Impressions from ICPWS16, the 16th International Conference on the Properties of Water and Steam

Time: 2-5 September 2013
Place: University of Greenwich, Greenwich, London, UK
Participants: 230 engineers and scientist from 28 countries
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Introduction

SIAPWS was represented at the conference by four members: Mats Hellman (SIAPWS chairman and delegate, Hellman Vatten), Jørgen Peter Jensen (PCC member, Dong Energy), Monika Nielsen (Dong Energy), Karsten Thomsen (SIAPWS secretary, PCC member, COWI). Anders Fredriksson (PCC member, Linköping Tekniska Verken) took part in the PCC (Power Cycle Chemistry working group) meeting on 1 September 2013.

The conference was held in historic surroundings at University of Greenwich situated at the banks of the river Thames. The picture on the previous page shows the SIAPWS representatives at the university campus.

The program of the conference is available at the SIAPWS website. The brief description below gives a personal view of the highlights of the conference, but many of the presentations may be of interest. The presentations of the PCC workshop on Wednesday are available at the SIAPWS website. Copies of the other presentations are available from either the chairman or the secretary of SIAWPS on request per mail.

Monday, 2nd September

Plenary lectures

IAPWS Gibbs Award lecture: Understanding the corrosion of metals in really hot water

Professor Digby D Macdonald, University of California, USA

The Gibbs Award is given at each ICPWS conference, i.e. each 4th or 5th year, to a distinguished scientist or engineer who has made substantial contributions within the working field of IAPWS. Digby Macdonald has worked with on-line measurements of pH, conductivity, redox and corrosion potentials, and dissolved hydrogen and oxygen in high temperature sub-critical and supercritical water for almost 40 years. He gave a review of the development in the field and described the corrosion mechanisms of carbon steel and stainless steel under these extreme conditions.

Supercritical water continuous reactors for inorganic nanomaterials synthesis

Professor Jawwad Darr, University College, London, UK

Jawwad Darr described the synthesis of inorganic particles at the nanoscale by means of reactants dissolved in supercritical water. By throttling the pressure over a valve and mixing in cold water in the jet stream particles of the right composition and size could be synthesised. The synthesis took place in a flow arrangement that made it easy to change the conditions and produce particles on a semi-large scale. This mode of operation made further scale-up and test of potential applications of the nanomaterials readily available.

IAWPS Helmholz Award Lecture: Who's afraid of the hydrophobic effect

Dr Hank Ashbaugh, Tulane University, New Orleans, USA

The Helmholz Award is given each year to a qualified researcher in the beginning of his/her carrier. Dr. Ashbaugh has been recognised for his studies on the properties of water and aqueous solutions, and in particular, the hydrophobic effect. His presentation centred on the insolubility of oils in water and his work so far focused on how biomolecules use this insolubility to stabilize self-assembled bio-molecular structures. His group has worked to develop new theories to describe these phenomena, with special attention to self-assembly in aqueous solution.

PCC FAC 1 (flow assisted corrosion)

Worldwide experiences with FAC in fossil and combined cycle plants

Dr Barry Dooley, Structural Integrity Inc., USA

Barry Dooley and co-workers have performed a large number of inspections of conventional and combined cycle plants during the last decade and have built up databases over the findings. On the basis of this large data material a clear picture may be drawn indicating the typical locations of FAC in the two types of plants. For the conventional plants especially LP- and HP-heaters (condensate drain pipes) are vulnerable to FAC – these damages presents a safety issue because they are often situated where people may be present. For the combined cycle plants FAC often appears in the tubes of the LP- or IP-evaporator. The presentation raises the question why FAC continues to be a major cause of damage when the mechanisms and tools to remedy the wear are both well known.

E.ON's experience with flow accelerated corrosion in heat recovery steam generators

Paul McCann, E.ON New Build &Technology, UK

E.ON operates a large number of HRSG's across Europe and has faced FAC problems and damages several times. Paul McCann summarised the experiences, which largely matched the picture drawn by Barry Dooley, and described the countermeasures and the limitations towards FAC protection imposed by (poor) design of the plants.

Analysis of the influence of anions and CO_2 on after-cation conductivity of steam samples during HRSG start-up using ion chromatography

Fiona Spelissy, ESB, Ireland

Fiona Spelissy described campaign measurements by means of ion chromatography during the start-up phase of a HRSG in order to demonstrate that the acid conductivity of the steam was due to carbon dioxide and not more dangerous salts. In connection with on-line measurements of degassed acid conductivity this allowed to cut the start-up time of the HRSG plant with 40 minutes, because it was not considered necessary to await the decline of acid conductivity as the carbon dioxide was removed by de-aeration after start.

All about water

PCC/Corrosion/Water treatment

Improving the efficiency of water transport systems

Dr A Ryzhenkov, Moscow Power Engineering Institute, Russia

Ryzhenkov demonstrated how surfaces treated with hydrophobic surfactants could alter the characteristics of the water in contact with them, for example change the flow resistance of a pipe. The application to district heating systems could potentially reduce the energy consumption of the circulation pumps with up to 40 % because of the easier flowing water.

Tuesday, 2nd September

PCC FAC 2 (flow assisted corrosion)

Measures taken by ESKOM to understand and mitigate flow accelerated corrosion in heater shells and distillate drain lines

Stephanie Marais, ESKOM, South Africa

Stephanie Marais gave an overview over the initiatives taken by ESKOM when it was realised that FAC in preheaters was a widespread problem at ESKOM power plants. An inspection program on plants operating both on AVT and OT was initiated. Studies on several plants showed that closing the vents of the preheaters was an efficient means to increase the oxygen content of the condensate and thereby establish an oxide layer more resistant to FAC. No adverse effects of closing the vents were identified, no matter whether AVT or OT conditioning was used.

Pipe wall thinning management in Japanese nuclear power plant and development of prediction strategy

K. Youneda, CRIEPI/EdF R&D, France

Youneda described methods for prediction of wall thinning caused by FAC with the purpose to avoid damages and perform maintenance before the critical wall thickness is reached. The concept is based on three steps:

- Initially, the wall thinning rate for critical components is based on the minimum wall thickness within specifications and the maximum FAC rate from experience. This gives a conservative estimation of the time when the critical wall thickness is reached
- Next, actual wall thicknesses are measured, and the life time calculated still with the conservative FAC rate.
- Next, after a couple of years the actual wall thicknesses are measured again and the actual FAC rate evaluated. This then goes in to the prediction of life time.
- Last, the measurement of actual wall thickness is repeated with a few years interval, and the FAC rate recalculated for adjustment of the life time prediction.

This seems to be a manageable way to keep track of the FAC – however, for a nuclear plant several thousand specific tubes and bends are under surveillance, so it is still a big task to keep track of them.

HRSG design considerations to enable optimal cycle chemistry to be applied

David Addison, Thermal Chemistry, New Zealand

Based on the worldwide experiences with FAC in combined cycle power plants David Addison summarized the points to consider in design of new plants to avoid problems with FAC during operation. Most importantly, the use of materials with a chromium content of at least 2.25 % for the critical components (LP- and IP-evaporators and ECO's) is the key to avoid problems later on. Furthermore, each pressure step should be designed with a feed water supply of its own. The designs where the LP-drum is used as feed water tank for the IP- and HP-evaporators are from a chemistry point of view a very poor design. This is

because the unfavourable distribution of ammonia between steam and water at the LP-drum pressure will lead to a low pH of the boiler water and because impurities are accumulated in the LP-drum and thus conveyed to the higher pressure steps. This presentation may be used as a very useful checklist for chemists when evaluating new HRSG designs.

PCC Corrosion 2

Control of corrosion in air-cooled condensers

Dr Barry Dooley, Structural Integrity, USA

Barry Dooley gave an interesting overview of the corrosion problems encountered in air-cooled condenser around the world. Again, FAC is the predominant cause of corrosion and may give serious corrosion damages after only few months' operation when the water chemistry is not considered appropriately. The key countermeasure is to increase the concentration of ammonia to reach a pH of 9.8. Even then mechanical filtration is a must and preferably also condensate polishing by ion exchange to avoid excessive transport of corrosion products into the water-steam cycle.

Selection of water chemistry for fossil plants with aluminium alloy heat exchangers

Professor Tamara Petrova, National Research Institute, MPEI, Russia

Tamara Petrova presented the characteristics of aluminium alloys with respect to corrosion stability and the consequences for the water chemistry when these materials are used in a water-steam circuit, in particular for air-cooled condensers. Aluminium is not stable in the slightly alkaline pH range typically applied for all ferrous systems, and the conditioning recommended is the neutral conditioning in which no alkalising agent is added to the feed water. This corresponds to the "Neutral Fahrweise" applied on several plants in Germany during the 1970-80'ties – here highly efficient condensate polishing and stringent demands on feed water purity are essential to avoid corrosion.

PCC Amine

All about water

Sampling amines from flowing steam-water mixtures

Piti Srisukvatananan, University of New Brunswick, Canada

Piti (nobody can say his last name) presented the latest results from a test sampling system simulating the conditions in a real power plant system. The steam at realistic pressure and temperature is initially saturated with iron corrosion products and then let through the sampling system in order to track the changes (deposition) occurring in the sample system during transport and cooling. In this study the focus was on the distribution of volatile amines and ammonia between the steam phase and the water film travelling along the wall of the sample line – these two entities were sampled separately. It was shown that the amines and ammonia distribute according to the pressure-dependent distribution ratio almost immediately and thus establish a distinct difference in pH between the water in contact with the surfaces and the bulk steam. This is also relevant for HRSG LP-evaporators when partial evaporation takes place along the way through the evaporator tubes. The water in contact with the tube walls will then have even lower pH than the water in the LP-drum.

Degradation kinetics of six alkalising amines

David Moed, Delft University of Technology, Netherlands

David Moed presented parts of his Ph.D-work that covers a study of the kinetics of degradation of amines frequently applied as conditioning agents in power cycles. The degradation rates were studied in a test rig resembling the conditions in a water-steam cycle. The main observation is that all amines degrade rather rapidly in time spans of 1-2 days at lower pressure and temperatures for the more stable compounds to time spans of few minutes at higher pressure and temperatures. The results were very convincing finally establishing scientifically based evaluation on this much discussed topic of amine conditioning. David was awarded the price for the best student presentation on the conference for his work.

Wednesday, September 4th

The presentations in this section are described very briefly because they are available at the SIAWPS website.

IAWPS cycle chemistry for fossil and combined cycle plants

Dr Barry Dooley, Structural Integrity, USA

Barry Dooley presented the background for the work in the PCC group of IAPWS and the intentions with the Technical Guidance Documents (TGDs) that have been issued in recent years. In the period since the last ICPWS conference (Berlin, 2008) TGD's covering conditioning (AVT and OT for once-through boilers, caustic (CT) and phosphate treatment (PT) for drum boilers), measurement of carry-over from drum boilers, and on-line instrumentation have been issued. The newest one covering steam purity was officially issued at the executive committee meeting at the end of the conference, and the next one covering sampling and analysis of corrosion products will appear later this year following the last revision of the current draft. The TGDs are freely accessible and may be used regionally as background for local guidelines or directly for a given plant after adaption to the specific conditions.

All about water

Instrumentation and control

Michael Rhiza, Siemens, Germany

Michael Rhiza presented the TGD on on-line instrumentation that establishes the minimum level to run a plant safely by means of on-line supervision and occasional lab analyses.

Guidance for fossil and combined cycle plants operating on AVT, OT, PT and CT

Dr Barry Dooley, Structural Integrity, USA

Barry Dooley presented the TGDs on conditioning covering both conventional plants and combined cycles.

Carry-over from drum boilers

Frank Gabrielli, Alstom Power, USA

Frank Gabrielli gave a summary of the oldest TGD covering measurement of carry-over from drum boilers and the experience gained during the life of it. It very quickly established itself as the preferred guideline to quantify carry-over and has been widely applied worldwide.

Steam purity
Dr R Svoboda, Svoboda Consulting, Switzerland

In the absence of Svoboda, Barry Dooley presented the most recent TGD on steam purity. This focuses on the steam quality from the viewpoint of the turbine and describes the implications of poor steam quality and poor/missing conservation during standstill.

Monitoring and analysing total iron and copper in fossil and combined cycle plants
David Addison, Thermal Chemistry, New Zealand

David Addison summarised the contents of the upcoming TGD on sampling and analysis of corrosion products. This guideline covers all steps in the process of obtaining reliable results for corrosion products: Sampling system design, sampling, preservation of samples, analysis, and quality control.

PCC Nuclear 3

Sampling nuclear reactor coolant systems
Derek Lister, University of New Brunswick, Canada

Derek Lister gave an overview of the theoretical and practical aspects of sampling reactor coolants for corrosion products, based on work performed under IAPWS international collaboration programs. Sampling the coolants in order to measure corrosion products accurately is difficult, because sample coolers induce precipitation of dissolved species and suspended particles are subjected to surface and thermal effects and may dissolve or grow correspondingly.

Water chemistry measurements in the Halden reactor and its experimental circuit
Peter Bennett, Institutt for Energiteknikk, Norway

The Halden boiling water reactor is a test reactor used for various tests of materials and fuels. Peter Bennett described the test facilities and the instrumentation supplied to follow the experimental conditions in the reactor core. The presentation focused on the on-line measurement of hydrogen, oxygen and, in particular, the measurement of the electrochemical corrosion potential.

Thursday, September 5th

PCC Design

Ammonium form condensate polishing at Lough Ree Power Station
C Bell, Ovivo UK, UK

Lough Ree is a peat burning circulating fluid bed boiler, which is equipped with a 100 % condensate polishing plant (CPP) consisting of a single mixed-bed filter. The CPP is regenerated externally with sulphuric acid (cation resin) and sodium hydroxide (anion resin). When the cation resin is exhausted with ammonia, the operation continues on the ammonium form. This prolongs the operating cycle from 87,000 m^3 to about 500,000 m^3 per regeneration. Even in the ammonium form the CPP is able to reduce the low amounts of sodium in the raw condensate. Operation in the ammonium form demands very low level of

cross-contamination of sodium from small amounts of anion resin in the cation resin under regeneration. The presentation focused on the measures taken in the external regeneration plant to obtain the low levels of cross-contamination.

Status of water conditioning for drum boiler and HRSG in Japanese fossil and combined cycle power plants.

H. Hirano, Central Research Institute of Electric Power Industry, Japan

Hirano gave an overview of the conditioning generally applied in Japan. The Japanese guidelines still recommends the use of AVT(R) with hydrazine as the reducing agent, even if hydrazine has been on the blacklist of chemicals during the last 20 years in Japan. The advantages of AVT(O) and OT with respect to corrosion protection, which have been realized worldwide during the last three decades, have not so far influenced the Japanese water chemistry guidelines.

PCC water treatment 2

ESKOMs approach to water management – philosophies, technologies and practices

Stephanie Marais, ESKOM, South Africa

Stephanie Marais gave a very interesting summary of the measures taken by ESKOM to reduce the water consumption at their power plants. Scarcity of water is a very obvious problem in most of South Africa and with the climate changes, the situation expected to be even worse in future. ESKOM has reduced the specific water consumption from 1.9 L/kWh in 1988 to 1.5 L/kWh in 2013 and the goal is to reach 0.7 L/kWh in 2028. Presently, the lowest specific water consumption is 0.12 L/kWh when indirect dry cooling is used instead of the conventional cooling towers. In indirect dry cooling the steam is condensed in a heat exchanger situated in a cooling tower through which the surrounding air is forced by large fans. Thus, water is not lost by evaporation as in the conventional cooling towers.

All about water