Report on the SWAN/PowerPlant Chemistry Power Cycle Instrumentation Seminar in Bangkok, Thailand

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ABSTRACT

This contribution is a report on the first Power Cycle Instrumentation Seminar, held in Bangkok, Thailand, on March 27–28, 2012. The presentations of the four seminar sessions, Chemical Regimes and the Respective Chemistry-Related Surveillance Requirements, Analytical Methods and Instruments, Cooling Water Sampling and Monitoring, and a Hands-On Session, are summarized.

INTRODUCTION

Southeast Asia is a fast growing region with a high demand for technical know-how and expertise. Due to a lack of travel budgets, station chemists, designers and operators are not frequently seen at international conferences in the USA and Europe. For this reason, Waesseri GmbH, publisher of the PowerPlant Chemistry journal, organized the first *Power Cycle Instrumentation Seminar* (March 27–28, 2012) in Bangkok, Thailand. The event was held under the sponsorship of the PowerPlant Chemistry® journal, and SWAN Analytical Instruments AG provided financial support.

The seminar consisted of four sessions:

- Chemical Regimes and the Respective Chemistry-Related Surveillance Requirements
- Analytical Methods and Instruments
- Cooling Water Sampling and Monitoring
- Hands-On Session

The proceedings of these sessions are summarized in this report.

CHEMICAL REGIMES AND THE RESPECTIVE CHEMISTRY-RELATED SURVEILLANCE REQUIREMENTS

The Importance of Instrumentation
Michael Rziha, Siemens AG

An overview of the most important plant cycle chemistry guidelines was presented. These are issued by the Electric Power Research Institute (EPRI), Palo Alto, CA, U.S.A., by the International Association for the Properties of Water and Steam (IAPWS), and by VGB PowerTech e.V. (VGB), Essen, Germany.

EPRI's Comprehensive Cycle Chemistry Guidelines for Fossil Plants (Report 1021767) was issued in December 2011. Information about this document may be downloaded at
http://my.epri.com/portal/server.pt?space=CommunityPage&cached=true&parentname=ObjMgr&parentid=2&control=SetCommunity&CommunityID=404&RaiseDocID=000000000001021767&RaiseDocType=Abstract_id.

IAPWS is an international non-profit association of national organizations concerned with the properties of water and steam, particularly thermophysical properties and other aspects of high-temperature steam, water and aqueous mixtures that are relevant to thermal power

cycles and other industrial applications. It has issued four very important Technical Guidance Documents:

- Phosphate and NaOH Treatments for the Steam-Water Circuits of Drum Boilers of Fossil and Combined Cycle/HRSG Power Plants (September 2011)
- Volatile Treatments for the Steam-Water Circuits of Fossil and Combined Cycle/HRSG Power Plants (July 2010)
- Instrumentation for Monitoring and Control of Cycle Chemistry for the Steam-Water Circuits of Fossil-Fired and Combined-Cycle Power Plants (September 2009)
- Procedures for the Measurement of Carryover of Boiler Water and Steam (September 2008)

All four documents may be downloaded (free) from the IAPWS homepage http://IAPWS.org.

The VGB Guidelines for Feed Water, Boiler Water and Steam Quality for Power Plants/Industrial Plants (2006) have been revised and are issued in German as Feedwater, Boiler Water and Steam Quality for Power Plants/Industrial Plants (VGB-S-010-T-00; 2011-12.DE). The revised Guidelines may be ordered at VGB PowerTech Service GmbH, Klinkestrasse 27–31, 45136 Essen, Germany.

In the revised guidelines, key and diagnostic parameters are introduced, normal levels are newly defined and have become plant-specific, a new Action Level philosophy has been developed and important hints for monitoring campaigns and statistics are included. Recommendations for sampling locations in the plant cycle are linked to the new VGB Guidelines on Sampling and Instrumentation.

Introduction to On-Line Water-Steam Sampling Systems
Manuel Sigrist

The principles of the upcoming new VGB Guidelines for Sampling and Instrumentation were explained. The focus of this presentation was on typical pitfalls between the actual plant process and correct on-line measurement values. Some examples:

- inadequate extraction points
- inadequate extraction probes
- incorrect sample pipe size and/or material
- excessive sampling line length
- suboptimal sampling line routing
- outdated design concepts

- missing safety functions
- excessive line and instrument sharing
- missing or incorrect temperature compensation
- lack of self-diagnosis capability
- maintenance-intensive operation
- inadequate process value ranges and/or scaling
- no remote diagnostic information

All above-listed issues are dealt with in detail in the VGB Guidelines for Sampling and Instrumentation that is in preparation.

The Cost of Instrument Failures – Potential Cost of Unreliable Instruments with Case Studies
David Addison, Thermal Chemistry Limited

Cycle chemistry troubleshooting is very challenging. Cycle chemistry problems are very complex, multi-dimensional issues that are influenced by plant or cycle design, system metallurgy, cycle chemistry program selection, and operating philosophy. Important is also whether there are adequate chemistry knowledge resources on site or the chemistry function is outsourced (contracted chemistry resources). Unfortunately, substandard sampling and analysis systems (very common within industry) and a poor level of data storage and/or analysis make troubleshooting very difficult, sometimes nearly impossible.

Case Study A – Stress Corrosion Cracking in the Low-Pressure Turbine The root cause of very expensive damage that occurred in the phase transition zone on the low-pressure turbine could not be identified due to limited sampling and analysis systems; only very minimal chemistry data were available. Only after installation of additional monitoring equipment could high sodium hydroxide mechanical carryover from the auxiliary boiler and inadequate steam turbine off-line storage be identified as the main root causes of this turbine damage.

Case Study B – Repeat Overheating Boiler Tube Failures Troubleshooting a cycle chemistry process is extremely difficult without good data. In this particular case, extremely limited sampling and analysis systems, a poor cycle chemistry program and third party chemical services resulted in an extensive corrosion product transport into the boilers. The majority of the data available was based on grab sampling, with the sample filtered before analysis. For this reason, the actual corrosion product transport could not be evaluated. Savings due to the installation of only insufficient sampling and monitoring systems have led to enormous costs and significant downtimes.

One thing should not be forgotten: one grab sample per day means that nearly 100 % of the time, the respective system is operated out of control.

ANALYTICAL METHODS AND INSTRUMENTS

Sample Conditioning for the Water-Steam Cycle
Manuel Sigrist

Sample conditioning is a very important step between the process and the on-line measurement. The correct sample conditioning should meet – among other things – the following demands:

- functional requirements
- safety requirements
- operation and maintenance requirements
- reasonable cost of ownership

Reliable sample flow for on-line instruments and for grab sampling as well as pressure and temperature safety are the essential demands of all sample conditioning systems.

Examples of all individual subsystems of state-of-the-art sample conditioning systems, such as sample cooling, flow throttle and pressure reduction, temperature shut-off, sample pressure regulation and distribution to individual instruments, were given. Instrument arrangement and primary and secondary cooling were also dealt with.

Instrumentation Requirements for Commissioning
Michael Rziha

The tasks of chemistry-related instruments during commissioning are very multiplex. Their listing would be almost endless. Some examples:

- supervision and control of overall plant chemistry
- automatic control of dosing of treatment chemicals
- requirement for startup of steam turbine
- requirement for boiler feedwater
- control of cycle clean-up
- control of protective layer formation
- detection of cooling water leaks
- detection of possible air ingress
- proof of function of deaerator
- control of mechanical carryover
- and, and, and...

Some issues are specific to commissioning. However, most requirements are valid for operation as well (the guidelines do not distinguish between normal operation and commissioning).

In contrast to normal operation, the protective layers are not yet completely formed during commissioning. This typically results in a high load of suspended solids and frequent clogging of sampling lines and/or probes. Frequent cleaning and calibration of probes are typical commissioning tasks. Sometimes it would be advantageous if the person responsible for chemistry issues during commissioning had more than one pair of hands....

Quality Assurance for On-Line Water-Steam Analyzers
Manuel Sigrist

How can an operator make sure he can rely on his on-line analyzers? Here is the solution:

- for on-line monitoring of key parameters, both on-line quality assurance (QA) and off-line QA measures are mandatory;
- for surveillance of diagnostic parameters (that do not require permanent on-line monitoring), periodic verification is required and off-line QA measures are sufficient.

On-Line QA Self-diagnostics performed automatically by the on-line instrument represents the state-of-the-art. It includes permanent, intermittent or triggered verification of elements of the measurement chain, local interpretation of conditions, remote signaling, and data logging on-line/off-line.

Self-diagnostics should inform the operator whether sample flow is correct, an adequate amount of reagents is on hand, sample temperature is within the given range, and whether the sensor is in best order. Remote derailed information about the quality of the process value is required. Summary alarms lead nowhere. Operation monitoring instruments without complete self-diagnostic information may result in incorrect values ("false truth") and false alarms.

Off-Line QA Periodic verification of an instrument by an operator is required. A plant-specific QA plan and logging and monitoring of QA activities are advisable. Naturally, procedures and methods used by the instrument have to be considered.

On-line instrument status verification (good, uncertain, or bad status) allows fast identification of real versus false alarms and detection of blind spots in monitoring (false truth), and enhances the quality of data logs used as inputs for further data analysis.

COOLING WATER SAMPLING AND MONITORING

This session consisted of two papers and a brief introduction to chlorine monitoring. It was David Addison again who reported on cooling water monitoring, drawing from his experience as a consultant. Manuel Sigrist then talked about the often neglected problem of correct sampling points and sampling technologies. The introduction to chlorine monitoring closed the session.

Cooling Water Monitoring Requirements

David Addison

For re-circulating cooling systems with cooling towers, adequate water treatment is required to control the scale formation, corrosion, and bacteria and microbiological growth. These treatments need to be monitored using either on-line instrumentation or effective manual sampling and testing.

Scale formation and corrosion are typically controlled by the level of total dissolved solids (TDS) and the saturation index. The TDS limit determines the cycles of concentration that the system can run to. TDS is controlled via an on-line direct conductivity meter. By use of system blowdown (removal of cycled up water and replacement by fresh makeup water), the TDS level can be mastered.

The oversaturation of hardness salts leading to scale formation is usually prevented by the control of the cooling water pH. Most often sulfuric acid dosing is applied as a remedy. The scaling potential of the water therefore can be relatively easily controlled and monitored via a pH or alkalinity set point. Polymer and phosphonate treatments can also be used as alternatives to acid dosing; polymers are often used for waters with a high silica level.

Monitoring of the corrosion rates in the cooling systems is often performed by means of corrosion coupons. This is not a real-time measurement but an average over the exposure time.

For microbiological control, biocides are added to the cooling water. The most common biocide is chlorine, injected in the system as sodium hypochlorite. Bromine-based biocides are also on duty. The residual of chlorine is monitored either with an N, N-diethyl-p-phenylenediamine (DPD) reagent (spectrometric/colorimetric measurement) or via monitoring of the oxidizing reducing potential (ORP). Non-oxidizing biocides are monitored with specialty systems supplied by the supplier of the chemicals.

Cooling Water Sampling

Manuel Sigrist

There are many differences between the water-steam cycle and the cooling water cycle with respect to sampling and on-line analytics:

Water-steam cycle	Cooling water cycle
– High temperature	– Low temperature
– High pressures	– Near atmospheric pressure
– Ultrapure water	– Fluctuating water quality
– Solids are mostly iron oxide particles	– Solids, algae, biofilms etc.
– Cycle is isolated from the atmosphere	– Cycle is open to the atmosphere
– Sampling systems are centralized	– Local sampling substations

Sampling system requirements are fundamentally different – different sample conditions and different analytics.

In-Line Measurement In-line measurement has some disadvantages: the sensors are exposed to process media, in-line measurement is not available for all parameters (just temperature, conductivity and pH), and maintenance/calibration is difficult or dangerous. However, there is not any bias from sample conditioning (advantage).

On-Line Measurement For on-line measurement, the sample is continuously extracted from the process stream. The sample might require conditioning (e.g., strainer, pump). Thus, the risk of sample alteration cannot be excluded. On-line measurement is available not only for temperature, conductivity and pH (like in-line measurement) but also for chlorine, turbidity, hardness etc. An advantage is the easier maintenance in contrast to in-line measurement.

Hydraulic Design Good practice for sound hydraulic design in cooling water sampling presupposes evaluation-effective process pressures and hydrostatic effects, and choosing of sample extraction points with sufficient sample pressure (this limits the need for sample pumps, reduces operating costs, and increases reliability), selection position and type of extraction to minimize possible disturbances by solids, gas bubbles or foam. If a sample pump is required, the sample suction height should be minimized to < 3 m (incompatibility between displacement pumps and particles in the sample).

Sample Lines Sample lines should be as short as possible. In the sample line, turbulent conditions should be ensured (Reynolds number > 2 000). In this way, fast response time and no sedimentation in the line will be achieved. Sample lines, typically DN 10 – DN 15, with a smooth inner surface, e.g., stainless steel, polyvinyl chloride (PVC) or high-density polyethylene (HD PE), are the optimum. In some cases, fast loop cycling is advised.

HANDS-ON SESSION

The last session was dedicated to operation and maintenance. The participants worked in groups with real instruments under the guidance of experts. Quality assurance was the most important issue. "How do you know it's right?" was the most prominent question. Hopefully, the session helped many a technician to feel more comfortable with his analyzers.

Specialists gave an introduction to the analytical methods, the sampling points and the critical issues for each parameter. For many participants this was a new way of looking at their instrumentation because the emphasis was on understanding the basic principles instead of focusing on specific brands.

CONCLUSION

The seminar drew over 60 station chemists, instrument technicians, designers and engineers from all over Asia. Linked to participation was a free e-paper subscription to PPChem until the end of the year. The feedback from the audience was very positive. The organizers are considering repeating this type of event to spread the knowledge of cycle chemistry and the awareness for analytical instruments.

THE AUTHOR

Ruedi Germann worked for 20 years as an independent business consultant before starting SWAN Analytical. He was instrumental in a management buy-out in 1991 and has served as the managing director ever since. The company has realized several information technology projects that integrate analytical instruments with modern software tools for quality assurance applications in thermal power plants.

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