that may lower capital and operating costs and simplify operation so that future polishing systems are suitable for use on fossil (conventional or combined cycle) plants.

Miroslaw Gruszkiewicz
Albert Bursik

PPChem 2005, 7(5), 289–296

Degassed Conductivity – Comments on an Interesting and Reasonable Plant Cycle Chemistry Monitoring Technique

Part 3: Degassing of Strong Inorganic Acids and a Final Assessment

This is the third part of a three-part publication focusing on the behavior of typical plant cycle contaminants during degassing in a typical degassed cation conductivity system. A rigorous thermodynamic approach was chosen for the evaluation of conditions in the degassing part of the system. As shown in Part 1, low-molecular acids are not removed during the degassing; carbon dioxide, however, is nearly completely removed (Part 2). In this part of the series, it is demonstrated that the relevant strong inorganic acids are not lost in the degassing device.

Degassed cation conductivity monitoring is not as common as specific and cation conductivity monitoring even though this technique offers some very interesting features. As shown in the case studies discussed, this technique can help to distinguish between

plant cycle contamination due to inorganic and/or organic acids and/or their salts and that caused by carbon dioxide. This may be important, e.g., during startup of a unit.

Luis Carvalho

PPChem 2005, 7(5), 297–304

Avoiding Costly Water Treatment Mistakes in Combined Cycle Power Plant Projects

In a typical power plant, water treatment is a relatively small slice of the operating budget, generally less than 2 % of the total cost of operation. However, its impact on the plant heat rate, net capacity factor and ultimate profitability can range from significant to disproportionately high. One area of particular concern is the high-purity water requirement in various areas of an increasingly complex power plant cycle. This ranges from several boiler feedwater loops to combustion turbine NOx control and combustion air-cooling.

Plant owners, developers, owners' engineers, and engineering/constructor firms often fail to understand the multitude, interaction and complexity of water treatment technologies (both equipment and chemical based) available in the market place today and how best to incorporate them at the design phase of the project. Equipment selection is also often made with complete disregard to the alternate use of more technically feasible and cost-effective chemical-based treatment options. The end result is plant designs unable or barely capable of meeting the performance specifications of critical equipment such as steam and gas turbines even during the start-up phase, leading to start-up delays and legal disputes, and later translating into high water treatment operating costs, plant downtime and potential expensive plant modifications.

This paper discusses water treatment technologies such as membrane separation (e.g., reverse osmosis), electrodialysis and electrodeionisation, and the fading yet unique role that ion exchange can play. It also addresses the critical role that well-qualified chemical water treatment companies can play in avoiding costly mistakes during power plant design, how to best fit chemical treatment options, and what can go severely wrong when the raw water to the plant is not critically evaluated.

Eric Maughan

PPChem 2005, 7(5), 305–308

Developments in On-Line Instrumentation

In this paper, some useful advice and answers to frequently asked questions are presented with respect to common problems occurring in the on-line monitoring of fossil plant cycle chemistry. Focus is on monitoring of the three most important cycle chemistry parameters, conductivity, oxygen content, and pH.

Klaus Weigl
Christopher C. Ayers
Ludwig Gockner
Josef Tauschitz

PPChem 2005, 7(5), 309–313

On-Site SCR Catalyst Rejuvenation Process as Part of a Catalyst Management Plan

The on-site catalyst rejuvenation process is a highly efficient tool to reduce operating and maintenance costs for lifetime extension of catalysts for selective catalytic reduction (SCR) of NOx compared to catalyst exchange and/or additional catalyst installation. Depending on the type of deactivation, the process is fit to the requirements based on our experience. Thus the tailor-made process can handle deactivation types like pluggage, alkali and earth alkaline depositions, and more. One of the important constraints is to perform the rejuvenation on-site within the given outage of the boiler to reduce any additional costs and risks. New results from rejuvenations performed on SCR catalysts from coal and oil fired units are presented. A cost analysis compared to the additional catalyst installation is given as part of a catalyst management plan.

Digby D. Macdonald

PPChem 2005, 7(6), 324–338

Fact and Fiction in ECP Measurement and Control in Boiling Water Reactor Primary Coolant Circuits

A review is presented of various electrochemical potentials, including the electrochemical corrosion potential (ECP), that are used in the mitigation of stress corrosion cracking in the primary coolant circuits of boiling water reactors (BWRs). Attention is paid to carefully defining each potential in terms of fundamental electrochemical concepts, so as to counter the confusion that has arisen due to the misuse of previously accepted terminology. A brief discussion is also included of reference electrodes and it is shown on the basis of experimental data that the use of a platinum redox sensor as a reference elec-

trode in the monitoring of ECP in BWR primary coolant circuits is inappropriate and should be discouraged. If platinum is used as a reference electrode, because of extenuating circumstances (e.g., potential measurements in high dose regions in a reactor core), the onus must be placed on the user to demonstrate quantitatively that the electrode behaves as an equilibrium electrode under the specified conditions and/or that its potential is invariant with changes in the independent variables of the system. Preferably, a means should also be demonstrated of transferring the measured potential to the standard hydrogen electrode (SHE) scale.

Beverly Newton
Mike Doyle
Luis Carvalho
Ian Scarth
Peet Lindau

PPChem 2005, 7(6), 339–345

Fear and Loathing at a Combined Cycle Power Plant – Ion Chromatography in a Box

The use of ion chromatography for monitoring corrosive ions in water has been implemented at several new combined cycle gas-fired power plants. Due to stringent requirements for clean water to prevent corrosion and plugging of turbine components, this methodology is predicted to have a significant impact in extending useful operating lifetimes and to measurably increase the availability of components in contact with water. Ion chromatography, due to its ability to identify individual anion and cation species, to achieve parts-per-trillion detection limits, and to operate on-line, has played a central role in the effectiveness of these water chemistry monitoring programs.

Combined cycle power plants are faced with tough choices for water monitoring. The lack of trained chemists to run low level analyses results in uncertainty as to the quality of the water used for steam going to the turbine and in some cases to the generator. This paper presents a report on a recent study of a low cost, hands-off ion chromatography solution to provide on-line monitoring at the water panel for chloride and sulfate ions at 1 part per billion or below.

Wilfried Rühle
Harry Neder
Günter Holz
Volker Schneider

PPChem 2005, 7(6), 355–363

Oxygen Injection into Reheating Steam of Moisture Separator Reheaters

The steam/water cycles of the nuclear power plants Philippsburg 2 (KKP-2), Isar 2 (KKI-2) and Biblis A/B (KWB-A/B) operate under high-AVT-chemistry conditions (pH at 25 °C ≥ 9.8 in final feedwater). After many years of excellent operating performance, flow-accelerated corrosion (FAC) in the carbon steel heater tubes of the moisture separator reheaters (MSRs) was observed. In order to counteract the flow-accelerated corrosion it was decided to inject oxygen into the reheating steam line upstream moisture separators. As is known, more stable protective oxide layers are formed in oxygen-containing steam condensate. However, reducing conditions in the recirculating water of the steam generators also had to be ensured after the implementation of oxygen injection at the plants to definitely exclude conditions under which localized corrosion could occur. Visual and eddy current inspections performed after four cycles of operation confirmed that FAC in the MSRs in KKP-2 and KWB-A/B could be stopped without negative side effects on the steam generators.

This paper describes the influence of the oxygen injection on the water chemistry parameters and system performance at KKP-2, KKI-2 and KWB-A/B.

Geoff Spowart

PPChem 2005, 7(6), 365–367

Hypochlorite and the pH in Cooling Water

This paper looks at the issues surrounding the relationship between pH and chlorine effectiveness in power station cooling water. In particular, the impact of changes to cooling water chemistry on Legionella counts is highlighted along with some strategies for optimizing biocide dosing and the pH set point.

K. Anthony Selby

PPChem 2005, 7(6), 369–372

The 25th Annual University of Illinois Electric Utility Chemistry Workshop – Extending the Life and Reliability of Power Plant Equipment through Improved Chemical Control

In May this year, the 25th Annual University of Illinois Electric Utility Chemistry Workshop took place in Champaign, IL, U.S.A. The abstracts of the papers presented at this event are compiled in this paper.

Eric V. Maughan

PPChem 2005, 7(6), 375–378

On-Line Calibrator for Verifying Sodium Ion Transmitters

The question of calibration and verification of on-line instrumentation at the concentration of interest is often raised. This paper describes a method using a conductivity measurement to calibrate and verify sodium ion analyzers, as well as pH and conductivity sensors.

Jean Belles-Baumann

PPChem 2005, 7(7), 388–396

Production of Makeup Water with Ion Exchange Resins

The use of ion exchange resins for purifying makeup water is the on-going state-of-the-art technology for this application. Water treatment with ion exchange resins is for the majority of sites the method of choice because of the high flexibility of this technology. In this paper, basic principles of ion exchange are explained, and the different ion exchange systems and technologies, including operating conditions, are reviewed and compared. Furthermore, the important role of proper pretreatment and operating temperature is discussed. Some principles of ion exchange plant design and plant monitoring are described in detail. Finally, technical hints are given for maintenance and protection of ion exchange resin plants during operation and shutdown periods.

Geoff Bignold
Robert Svoboda

PPChem 2005, 7(7), 411–414

Meetings of the IAPWS Working Group "Power Cycle Chemistry" in Santorini, Greece, July 3–8, 2005

In July 2005, the 2005 Annual Meeting of the International Association for the Properties of Water and Steam (IAPWS) took place in Santorini, Greece. This paper reports on the sessions of the IAPWS Working Group "Power Cycle Chemistry" and other power plant chemistry-related activities of the IAPWS. Included are a review of the current priority list (a list of areas considered by the working group members to need basic research), a summary of the conclusions of the 2004 international collaboration project initiated by the Working Group, summaries of the research presentations given during the meeting, a list of the presentations made during the focused topic discussions, a summary of the Working Group's plans for the coming year, and a list of the presentations made at the IAPWS Symposium on Applied Water Treatment Processes for Power Plant Cycles.

Karol Daucik

PPChem 2005, 7(7), 417–421

Sampling of Particulates in the Water/Steam Cycle

Analysis of particulate components in the water/steam cycle is an important issue in the chemical control of fossil and nuclear power plants. Sampling is the most difficult part of this issue. In this paper significant parameters affecting the quality of the sample are discussed and their importance is demonstrated by field investigations. The author emphasizes the importance of turbulence through the sample line during isokinetic sampling. Well-designed sampling devices and sampling procedures are prerequisites for reliable sampling of particulates.

Kazuo Marugame
Li-Bin Niu
Hiroshi Takaku

PPChem 2005, 7(7), 422–428

Development of a Gluconate Ion Selective Electrode for Gluconate Measurement in the Boiler Water

To develop a gluconate ion selective electrode for the measurement of the gluconate ion concentration, sensitive liquid ion exchangers were incorporated into a polyvinyl chloride membrane to form a gluconate ion selective electrode. The newly developed electrode showed a linear response to the gluconate ion activity between 10^0 mol · dm^{-3} and 10^{-4} mol · dm^{-3}, and the average potential change in this concentration region was –51 mV, when tridodecylmethylammonium gluconate was used as the ion exchanger. The selectivity coefficients of the electrode for various anions were determined with the mixed solution method. The electrode showed a constant potential in the pH range of 4 to 10, and also exhibited a steady potential within 3–10 s after a gluconate concentration change of $10 \cdot 10^{-3}$ mol · dm^{-3} to $5.5 \cdot 10^{-3}$ mol · dm^{-3} in an aqueous solution.

Eric V. Maughan

PPChem 2005, 7(7), 429–433

On-Line Chemistry Analysis of Stator Coolant Systems

Water-cooled generator stator systems with copper conductors suffer from plugging with corrosion products, which invariably leads to localized overheating. To avoid plugging, the correct chemistry and subsequent monitoring of the core parameters must be carried out. This paper focuses on the in-line measurement of essential chemical variables in the stator coolant water.

Vitaly A. Prisyazhniuk

PPChem 2005, 7(7), 435–442

The Langelier Saturation Index: Further Development

A simplified technique has been worked out to calculate the Langelier saturation index as an index of the corrosive and scale-forming properties of water. To perform the calculations it is necessary to know the total alkalinity of the water, its electrical conductivity, and pH. A method is presented for making semi-quantitative estimation of the water scaling capacity based on the thickness of the deposits formed. To calculate the thickness of the scale layer it is necessary to know the conductivity of the water at room temperature and the "operative" temperature of the surface on which scale formation is expected.

Miroslav Šťastný
Miroslav Šejna

PPChem 2005, 7(8), 455–462

The Effects of Steam Chemistry on the Condensation Process

A two-population numerical model of hetero-homogeneous condensation is used for the calculation of the wet steam flow with condensation in convergent-divergent nozzles. This computational model applies governing equations of the wet steam flow and equations of spontaneous nucleation. Parallel heterogeneous nucleation is evaluated on the assumption that heterogeneous water droplets originate by nucleation on chemical impurities (for instance sodium chloride) in the salt solution zone close above the steam saturation line. The calculation results of the flow in the nozzles with mean expansion rates of 4 500 s^{-1} and 1 000 s^{-1} in divergent nozzle parts are described and the effects of heterogeneous and/or spontaneous nucleation and condensation are discussed and compared with experiments. The concentrations of heterogeneous droplets were found by fitting of calculation results to experimental ones. A possible dynamic gradual origin of heterogeneous droplets during expansion was observed.

Robert Svoboda
Albert Bursik

PPChem 2005, 7(8), 472–480

Carbon Dioxide and Feedwater Chemistry

In this paper, the influence of carbon dioxide contamination on the pH of condensate/feedwater at temperature in fossil plant cycles is investigated. It is shown that in particular at temperatures below 200 °C, automatic feedwater pH control (ammonia dosing) has to be adapted to the overall cycle conditions (e.g. to a carbon dioxide ingress into the cycle. While at higher temperatures the presence of carbon dioxide has nearly negligible influence on pH (at cation conductivity $\leq 2\ \mu S \cdot cm^{-1}$), at temperatures lower than 200 °C, the pH at temperature may significantly decrease. Disregarding adequate pH (25 °C) control during periods with increased carbon dioxide content (increased cation conductivity) may create dangerous environmental conditions that favor flow-accelerated corrosion.

Francis Nordmann

PPChem 2005, 7(8), 481–488

Optimization of Chemistry in PWR and VVER Nuclear Power Plants

This paper, based on international feedback and studies, proposes potential improvements for PWR and VVER operation:

- pH optimization in the primary coolant in order to minimize corrosion product transport/deposition and associated radiation exposure, crud induced power shifts (previously called axial offset anomaly), and fuel failure;
- use of enriched boron acid (enriched with ^{10}B) to easily optimize the above described pH, particularly with the increased use of higher fuel enrichments;
- zinc addition in the reactor cooling system;
- establishment of secondary water chemistry specifications which take into consideration the steam generator tubing materials and design to minimize corrosion risk while keeping sufficient plant availability and decreasing environmental impact;
- amine selection for the secondary system aimed at mitigating steam generator tube fouling, power loss and maintenance costs as well as corrosion risks;
- overall operating chemistry options designed to minimize environmental impact, such as elimination of condensate polishers and optimum ion exchange resin use.

J. Barry Hughes

PPChem 2005, 7(8), 489–493

Automated Control of Chemistry Whilst under Cycling Regime at Teesside Power Station

Today a large number of power plants are run under cycling regimes. This calls for detailed control of the chemistry using automatic analysis and process control. The best determinant for analytical control has to be one that is directly measurable and control-

lable. A number of processes on the overall plant cycle at Teesside Power Station will be discussed and the reason for each determinant will be shown.

Muthiah Puspha
Keezhanatham S. Seshadri
Pradeep Kumar Sinha
Kamal Bihari Lal

PPChem 2005, 7(8), 494–499

A Comparative Account of the Wet Oxidation of Cation Exchange Resin with Hydrogen Peroxide Using Titanium, Vanadium, and Molybdenum Doped MCM-41 as Catalysts

Ion exchange resins are widely used in the nuclear industry for treatment of radioactive waste as well as for the upgrading of heavy water used in the primary heat transport system and moderator system. Repeated usage of the resins calls for replacement and treatment before disposal. The present work involves the application of metal-doped MCM-41 material as a catalyst for the wet oxidation of cation exchange resins using hydrogen peroxide as an oxidizing agent. The sulfate produced from the exchangeable group of the resin reflects the extent of decomposition and the carbonate produced reflects the extent of oxidation of the ion exchange resin. Results indicate that the percentage decomposition and oxidation increase with the weight of the catalyst and the volume of the oxidant, i.e., hydrogen peroxide. As much as 0.5 g of the resin could be decomposed by 12 mL of 30 % hydrogen peroxide to 98.7 % and oxidized to 99.25 % using molybdenum doped MCM-41. Vanadium doped and titanium doped MCM-41 required 14 to 16 mL for complete decomposition and 18 to 20 mL for complete oxidation of the ion exchange resin..

Eric Maughan

PPChem 2005, 7(8), 500–507

The Measurement of Dissolved Oxygen in Condensate and Feedwater Circuits

Questions often arise about the calibration, verification, and maintenance of oxygen sensors. This paper offers an overview of the available systems and gives advice with respect to troubleshooting related to the on-line measurement of oxygen and to the storage of oxygen sensors.

Frederick J. Pocock, Jr.
Jack W. Stewart

PPChem 2005, 7(9), 517–531

The Solubility of Copper and Its Oxides in Supercritical Steam

This paper contains a study of the solubility of copper and its oxides in supercritical steam which was undertaken because of difficulties experienced with copper deposition in the high-pressure turbine of the Ohio Power Company's Philo 6 supercritical steam-generating cycle. This study shows that copper has appreciable solubility in superheated supercritical steam. The extent of solubility is apparently a function of the oxidation state of the metal, with the highest state of oxidation (CuO) showing the greatest solubility. A slightly increased solubility was effected by increasing pH values from 7.5 to 9.5 with ammonia. It is also shown that copper solubility is principally a function of pressure over the narrow temperature range tested (900 °F to 1 150 °F) probably because this parameter has the greatest effect on specific volume.

Brian R. Ohler
Jasbir S. Gill

PPChem 2005, 7(9), 534–538

Improving the Performance of ZLD Cooling Water System through Innovation in Chemistry and Control

An innovation in chemistry and control technology was deployed at Deseret power station to control corrosion, scale, and biofouling. A low phosphate molecule containing no heavy metals was used for both scale and corrosion control. The monitoring and control is based on several fluorescence-based probes to determine the optimum dose and monitor the treatment performance for scale, bio, and corrosion control. The new treatment in combination with the on-line 24/7 monitoring, control, and the ability to communicate performance via web or modem resulted in optimum performance and cost. The study was deemed successful and is currently deployed as a commercial technology.

Peter L. Andresen

PPChem 2005, 7(9), 541–560

Critical Processes to Model in Predicting Stress Corrosion Response in Hot Water

Structural materials have a fundamental susceptibility to stress corrosion cracking (SCC) in high temperature water, and extensive efforts have been made to quantify their specific response as a function of material and condition, water chemistry, temperature, stress, etc. There are many primary variables, and dozens of important factors, all of which are inter-dependent in establishing SCC response. The only comprehensive way

of tackling this problem is to identify the underlying processes that control SCC, which provides a fundamental framework for understanding the myriad of interdependent factors. This paper discusses the processes that must be understood and modeled, and compares various approaches in this quest.

R. Barry Dooley
James E. Castle
Peter A. Zhdan

PPChem 2005, 7(9), 561–567

Minimizing Copper Pickup from Copper Alloys in the Feed Train by Control of pH and ORP: New Operating Limits

This paper reviews recent research, sponsored by EPRI, by which the amount of copper release from the copper alloys commonly found in the feed train of power stations has been determined. The investigations have been undertaken under carefully controlled laboratory conditions to simulate feedwater. Release rates are given for pure water as a function of the pH value and the oxidation-reduction potential (ORP). The ORP responds directly to the level of dissolved oxygen and is a sensitive indicator of whether the feedwater is oxidizing or reducing with respect to copper. For all conditions of exposure, the copper alloy surfaces have been characterized in terms of the morphology and composition of the surface oxides. The mechanism of release is discussed on the basis of the surface characteristics.

Measurements relevant to the LP heaters were made using a standard test temperature of 95 °C (203 °F). Under reducing conditions (defined by an ORP of –300 mV) the minimum release is found, for admiralty brass, 90/10 cupronickel and aluminum brass, to be close to a pH value of 9.5. Under fully oxidizing conditions (an ORP of +100 mV), the minimum is shifted to a lower pH value, in the range 7–8. Copper release decreases on reduction of oxygen concentration, but evidence is found for very high release rates in the ORP range –50mV to +50 mV, associated with the transition between Cu_2O and CuO as the thermodynamically stable surface phase. In this region of instability, approximately between 0.1 and 1 $mg \cdot kg^{-1}$ O_2 or –50 to +50 mV ORP, very high release rates may be found. It should be considered unsafe to operate in this range. Transitions through the range in either direction must be made promptly in order to minimize copper pick up by the feedwater. Measurements relevant to HP heaters were made using test temperatures up to 350 °C (660 °F). Release from 70/30 cupronickel followed a similar pattern to that observed for the LP train.

Based on these measurements, a new set of operating limits for these alloys under typical fossil fueled plant conditions has been incorporated into the latest revisions of the EPRI Guidelines for AVT, Phosphate Continuum and Caustic Treatment. These limits minimize copper pickup from copper alloy and mixed-metal feedwater systems.

Masahiko Kurashina
Hideo Uzawa
Toshiaki Aoki
Li-Bin Niu
Hiroshi Takaku

PPChem 2005, 7(9), 569–573

Development of Electric Cation Exchanger for Measurement of High pH Secondary Water Quality in PWR Plants

High pH operation is applied to the secondary water treatment of Japanese pressurized water reactor (PWR) plants. To reduce the maintenance frequency to as low as possible, an electric cation exchanger used with electric dialysis film as a substitute for the cation exchange resin was developed. Some tests conducted at an actual PWR plant as well as at our laboratory have confirmed that the performance of the developed electric cation exchanger may be promising for actual use.

R. Barry Dooley
Albert Bursik

PPChem 2005, 7(10), 581–585

International Conference on "The Interaction of Organics and Organic Cycle Treatment Chemicals with Water, Steam, and Materials" – Conference Discussion Groups and Summary

At the beginning of the conference, Dooley and Bursik had presented five key topics in the world of organics in power generation cycle chemistry for which they thought knowledge was deficient. Following the working group summaries, the conference chairmen came back to the same points and provided the following summary.

The conference provided a great cross-section of the science, applications and results in all aspects of organics in the energy cycle chemistry cycle. The science appears to be improving. The number of applications is also increasing. But quantitative assessments remain weak and thus raise more questions than they provide answers. Particularly,

answers will be needed in the first five areas before any quantitative guidelines can be derived:
- Effect on cycle materials
- Properties of organics in the cycle
- Organics as treatment chemicals
- Shutdown/layup protection
- Role of organics in efficiency/performance improvement
- Economics

Albert Bursik
R. Barry Dooley

PPChem 2005, 7(10), 593–598

Organics: A Retrospective Look at Fossil Plant Cycle Chemistry and the Possible Requirements for the Future

The current suite of EPRI fossil plant cycle chemistry guidelines for all-volatile treatment (AVT), oxygenated treatment (OT), phosphate continuum (PC), and caustic treatment (CT) have established themselves as the treatments of choice around the world. These guidelines contain little information on the presence of organics in the cycle nor do they advocate the use of organic additives during either operation or shutdown. This paper, and indeed the conference *Interaction of Organics and Organic Cycle Treatment Chemicals with Water, Steam, and Materials*, has been assembled to review the status of all aspects of organics in a fossil plant cycle. The two main thrusts are to thoroughly review the science and application and to recognize the main areas of deficiency in that knowledge so that a structured research program can be developed. Interest is focused not only on the adventitious ingress of organics through the makeup and cooling water systems, but also on the purposeful addition of organics to the cycle as treatment chemicals or preservatives.

Peter J. Millett
Keith Fruzzetti

PPChem 2005, 7(10), 599–603

Status of Application of Amines in US PWRs

Prior to 1990, the majority of US units with pressurized water reactors (PWRs) were using ammonia as the primary pH control agent in secondary systems. Morpholine was used in one plant that did not employ condensate polishers. With the introduction of ethanolamine and other advanced amines in 1992, US PWRs could now get the benefit of improved pH control and still operate condensate polishers in the H-OH form. In this paper, the current practice with amines in US PWRs is reviewed with consideration for the optimization of pH control in secondary systems.

Kazuo Marugame
Li-Bin Niu
Hiroshi Takaku

PPChem 2005, 7(10), 605–610

Corrosion Behavior of Magnetite Grown from Amine-Carboxylate and Amine Aqueous Solutions

A unique boiler water treatment using amine-carboxylate and amine for the application in the temperature range of 150–364 °C and at pressures from 0.5–20 MPa has been developed. The size of the magnetite formed by this method is very fine 0.3–1.5 µm, while that of magnetite formed by the conventional boiler feedwater treatment is 20–40 µm. Laboratory test results have shown that the specimens treated with this magnetite have good corrosion resistance in both severe acidic and caustic environments, while those formed by the conventional boiler feedwater treatment experience severe general and pitting corrosion. Results from an actual power plant test show the same corrosion behavior as in the laboratory tests. The formation of this fine and tight magnetite on the boiler tube inner surface is very effective for corrosion suppression.

Melanie Montgomery
Ole Hede Larsen

PPChem 2005, 7(10), 611–622

Field Investigation of Various Weld Overlays in a Waste Incineration Plant

A test waterwall was fabricated so that alternatives to alloy 625 could be exposed in the first pass of the waste incineration plant Haderslev. The difference between application method was also a parameter, such that manual welding, machine welding and arc spray coating of alloy 625 were compared. In addition to the test waterwall exposure, the chemical environment from the waste incineration was also monitored by analyzing deposits and corrosion products from various locations in the boiler. These were analyzed with respect to morphology and composition using electron microscopy with energy dispersive spectrometry. Based on these results it was detected that the aggressive environment had changed during the exposure period, which made direct comparison difficult between alloys that had been exposed the first year and those exposed for

the second year. However, all candidate alloys could be compared with alloy 625, which was present in every test panel. It was observed that all the weld overlay test sections behaved similarly to machined alloy 625 in that there was general corrosion and pitting corrosion. In addition, alloy 622 also exhibited preferential corrosion with respect to its dendrite structure.

Raúl B. Rebak

PPChem 2005, 7(10), 623–631

Environmentally Assisted Cracking of Commercial Ni-Cr-Mo Alloys – A Review

Nickel-Chromium-Molybdenum alloys (Ni-Cr-Mo) are highly resistant to general corrosion, localized corrosion and environmentally assisted cracking (EAC). Chromium acts as a beneficial element under oxidizing acidic conditions and molybdenum under reducing conditions. All three elements (Ni, Cr and Mo) act synergistically to provide resistance to EAC in environments such as hot concentrated chloride solutions. Ni-Cr-Mo alloys may suffer EAC in environments such as hot caustic solutions, hot wet hydrofluoric acid solutions and in supercritical water oxidation applications. Not all the Ni-Cr-Mo alloys have the same susceptibility to cracking in the mentioned environments. Most of the available data regarding EAC is for the oldest Ni-Cr-Mo alloys such as N10276 and N06625.

Miroslaw S. Gruszkiewicz
Donald A. Palmer

PPChem 2005, 7(11), 644–655

Modeling the Behavior of Formate, Acetate, and Carbon Dioxide in Water/Steam Cycles

Organic substances persist in high-temperature aqueous environments for varying periods of time depending on temperature, pH, contact with solid surfaces, and other factors. Since carboxylic acids and CO_2 affect the pH and can potentially play specific roles in the promotion or inhibition of turbine corrosion, it is important to be able to predict the amounts of these substances that are transferred to steam and the composition of the early condensate as a function of condensation ratio for various boiler chemistries. Such predictions can only be made using a speciated model including all the solutes. Example calculations for AVT and OT chemistry show complex relationships between early condensate enrichment ratios and boiler pressure, boiler water composition, and condensation ratio. Even small amounts of sodium and chloride below 0.1 $\mu g \cdot kg^{-1}$ in the steam are relevant to early condensate pH and carboxylic acid concentration. The calculations show that the enrichment of the early condensate relative to steam is typically 10 times greater for formate than for acetate.

Ursula Hollwedel

PPChem 2005, 7(11), 656–664

Secondary Side Chemical Cleaning of Steam Generators of Pressurized Water Reactors

Chemical cleaning (CC) is a qualified, efficient method to remove not only sludge piles from the tube sheets of steam generators (SGs) but in addition scales from the heat transfer tubing. A major component of SG deposits is magnetite, which is dissolved using an organic chelating agent, usually ethylenediaminetetraacetic acid, in an alkaline, reducing environment. If copper is present in the SGs, it is removed in a separate step using organic chelants under oxidizing conditions. There are two well-known processes on the market for magnetite and copper removal, the EPRI/SGOG developed chemical cleaning process open for application by all interested companies and the Siemens/KWU developed and patented High Temperature Steam Generator Chemical Cleaning (HT-SGCC) process. The characteristic features of both processes are compared and the application and results of the latest HT-SGCCs performed with respect to the amount of deposits removed and application time are summarized.

Walter Guhl
Wolfgang Hater

PPChem 2005, 7(11), 667–673

Snails and Mussels in Cooling Systems

Foreign matter in cooling systems may seriously deteriorate the effectiveness of the cooling cycle, especially if this matter reduces the regular flow of the cooling water by blocking the condenser tubes. Often, these foreign bodies are mussels and snails, which may be present in large numbers and whose shells may block the flow through the tubes. The most important species living in cooling systems are presented and their behaviour in cooling systems is described. Comprehensive studies have shown that the biocides P3-ferrocid 8591 or P3-ferrocid 8580 in combination with the biodispersant P3-ferrofos 8460 are excellent for controlling mussels and snails. This procedure is more effective if a partial stream filtration is also used at the same time.

Ashok G. Kumbhar
Arvind D. Belapurkar
Gopala Venkateswaran
Kamal Kishore

PPChem 2005, 7(11), 674–679

Impact of Different Metal Turbidities on Radiolytic Hydrogen Generation in Nuclear Power Plants

Radiolytic hydrogen generation on gamma irradiation of turbid solutions containing metal turbidities such as titanium, nickel, iron, chromium, copper, indium, and aluminium was studied. It is suggested that the chemical reactivity of the metal in the turbid solution with radicals produced by radiolysis of water interferes with the recombination reactions which destroy hydrogen and hydrogen peroxide, thus leading to higher yield of hydrogen. The rate of generation of hydrogen and the radiolytic yield of hydrogen is related to the reactivity of the metal ion/hydroxylated species with the free radicals.

Steef H. M. Vrijhoeven,
Paul B. Desch
James J. Dillon

PPChem 2005, 7(11), 680–693

Case Histories of Unusual Boiler Failures

Case histories are presented that describe atypical failures in boiler systems that are related to nonstandard or improper design, installation, materials specification, and operating practice. Some cases demonstrate how residual stresses in boiler components combine with unexpected environmental conditions to produce damage. The specific circumstances that promoted the failures are described and corrective actions are discussed.

Václav Roubíček
Pavel Kolat
Bohumír Čech
Dagmar Juchelková
Zdeněk Kadlec

PPChem 2005, 7(11), 695–702

Utilization of Alternative Fuels in Fluidized-Bed Boilers

The energy utilization of alternative fuels is one of the main topics for future development of recoverable resources in the European Union and in the Czech Republic. The subject of the research is combustion tests in a fluidized-bed boiler located at Štětí, Czech Republic. The experiments were carried out using Czech brown coal, wood, sewage sludge and wastes. Analyses and recommendations for optimal thermal utilization and minimization of harmful emissions were developed. The second step was thermal analyses of coal and the alternative fuels wood pellets and sewage sludge from treatment plants. From the results of the experiments and thermal modeling it is clear that 15 % alternative fuels can be used in the large fluidized-bed boilers located in the Czech Republic.

Andrew G. Howell
George E. Saxon, Jr.

PPChem 2005, 7(12), 708–716

Condenser Tube Fouling and Failures: Cause and Mitigation

The two most common condenser tube problems faced by chemists are internal tube fouling and tube failure. Fouling can have a major impact on power station generating efficiency and/or capacity, and tube leaks can seriously impact unit availability and reliability. Fundamental understanding of the root cause(s) of these issues and their mitigation is essential to resolving these problems and/or preventing their occurrence.

Ruedi Germann

PPChem 2005, 7(12), 718–720

Process Monitoring: What Really Matters

This paper focuses on an increasingly important topic: problems with bidding procedures for process monitoring instrumentation. The recent calls for bids are exclusively focussed on prices and do not take into account the kind of application and the specific requirements with respect to instrument maintenance and quality assurance. As a rule, the cheapest instrument selected does not in the majority of cases represent the best solution, in particular for cycle chemistry monitoring in power plants.

David M. Gray

PPChem 2005, 7(12), 729–731

Measurement of Organics in Power Plant Makeup Water Treatment

Most efforts at producing pure water have focused on removing minerals, with processes that do not necessarily remove organic compounds. There is increasing awareness of the problems that organics can cause in the power plant cycle and this can drive changes in water treatment methods. A key to confirming and trouble-shooting organics removal processes is a reliable TOC (total organic carbon) measurement. Presented here is a particularly applicable and economical instrumentation approach for rapidly detecting organic contamination in various stages of pure water treatment systems. The instrument platform uses a separate TOC sensor and transmitter which enable simultaneous measurements of conductivity, pH, dissolved oxygen and flowrate, in addition to TOC, on the same transmitter.

Jo Savelkoul
Roy van Lier

PPChem 2005, 7(12), 733–739

Operational Experience with Organics in Industrial Steam Generation

In the chemical process industry, the steam cycle is of secondary importance: the (petro)chemical process comes first. High heat flux designs and – generally unavoidable – water quality problems make industrial boilers susceptible to corrosion.

The selected steam cycle treatment has to be tolerant towards (in)organic contaminants. Conventional programs are not always suitable to meet the specific challenges of individual plant steam cycles. Moreover, degradation products of classic organic alkalizing agents like morpholine may worsen the situation in some respect.

A polyamine program can be a worthwhile alternative. Our experience with polyamines so far has been very positive and has made us confident enough to now consider these products for 12.5 MPa steam systems.

Dennis P. Raught
Gary L. Foutch
Allen Apblett

PPChem 2005, 7(12), 741–747

Ion Exchange Resin Fouling by Organic Amines in Secondary Systems at U.S. Nuclear Power Plants

Organic amines added to power plant feedwater to control iron concentrations have an impact on ion exchange resin performance. Several theories attempt to explain the cause. One such theory is that cation resin reacts with the amine, cleaving fragments, which then deposit on the anion resin. The deposition blocks pores or permanently utilizes exchange capacity on the anion resin, resulting in reduced exchange of impurities. Nuclear industry operators have recognized this phenomenon and are working with researchers to apply laboratory experience to improving plant performance.

Matthias Meierer

PPChem 2005, 7(12), 753–762

Studies on the Issue of Fine Dust Based on the Example of Grosskraftwerk Mannheim AG

Recently, the issue of fine dust has come to the fore in the public interest because of repeated incidents where the maximum permissible levels for ambient pollution (immissions) were violated significantly. A recent EU directive has defined new limit values, which have already been integrated into German law through an ordinance under the Federal Immission Control Act. The new limit values came into effect in January 2005. This report provides some background information regarding the sources and mechanisms of fine dust formation, as well as the transfer and the separation of fine dust. Specific measuring and analytical methods are capable of identifying the concentration of both fine dust emissions and immissions (ambient pollution levels).

Over the past decades, effective technical measures have helped to significantly reduce dust emissions from power plants and industrial facilities in Germany. The current situation of ambient pollution in Germany is characterized by great regional differences. In particular, traffic has a share in limit value violations. The report describes other types of emission sources as well. The share of fine dust pollution specifically attributable to fossil-fired power plants is very low in Germany. This has been confirmed for the local pollution scenario in the Mannheim area by an examination of the dust ratios emitted from the Grosskraftwerk Mannheim AG plant using propagation calculations.
