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2021's Scientific and Technical Contributions

PPCHEM® Journal, January/February 2021, 23(1), 4–16

TECHNOECONOMIC BENEFITS OF FILM-FORMING AMINE PRODUCTS APPLIED TO STEAM SURFACE CONDENSERS

Sean H. Hoenig, Mahesh Budhathoki, Gregory Robinson, Claudia Pierce, Donald Meskers, Michael C. Ellis, and Richard W. Bonner III

In a conventional Rankine cycle, the majority of power plants employ surface condensers that use pumped cooling water to reject heat from the cycle. In such cases, heat rejection occurs in a shell and tube heat exchanger by filmwise condensation of low-pressure steam on stainless steel, titanium, brass, or copper-nickel tubing. To improve the thermal performance of steam surface condensers, a replenishable film-forming substance (FFS) can be applied to the condenser tubing to promote efficient dropwise condensation. Conventionally, film-forming amine product (FFAP) coatings protect boiler surfaces from oxidative corrosion, which substantially reduces the operation and maintenance costs. To quantify the technical and economic benefits of FFAP coatings applied to condenser tubing due to the promotion of dropwise condensation, a thermal resistance network model was established. Using a representative steam surface condenser, the improvements in thermal performance (overall heat transfer coefficient) and process parameters (net plant efficiency, cooling water flowrate, and turbine backpressure) were determined due to the enhancement in the condensation heat transfer coefficient. Experimentally measured condensation heat transfer coefficients for common condenser materials were compared with the modeling results and were found to be within attainable bounds. Finally, the trend in total heat exchanger cost reduction is generalized to understand the trade-off between reduced surface area for heat rejection and increase in coating application costs for a replenishable coating system.

PPCHEM® Journal, January/February 2021, 23(1), 20–30

THE ROLE OF HUMAN PERFORMANCE SCIENCE IN CYCLE CHEMISTRY IMPROVEMENT – IS THIS THE MISSING LINK?

Brad Burns and Doug Hubbard

On most units assessed by the Electric Power Research Institute (EPRI) across the world, cycle chemistry is well controlled and good results are obtained a majority of the time. Fossil and combined cycle power plants on a global scale continue to boast higher cycle chemistry benchmarking scores, installation of new instrumentation and alarming, and management support for cycle chemistry. The exception, however, continues to be major cycle chemistry excursion events that happen infrequently, yet with great consequences.

Often, when an unmitigated major cycle chemistry upset event occurs, root cause investigations pin the event on inadequate skills or knowledge (of individuals). It is therefore believed that additional training and/or disciplinary corrective action solves the root cause of the event and will prevent poor operator response to out-of-spec chemistry from recurring.

But does this approach produce desired results? This article examines that question and offers an approach with the potential to lead your organization toward a more critical review of systems and processes where countermeasures and defenses are checked and tested to determine efficacy.

Incorporating the science of human and organizational performance into a cycle chemistry program may well be the "missing link" to obtaining true cycle water chemistry improvement by preventing chemistry-influenced damage that occurs when plant personnel don't properly respond to acute and chronic cycle chemistry upsets.

PPCHEM® Journal, January/February 2021, 23(1), 34–37

ISSUES RELATED TO THE MEASUREMENT OF THE PH-VALUE IN PURE AND ULTRAPURE WATER

Michael Rziha

In all my years working in the area of power plant chemistry, I have been repeatedly confronted with either specifications or operators requesting the measurement of the pH-value either in pure water or even in ultrapure water. This often results in useless, time consuming discussions when those "measurements" are made, where some "experts" simply compare those results versus "specifications" and request that this pH-value must be 7±0.5, or something similar. When asked why this is specified for an ultrapure water (e.g. outlet mixed bed filter) with a conductivity of <0.1 µS·cm^{-1}, the most classic answer is we don't know, but it is specified, hence it must be fulfilled. Consequently, those specifications and the hopeless and wrong trial to measure it will lead in many projects to costly delays and consumption of precious working hours of many people involved.

Every chemist with a sound chemical education and understanding will of course immediately understand that this measurement is not only useless (I would even say nonsense), but also unnecessary.

In this brief article, the background and scientific, chemical facts will be explained for why this measurement is dispensable.

PPCHEM® Journal, March/April 2021, 23(2), 56–72

NGATI TUWHARETOA GEOTHERMAL ASSETS LTD REBOILER PLANT WATER/STEAM CHEMISTRY IMPROVEMENTS TO RESOLVE ONGOING CORROSION ISSUES AND PREVENT FUTURE TUBE FAILURES

David Addison, Nik Vandervegte, and Nellie J. Olsen

Since its commissioning in 2010, the Ngati Tuwharetoa Geothermal Assets Ltd Kawerau reboiler plant has suffered from major corrosion and plant failure issues. Corrosion-related failures which occurred due to water/steam chemistry issues and interactions with plant materials have led to premature complete replacement of the tube bundles.

In 2018 a major root cause analysis was undertaken into the failures that included a detailed chemical and metallurgical investigation and successfully identified the failure mechanisms. A number of simple chemical treatment changes, including hydrogen sulfide neutralisation, pH correction and the application of corrosion inhibiting film forming substances, were carried out to successfully mitigate ongoing corrosion of the plant and to significantly extend asset life.

PPCHEM® Journal, March/April 2021, 23(2), 74–81

A NOVEL COMBINATION OF CMIT/MIT WITH A NEW NON-BIOCIDE DISPERSANT IN COOLING TOWER BIOFILM CONTROL

Henk A. Jenner

Microbial biofilm communities are a significant problem in recirculating cooling water systems resulting in reduced heat transfer efficiency, and the risk of microbial influenced corrosion (MIC) and Legionella infection of operators. Most biocides are generally only effective in the control of microorganisms when in the water phase. A new dispersant was tested that is able to remove biofilms from their substrate, releasing the biofilm community into the water phase. This study investigated how the effectiveness of (chloro)methylisothiazolinone/methylisothiazolinone (CMIT/MIT) (non-oxidizing biocide) in a heavily fouled scale cooling tower model with condenser tubes could be improved by the new dispersant. Dosing tests with CMIT/MIT separately and combined with the new dispersant were performed with different CMIT/MIT concentrations. Microbial activity in both water samples and biofilm samples was measured by the analysis of adenosine triphosphate (ATP). Additionally, the biofilm mass in the transparent condenser tubes was visually inspected by photos. The new dispersant was shown to be effective in loosening the biofilm and the biocidal efficacy of CMIT/MIT was greatly increased due to this combination.

PPCHEM® Journal, March/April 2021, 23(2), 86–91

ONLINE ANALYSIS OF FILM FORMING AMINES

Harold Stansfield

Waltron has developed an online colorimeter for online analysis of film forming amines (FFA). The design basis and development process are discussed. Data from beta testing and two working case studies are presented. The analyzer can monitor FFA-based products in a working range of 0–1000 $\mu g \cdot L^{-1}$, with an accuracy of ± 2% of full scale or ± 5 $\mu g \cdot L^{-1}$, with a lower detection limit of <5 $\mu g \cdot L^{-1}$ as FFA.

PPCHEM® Journal, March/April 2021, 23(2), 92–93

IAPWS FOURTH INTERNATIONAL CONFERENCE ON FILM FORMING SUBSTANCES (FFS2021) HIGHLIGHTS AND PRESS RELEASE

Barry Dooley

The IAPWS Fourth International Conference on Film Forming Substances (FFS2021) was held on the 23rd and 25th March 2021 as a virtual event chaired by Barry Dooley of Structural Integrity Associates. FFS2021 was a unique conference on a narrow topic in cycle chemistry control of power plants and steam generating facilities. In 2021 the conference attracted a record number of 130 participants from 28 countries which included 41 plant operators/users and 27 people from the Film Forming Substances chemical suppliers.

The FFS conferences are developed and supported by the International Association for the Properties of Water and Steam (IAPWS), and the FFS2021 was organized by PPCHEM AG, publisher of the PPCHEM® Journal. Three sponsors supported FFS2021: Trace Analysis, Fineamin Swiss Water-Treatment Chemicals and Swan Analytical Instruments.

PPCHEM® Journal, May/June 2021, 23(3), 108–119

AVOIDANCE OF COMMON MISTAKES DURING FAILURE ANALYSES AND MISINTERPRETATION OF LAB RESULTS – PART 1: SAMPLING

Frank Udo Leidich

For a proper failure analysis or root cause analysis (RCA) a great deal of data and evidence-based information is needed. Within this context, various types of samples from different locations need to be taken for chemical and/or metallurgical examination. Therefore, proper and correct sampling, without alteration of the composition or contamination of the samples, is of utmost importance. Unfortunately, this is often not practiced correctly and so the risk of incorrect conclusions is high. This article is intended to help personnel obtain these samples in a proper manner and avoid common and repeated mistakes.

PPCHEM® Journal, May/June 2021, 23(3), 122–131

UPDATE ON PREDICTING RIHT USING THE UNB-CNER CANDU-6 PHT SYSTEM MODEL

Olga Y. Palazhchenko, William G. Cook, Alex L. Martin, and Jennifer Lennox

Reduced heat transfer in CANDU steam generators has safety consequences such as lower margins to fuel dryout due to higher reactor inlet header temperature (RIHT). To identify methods to maintain the RIHT within operational margins, it is necessary to model the effect of thermal degradation mechanisms on boiler heat transfer.

A comprehensive steam generator heat transfer and fouling add-on has been developed at the University of New Brunswick, Canada, and previously benchmarked using historic data from Point Lepreau Nuclear Generation Station. The one-dimensional, steady-state heat transfer code mechanistically predicts the effect of primary-side fouling, and semi-empirically models the effects of divider plate leakage and secondary-side fouling. This paper presents the most recent predictive modelling, where simulations of post-refurbishment operation (2012–2042) were conducted based on the benchmarked mechanisms. The predictive simulations inform the timeline for mitigating strategies such as a primary-side clean during the plant's operating lifetime.

PPCHEM® Journal, May/June 2021, 23(3), 132–133

IAPWS SEVENTH MEETING OF THE EUROPEAN HRSG FORUM (EHF2021) HIGHLIGHTS AND PRESS RELEASE

Barry Dooley and Bob Anderson

The seventh annual IAPWS European HRSG Forum was held on the 18th and 20th May 2021 as a virtual event. It was chaired by Barry Dooley of Structural Integrity and Bob Anderson of Competitive Power Resources. EHF2021 attracted 90 participants from 17 countries and included 55 users.

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). The 2021 EHF had two sponsors: Trace Analysis and Swan Analytical Instruments. The conference was organized by PPCHEM AG.

PPCHEM® Journal, May/June 2021, 23(3), 134–142

ATP TESTING – A REAL TIME MONITORING OF MICROBIOLOGICAL GROWTH IN THE COOLING WATER SYSTEMS OF POWER PLANTS

Kiran Diwakar, Rajendra K. Saini, Upain Kumar Arora, Janakiraman Pattabhiraman, and Gopi Kanta Nayak

In power plants, the warm environment of recirculating cooling systems is ideal for the growth of microorganisms. As microorganism communities grow in cooling systems, they can attach to tubes,

pipe walls, and cooling tower fills, and form biofilms. Uncontrollable biological growth causes fouling, loss of heat exchange capacity, equipment failure, and energy wastage.

Due to the large volume of a cooling system with a flow rate of 60000–75000 $m^3 \cdot h^{-1}$ (500 MW plus unit) and the diverse types of bacteria, spores, and algae, no one chemical can kill everything. There must be proper selection of a biocide, adequate contact time, and real time monitoring techniques to allow control of biological problems.

The best solution for any system is the fast and early detection of biological contamination, and the setting up of proactive actions and subsequent corrective treatments. For the measurement of microbiological counts, we can use culture tests like the heterotrophic plate count (HPC) method. However, these culture tests only measure culturable organisms while adenosine triphosphate (ATP) testing measures all microorganisms within a sample. There are two types of ATP – intracellular ATP contained within living biological cells and extracellular ATP located outside of biological cells, which has been released from dead or stressed organisms.

In one thermal power plant cooling water system of NTPC Ltd., India, this technique was demonstrated with successful results.

PPCHEM® Journal, July/August 2021, 23(4), 152–157

MONITORING INDUSTRIAL PLANT DISCHARGE METALS AND TOC

Brad Buecker and Ken Kuruc

Industrial facilities such as refineries, petrochemical plants, steel mills, metal finishing facilities, pulp and paper mills, pharmaceutical plants, etc. require substantial wastewater treatment, as some processes at these facilities can release many complex carbon compounds or other toxic constituents, including metals, to waste streams.

While various techniques are available for measuring trace level metals in process water, to date they have been rather unavailable to many industrial locations because of capital cost requirements or the need for specially trained technicians. Two well-known techniques are inductively-coupled plasma and atomic absorption spectroscopy, which need specially trained operators and require complex sample preparation and expensive instrumentation.

This article discusses another existing technology, colorimetry, which has been modified for on-line monitoring. The method is suitable for many facilities and can be operated by a wide range of plant personnel. In many cases, the readings can be enhanced with TOC analyses to provide additional protection for industrial water/steam systems.

PPCHEM® Journal, July/August 2021, 23(4), 162–175

FILM FORMING AMINES – AN APPRAISAL

Wolfgang Hater

The technology of film forming amines or more generally film forming substances in water treatment has been well known for decades. The acceptance of their application in water-steam cycles was significantly increased by two IAPWS Technical Guidance Documents issued in 2016 and 2019. These documents provide a brief synopsis of the scientific know-how, and, more importantly, give practical guidance to people interested in this technology. This paper reviews and summarizes the scientific progress since then and identifies further research needs. Film forming substances have an important potential for the reduction of plant emissions, which, in addition to the demand for molecules with improved environmental properties, is looked upon as a driving force for future development.

PPCHEM® Journal, July/August 2021, 23(4), 180–185

CONFERENCES AND SEMINARS ORGANIZED BY PPCHEM AG – AN OVERVIEW

Tapio Werder and Michael Rziha

Since 2012, PPCHEM AG and its precursor organization, Waesseri GmbH, have organized more than 30 conferences and seminars around the world with the mission of expanding the knowledge of cycle chemistry and the understanding of analytical instruments. Over the past 9 years, different formats of events have been developed to fit the different needs and interests within the power plant chemistry community.

The first kind of event series developed was called Power Cycle Instrumentation Seminars (PCIS), with the mission of expanding the knowledge of cycle chemistry and the understanding of sampling techniques and analytical instruments. Based on the feedback from the PCIS participants a new series of events – PowerPlant Chemistry Forums (PPCF) – was introduced in 2016. Compared to the PCIS the PPCF does not concentrate exclusively on sampling and instrumentation, but instead includes a wide variety of nearly all aspects of power plant chemistry, such as life-cycle chemistry optimization, start-up chemistry and early operation experience, and plant failures and subsequent chemistry adjustments. The forum is basically a typical conference, where numerous international speakers from many different organizations present, hence it is a platform for all participants to exchange information and knowledge and for networking.

Beside the PCIS and the PPCF, educational seminars have also been developed and offered. These seminars are typically focused on a "hot topic" from power plant chemistry and usually they are conducted by PPCHEM's chief key expert power plant chemistry Michael Rziha.

This contribution outlines the developments in the past years and gives more details on the different formats of events which are currently organized by PPCHEM AG.

PPCHEM® Journal, July/August 2021, 23(4), 186–187

PRESS RELEASE: EPRI 13TH INTERNATIONAL CONFERENCE ON CYCLE CHEMISTRY IN FOSSIL AND COMBINED CYCLE HRSG PLANTS (ICCC13): DETAILS ADVANCES IN R&D

EPRI's 13th International Conference on Cycle Chemistry in Fossil and Combined Cycle HRSG Plants was conducted virtually June 22–24, 2021.

The conference was attended by 146 different professionals representing 10 countries, including Australia, Canada, Malaysia, Philippines, Taiwan, South Africa, Switzerland, United Kingdom, United Arab Emirates, and the United States.

The EPRI Boiler and Turbine Steam and Cycle Chemistry R&D program (Program 226) conducts collaborative research led by Program Manager Brad Burns. The collaborative program is a global leader in comprehensive research in power plant steam and water cycle treatment to minimize corrosion and deposition.

The conference is hosted by EPRI every three years. This latest event featured 21 presentations by international experts, equipment manufacturers, chemical suppliers, and power plant chemistry users. Discussions on a wide range of cycle chemistry-related topics added participation value to plant users, equipment and chemical suppliers, and researchers.

PPCHEM® Journal, September/October 2021, 23(5), 198–205

CONSIDERATIONS FOR COMPLEX INDUSTRIAL COOLING WATER MONITORING AND TREATMENT

Brad Buecker and Rajendra P. Kalakodimi

Heat exchangers are, of course, a critical component of power and heavy industrial plants. Many of these are water cooled, with the source being a cooling tower (commonly known as an open cooling system) or sometimes once-through cooling. Often, "closed" systems are also present, which are cooled by primary heat exchangers, but whose chemistry is significantly different from that of open systems. Successful chemical tre atment of the wide variety of cooling systems in plants requires analysis of many factors, including the potential for corrosion, scaling, and microbiological fouling, system metallurgy, operating temperatures, and others, all of which are examined in this article. Also discussed are several significant improvements to chemical treatment programs in recent years, improvements that maintain proper heat transfer and reliability of cooling systems.

PPCHEM® Journal, September/October 2021, 23(5), 206–210

WEIGHTED SALT HOURS – A NEW APPROACH IN CYCLING PLANTS

Frank Udo Leidich

Thus far, the chemist in a power plant has quite often been regarded as a necessary evil or as inevitable costs. To leverage the activity of the power plant chemist and make his/her work observable and tangible in an economic sense to the management, it is proposed to introduce a new parameter, weighted salt hours, that can be used to link the key chemistry parameters with key economic performance indicators. To do this, data mining and application of statistical methods, like gauging of repeatability and reproducibility, multi-factor analysis, and others analyses, are needed. Of course, such efforts can only be successful if a very high number of power plants participate and contribute to this.

PPCHEM® Journal, September/October 2021, 23(5), 212–220

FLEXIBLE OPERATIONS IN THE ENERGY TRANSFORMATION: HIGH-LEVEL IMPACTS ON CYCLE CHEMISTRY

Mike Caravaggio

Electricity generation is changing, and these changes impact all aspects of the plant. The following paper sets out some of the key changes and the high-level impacts on cycle chemistry in thermal plants. It is incumbent upon power plant chemists and chemical engineers to understand the details of how flexible operation affects their specific units, so that they can develop optimal, unit-specific solutions.

PPCHEM® Journal, September/October 2021, 23(5), 222–228

ASSESSING CORROSION IN AIR-COOLED CONDENSERS AT ESKOM MEDUPI POWER STATION

Sabelo Khanyile, Stephanie Marais, Setsweke Phala, Zanele Dladla, and Nestor van Eeden

Steam side surfaces of air-cooled condensers (ACC) are prone to corrosion. If the corrosion mechanism is not understood and mitigated, it can lead to ACC tube failure(s), and subsequent vacuum and/or condensate chemistry deterioration. Most importantly, the total iron levels entering the condensate and feedwater systems will be much greater than international guidance. This paper reports on the ACC corrosion assessment performed on Unit 5 of Medupi power station. The ACC condensate chemistry is reviewed and the "Dooley Howell ACC Corrosion Index" is reported. The latter was derived from the physical inspections of the internal surfaces of the ACC. The inspections were conducted when the unit was on all-volatile treatment, under oxidising conditions (AVT(O) regime), as well as after transitioning to an oxygenated treatment (OT) regime. The benefits of transitioning from AVT(O) to OT are also reported.

PPCHEM® Journal, November/December 2021, 23(6), 242–252

HUMAN PERFORMANCE & CYCLE CHEMISTRY – THE MISSING LINK? PART 2

Brad Burns and Doug Hubbard

On most units assessed by the Electric Power Research Institute (EPRI) across the world, cycle chemistry is well controlled and good results are obtained 99.9 % of the time. Fossil and combined cycle power plants on a global scale continue to boast higher cycle chemistry benchmarking scores, installation of new instrumentation and alarming, and management support for cycle chemistry. The exception, however, continues to be major cycle chemistry excursion events that happen infrequently, yet with great consequences.

Often, when an unmitigated major cycle chemistry upset event occurs, root cause investigations pin the event on inadequate skills or knowledge (of individuals). It is therefore believed that additional training and/or disciplinary corrective action solves the root cause of the event and will prevent poor operator response to out-of-spec chemistry from recurring.

But does this approach produce the desired results? This article continues part 1, which was published in the January/February 2021 edition of this publication. Human performance improvement was described as the potential "missing link" to achieve true cycle chemistry improvement. This article builds upon the previous one by providing practical examples and suggestions for implementing improved defenses in a plant.

PPCHEM® Journal, November/December 2021, 23(6), 254–263

THE ECONOMIC BENEFITS AND GOALS OF POWER PLANT CHEMISTRY

Frank Udo Leidich and Michael Rziha

Thus far, the chemist in a power plant has quite often been regarded as a necessary evil or as inevitable costs. The purpose of this paper is to explain the economic benefits of a chemist, the need to have a specialist on the operation team, the purpose and goals of the job, and the expectations of the chemist from the power plant management's point of view.

Of course, the economic impact, the possible risks, and (monetary) damage that might arise if the job is not done as it should be are discussed here as well.

This paper concentrates on the goals and purpose of the chemist's activities regarding the water/steam cycle and the components therein. Future papers will also deal with the chemist's footprint on the cooling system, including the cooling water make-up system, the flue gas path, and the treatment of other systems and machines.

PPCHEM® Journal, November/December 2021, 23(6), 264–270

ACCURACY, TRUENESS AND PRECISION OF MEASUREMENT METHODS AND RESULTS

Michael Rziha

The present paper is an updated revision of a paper presented 22 years ago at the joint European NUSIS-ICMG-VGB Chemistry Online Process Instrumentation Seminar in Brügge, Belgium (April 20–22, 1999).

The original paper was prepared by Dr. J. Fahlke, Grosskraftwerk Mannheim, Mannheim Central Power Station, Mannheim; W. Fichte, Consultant, Ismaning; E. V. Maughan, Tablar Messtechnik, Duisburg; H. D. Pflug, Consultant, Bergen-Enkheim; and H.-G. Seipp, ABB, Mannheim – all located in Germany.

I would like to express my sincerest thanks to Dr. J. Fahlke for providing me with the original paper and permitting me to use it as the basis for this updated version.

This paper is an attempt to facilitate understanding of the rather abstract and in part complicated definitions of the ISO 5725 by combining them with some illustrations. This approach, although it may require getting used to, will help to promote a better understanding between manufacturers, suppliers, purchasers and operators of continuously operating measuring instruments in plant cycle chemistry.

PPCHEM® Journal, November/December 2021, 23(6), 272–274

PPCHEM® INTERVIEW WITH WOLFGANG ROST

Tapio Werder

Wolfgang Rost joined the PPCHEM team in October 2021 as Senior Key Expert for Power Plant Technology. Tapio Werder, Editor in Chief of the PPCHEM® journal, has interviewed Wolfgang to introduce him to our readers.