IAPWS Fourth International Conference on Film Forming Substances (FFS2021) Highlights and Press Release

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.

Film Forming Substances (FFS) consist of two main categories of chemicals using the international nomenclature: amine based (FFA, Film Forming Amine, and FFAP, Film Forming Amine Product) and non-amine based (FFP, Film Forming Products) which are proprietary compositions. The meeting provided a forum for the presentation of new information and technology related to FFS, new research results, case studies of fossil, combined cycle/HRSG, nuclear, geothermal and industrial plant applications. Discussion took place among plant users, equipment and chemical suppliers, researchers and industry consultants. The conference provided an opportunity for plant operators/users to raise questions relating to all aspects of FFS with the industry's international experts and researchers.

Key highlights from FFS2021 included:

- The participation of attendees from 28 countries illustrated the strong and increasing interest around the world in understanding and applying FFS.
- International updates were presented on recent experiences from fossil, combined cycle/HRSG, nuclear and geothermal plants. Universally the presentations indicated reductions in the measurement of feedwater total iron and copper corrosion products.
- There was general observation of hydrophobic films in the water-touched areas of feedwater and condensate, and the conference underlined that a hydrophobic surface (contact angle) does not necessarily prove the presence of protection. Film formation is still questionable in dry steam areas. Suggestions were made to improve the verification process using tube samples and corrosion product monitoring during startups.
- Most users had appreciation of, and had applied the IAPWS Technical Guidance Documents (TGD) for Conventional Fossil and Industrial plants. Common aspects were that more consideration was given to pre-application review of the plant and chemistry as per Sections 8 and 9 in the IAPWS TGD. Information on "Boiling Out" with FFS and application in geothermal systems provided opportunities to update the IAPWS guidance.
- One of the continuing conclusions from previous FFS conferences was the important requirement to first optimize the current chemistry on a plant with verification through baseline monitoring before application of any FFS. It was again emphasized throughout the 2021 conference that FFS should be regarded as an extension of optimized cycle chemistry control.

- Problems are still occurring in a few plants worldwide following application of an FFS where there were no pre-application chemistry reviews of corrosion product transport and deposition levels in boiler waterwalls and HRSG HP evaporators. Some examples of problems were presented: increased levels of internal deposits, tube failures especially under-deposit corrosion, and formation of "gunk" (gel like deposits) on heat transfer surfaces and in steam turbines. These problems need further definition.
- The history (from 1980s) and experience in nuclear plants was discussed and continues to be good with ODA being the current FFA of choice. Participants mentioned that it would be very interesting to have access to these early operating experiences and translations of papers and books on USSR and East German applications.
- Future planned research for the nuclear plants was discussed with special regard for corrosion and flow-accelerated corrosion in typical secondary water chemistry, corrosion under layup conditions, and the effect of FFS on degradation of gaskets and elastomers.
- Research was presented on electrochemical impedance spectroscopy (EIS) studies of FFA on the corrosion protection of bare carbon steel surfaces. This research showed how EIS can be used in the laboratory to evaluate in-situ film formation, thickness and porosity, and thus the effectiveness of a protective film. These techniques will need to be developed further for plant applications.
- The conference included presentations of online instrumentation, analytical procedures for measurement and quantification for both FFA and FFP, and on surface wipe techniques to supplement visual observations.
- There was new and interesting research reported on decomposition / breakdown products of FFA, thermolysis and distribution of FFA, and adsorption kinetics of film formation.
- The important effects of FFA on single- and two-phase flow-accelerated corrosion (FAC) were reported and discussed. The latest laboratory results provided verification again of the reduction of single-phase FAC, but there is still variability between laboratory results and field observations of two-phase FAC; for example the benefits accrued in air-cooled condensers (ACC) by FFS application. This FAC investigative work needs to be extended to a wider range of FFA and FFP.
- As a direct follow-on from the IAPWS 2018 and 2019 FFS conferences no new work was presented to understand the mechanism of the interaction of FFS with surface oxides, and how an FFS film might change the growth mechanism and morphology of the oxides and result in the reduced levels of iron and copper corrosion product transfer that are reported in all FFS plant applications. Future work was encouraged on the interaction of FFS films with existing oxide/deposit surfaces of Fe_3O_4, Fe_2O_3, FeOOH, CuO and CuO_2 in condensate/feedwater and boiler/evaporator water environments.
- There was discussion on the lack of understanding on the effect of FFS on the oxides which grow in steam circuits, and on the chromia oxides which form in the phase transition zone (PTZ) of the steam turbine. Hopefully, more observations during future plant applications will be focused on these areas.
- Overall, it was clear that the understanding of FFS application is improving worldwide but that there is still much to learn and a lot of fundamental work that needs to be done to understand the mechanisms at play with FFS. This includes film formation kinetics, equilibrium and stability, film structure (e.g., thickness or number of layers) and porosity, how adsorption is affected by other amines, and the correspondence to the reduction in corrosion rate through understanding of the interactions with oxides and deposits. Another remaining open question is whether an FFS improves heat transfer.

Please contact Barry Dooley (bdooley@structint.com or bdooley@IAPWS.org) for further information on FFS and the IAPWS FFS Conferences.