ICRN 22

IAPWS Certified Research Need - ICRN

Steam Chemistry in the Turbine Phase-Transition Zone

The behavior of chemical species in the turbine phase-transition zone can have a marked influence on turbine efficiency and reliability. The nucleation and development of deposits on blade surfaces can reduce turbine efficiency and promote the formation of corrosive environments. Conversely, chemical species in steam can potentially improve the efficiency of condensation, thereby improving overall cycle efficiency. The IAPWS Working Group Power Cycle Chemistry has reviewed published work in the area of steam chemistry in the turbine phase-transition zone.

IAPWS recognizes that further research work is needed to improve knowledge in this field and has prepared this document to assist potential investigators to obtain sponsorship. Improved understanding of heterogeneous nucleation, condensation and concentration processes and deposit development are needed to help reduce plant deposition and corrosion associated with phase transition in low-pressure steam turbines and to optimize cycle efficiency.

Although encouraging this work, IAPWS is not able under its statutes to provide financial support. The IAPWS contact can provide further information and liaison between research groups upon request.

Issued by the
International Association for the Properties of Water and Steam

President:	Dr. D. G. Friend National Institute of Standards and Technology 325 Broadway Boulder, Colorado 80305, USA.
Executive Secretary:	Dr. R. B. Dooley Structural Integrity Associates Inc. 2616 Chelsea Drive Charlotte, North Carolina 28209, USA email: bdooley@structint.com

IAPWS Certified Research Need – ICRN

Steam Chemistry in the Turbine Phase-Transition Zone

Background

About 80% of electricity generated in the world is produced through the use of steam turbines. Hence, improvements to turbine efficiency, reliability and service life are of considerable commercial benefit. Significant energy losses occur in the phase-transition zone in low-pressure parts of condensing steam turbines, resulting in reduced overall efficiency.

Steam chemistry in the phase-transition zone can lead to:

- thermodynamic losses associated with non-equilibrium phase transition;
- the formation of solutions that are concentrated in corrosive species and/or are deficient in species that provide corrosion protection;
- the formation of deposits that adversely impact operational efficiency or can result in the formation of corrosive solutions under different load conditions.

Modification of the steam chemistry may improve turbine efficiency in two aspects:

- improvement in heterogeneous nucleation to promote earlier droplet formation and reduce energy losses;
- a reduction of deposits on blades that may be responsible for efficiency losses.

Currently, there is a lack of detailed understanding of hetero-homogenous nucleation and condensation mechanisms, and this includes the mathematical simulation of these processes.
At present, there are no marketed additives for use in steam cycles that could improve the condensation process to something nearer the theoretical thermodynamic equilibrium. Also absent are technologies to reduce the formation of harmful deposits on blade surfaces or technologies to remove such deposits.

Research Needs

1. Research is needed to investigate the formation of chemical substance clusters that occur in low-pressure steam and that act as precursors to nucleation.

2. Also important is research into the chemistry of the first condensate, as a function of steam chemistry, and its role in the nucleation mechanism.

3. It is recommended that additives that can influence nucleation be investigated, with the aim of decreasing thermodynamic losses associated with phase transition, while having no adverse impact on other aspects of the steam and water cycle chemistry.

4. The development of tools for the mathematical simulation of hetero-homogenous nucleation and condensation process is judged to be very important. These should take into account the concentrations of chemical impurities and additives present in the steam, and should provide a tool for optimizing the chemical and thermo-hydraulic conditions for turbine operation.

5. Finally, research is recommended to study the chemical and mechanical structure of deposits that form on turbine blades. This could assist in the development of technologies for the prevention and/or removal of such deposits.

IAPWS Contacts

Prof. M. Stastny
Consultant
Ruska 76
32600 Plzen
Czech Republic
Tel: +420-3772-43186
Email: mfstastny@volny.cz

Dr. A. Rudge
British Energy Generation Ltd
Barnett Way
Gloucester, GL4 3RS
United Kingdom
Tel: +44 1452 652610
Email: andy.rudge@british-energy.com

ICRN Issue Date: July 2010

ICRN Expiration Date: September 2013

References

(1) Bellows, J.C., Chemical Processes in Steam Turbines, *Power Plant Chemistry* **1**, 26-30 (1999).

(2) McCloskey, T.H., Dooley, R.B., and McNaughton, W.P., *Turbine Steam Path Damage: Theory and Practice*, EPRI report 108943, Palo Alto, CA, USA (1999).

(3) Petrova, T.I., Povarov, O.A., Semenov, V.N., Martynova, O.I., Petrov, A.Yu, and Dooley, R.B., Influence of Different Chemistries on Early Condensate and Liquid Phase Generation in Turbines, in *Proceedings*, Fifth International Conference on Cycle Chemistry in Fossil Plants, EPRI, Charlotte, NC, USA (June 10-12, 1997).

(4) Stastny, M., Dooley, R.B., Jonas, O., and Sejna, M., Effect of Surface Tension on the Steam Flow with Condensation through Turbine Cascade, in *Proceedings*, Steam Chemistry: Interaction of Chemical Species with Water, Steam, and Materials during Evaporation, Superheating, and Condensation, VGB, EPRI, Freiburg, Germany (June 22-25, 1999).

(5) Stastny, M., and Sejna, M., The Effects of Steam Chemistry on the Condensation Process, *Power Plant Chemistry* **7**, 455-462 (2005).

(6) Stastny, M., Blahova, O., Jiricek, I., and Lorenc, B., Effects of Steam Chemistry on the Turbine Blades in Transition Zone, *Power Plant Chemistry* **8**, 629-634 (2006).

(7) Svoboda, R., and Bodmer, M., Investigations into the Composition of the Water Phase in Steam Turbines, in M. Nakahara, N. Matubayasi, M. Ueno, K. Yasuoka, and K. Watanabe (eds.), *Water, Steam, and Aqueous Solutions for Electric Power, Advances in Science and Technology*, Proceedings 14th International Conference on the Properties of Water and Steam, Kyoto, Japan, August 29 – September 3, 2004 (Maruzen, 2005), pp. 594-601.