

Minutes of the IAPWS working group IRS, Banff, Canada, 29 September – 4 October 2019

(Numbering of topics follows TPWS agenda, except where denoted "...-IRS")

1. The Chair, Nobuo Okita, opened the IRS joint at 10:30 am, 30. September 2019. Agenda was adopted without changes.
2. Appointed Shigeaki Senoo as a clerk of minutes
3. No potential collaborative projects reported
4. Industrial Requirements and Solutions for Steam Property Calculations [joint with WG TPWS]

4.1 Report of the Task Group "Categories of industrial requirements" (N. Okita, A. Nový, I. Weber, A. Anderko, M. Rziha, R. Span)

N. Okita reported the status of the TG as new member has joined the TG: K. Yoshida in place of A. Anderko (PCAS).

N. Okita summarized the progress since the last IAPWS meeting in 2018 briefly explained three examples of the requirements;

- 1) wet steam properties in steam turbines
- 2) Acid dew points under low sulfur contents for HRSG design.
- 3) Geothermal steam turbine cycle with non-condensable gas and Impurities.

Also explained added items into Group A and B of categories, then proposed industrial support documents as WG output and future direction in short and medium terms.

D. Friend asked the material has been uploaded?

N. Okita answered that not yet, but it will be uploaded in the IAPWS web.

A. Harvey asked what kind chemicals are involved in steam in geothermal power plant?

N. Okita answered that CO₂ is major but widely distributed from 2 to 10 %, others are H₂S, ammonia(some times) and so on.

4.2 Report of the Task Group "Wet steam properties Calculation" (A. Nový, J. Hrubý, K. Orlov, R. Span, K. Meier)

Skip, because of absence of A. Nový and no progress so far.

4.3 Report of the Task Group "Wet Steam Data from Operating Turbines" (N. Okita, A. Nový, I. Weber, S. Senoo)

N. Okita explained the purpose and plan.

S. Senoo explained the research requirement of coarse droplets causing blade erosion in steam turbine.

The research goal is erosion reduction in steam turbine. The required data are number density distributions of coarse droplet size as a function of steam velocity and liquid mass flow rate. The requests to experts are measurement technologies in steam turbine and a physical and mathematical model for the number density distributions of coarse droplet size.

The following discussion:

Jan Hrubý informed visualization technique is developed by using a small camera in Czech technical university.

Richard Harwood informed EPRI developed such measurement technologies in 1980's.

Daniel Friend and Allan Harvey recommended the requirement will be an ICRN after TG clarifies the gap between current knowledge and the research goal, and TG summarizes an IAPWS guideline.

4.4 Requirements for CFD calculation (N. Okita, M. Kunick, F. di Mare, Hans-J. Kretzsmar)

N. Okita explained requirements to IAPWS IF-97 for applying to CFD calculation, especially an improvement of accuracy of metastable regions and inconsistencies at the region boundary.

IRS Discussion (including joint discussion with PCAS in the related agenda item)

[GOAL in the next few years]

Two ICNRs, but start with „ICRN for condensation“.

- 1) Wet Steam Data from Operating Turbines
- 2) Acid dew point under low sulfur contents for HRSG design

[TO DO]

a) Coarse droplets causing erosion in " Wet Steam Data from Operating Turbines "

a-1) Hans-Joachim Kretzschmar looks for reserachs and experts on two-phase flow in Germany, such as in Helmholtz institute, Fraunhofer institute, and thermodynamic and two-phase flow related conferences.

a-2) S. Senoo hears past research in EPRI from Barry Dooley during the IAPWS.

-> Barry Dooley answered that he does not have any EPRI materials any more and know no contact person.

a-3) Task member continue the literature survey to clarify the gap between the present knowledge and the reserach goal.

b) Categories of industrial requirements

b-1) N.Okita uploaded the presentation material with the updated full list.

(OPAL password protected site, in "File Transfer")

b-2) Promote TGs focusing on common issues so that many IAPWS members can contribute and IRS members would cooperate with other WGs.

c) Requirements for CFD calculations

c-1) Hans-Joachim Kretzschmar transfer the IAPWS discussion to Francesca di Mare in Ruhr-University Bochum and Matthias Knunick in Zittau/Goerlitz University of Applied Science, and introduce Francesca and Matthias to S.Senoo with N.Okita.

c-2) N.Okita and S.Senoo discuss the requirements for CFD calculations with Francesca and Matthias, including the SBTL (Spline-Based Table Look-up Method) and equation of state in metastable vapour.

c-3) confirm the new IAPWS scientific formulation to TPWS.

d) Wet steam properties calculation (no discussion due to absence of leader)

8-IRS/PCAS. (joint with WG PCAS)

8.1 Report of the Task Group “Wet Steam Data from Operating Turbines” (N. Okita, A. Nový, I. Weber, S. Senoo)

N. Okita explained the purpose.

S. Senoo explained the research requirement of coarse droplets causing blade erosion in steam turbine as same as the item 4.3.

The following discussion:

M. Nakahara asked about theoretical approach. S. Senoo answers that Kelvin-Helmholtz and Rayleigh-Taylor instability theories have been applied to estimate Weber number for maximum or Suater mean droplet diameter. No theory, however, can produce the number density function.

M. Nakahara asked how the number distributions of droplet diameters and velocities in the slides were obtained. S. Senoo answered that the distributions were obtained by measurement based on Mie scattering theory in model steam turbines. The measurement technologies are not established yet.

P. Tremaine asked influences of chemicals and electric charge on erosion. S. Senoo answered that the impact shock would be dominant, but erosion associated with corrosion would be affected by chemicals and electric charge.

Tomas Nemecek asked the coarse droplet size. S. Senoo answered that it is exactly what we want to know. The coarse droplet diameter would be from 10 to 500 microns according to our literature survey.

8.2 Report of the Task Group “Categories of industrial requirements” (N. Okita, A. Nový, I. Weber, A. Anderko, M. Rziha, R. Span)

N. Okita reported the status of the TG as new member has joined the TG: K. Yoshida in place of A. Anderko (PCAS).

N. Okita summarized the progress since the last IAPWS meeting in 2018 briefly explained three examples of the requirements and proposed industrial support documents and future directions as same as the item 4.1.

The following discussion:

P. Tremaine asked the material has been uploaded. N. Okita answered that not yet, but it will be uploaded in the IAPWS web.

P. Tremaine asked about CO₂ influence on steam in geothermal steam turbine. He mentioned the REFPROP is accurate enough to resolve the issue. N.Okita answered the issue is related to solubility and equilibrium constant in the flusher.

P. Tremaine asked about dew point under low sulfur condition in HRSG. He mentioned the REFPROP could calculate the dew point even in binary gas with sulfur. N.Okita answered the measured dew point temperature under low sulfur region does not agree the temperature predicted by thermodynamic equilibrium calculation.

P. Tremaine asked whether SO₃ causes SCC. N.Okita answered SO₃ creates start points of condensation, then NO₂ is induced nitric acid condensation causing SCC.

[TO DO]

Both PCAS and IRS specialists send each other the related useful papers and/or information for understanding the gap between the present knowledge and the research goal.

10-IRS. Discussion on „wet Steam Data from Operating Turbines“

Covered by point 4.

15 IAPWS Certified Research Needs (ICRN)

15.1 Report of task Group on ICRN for acid gas dew points

N. Okita summarized the progress since the last IAPWS meeting in 2018 briefly explained acid dew points under low sulfur contents for HRSG design.

The discussion is covered by item 14.1 of TPWS minutes.

16-IRS. Discussion on “Categories of industrial requirements” and promotion of IRS activities.

Covered by point 4.

17-IRS. Other Business

No other business.

18-IRS. Membership

IRS members agree to remove from the list for the following three persons.

1) Dr. F. Gachon (EDF, France)

New job and request to remove from the list.

2) Dr. B. Le Neindre(LDPM, France)

As F. Gachon, wish to be removed from the list.

3) Mr. W. T. Parry (former GE, USA)

No more active (from US national committee)

19-IRS. Contribution to Press Release

20-IRS. Preparation of the Formal Motion to the EC

21-IRS. Adjournment

N. Okita closed meeting at 14:20, 3. October 2019.