IWAIS 2015 16TH INTERNATIONAL WORKSHOP ON ATMOSPHERIC ICING OF STRUCTURES

Book of Abstracts

IWAIS 2015, Uppsala, 28 June to 3 July

Swedish Energy Agency

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IWAIS 2015 PROGRAM

72 abstracts, 59 lectures, 13 electronic posters and more than 70 participants. We're now ready to launch IWAIS 2015, a world leading conference on atmospheric icing of structures.

SUNDAY JUNE 28	
18:00–20:00	ICE BREAKER AND REGISTRATION
MONDAY JUNE 29	
08:30–18:30	STUDY VISIT TO LUDVIKA
19:00–20:00	REGISTRATION EXHIBITOR STANDS AND POSTERS TO BE INSTALLED

TUESDAY JUNE 30

TIME	EXHIBITION HALL & OTHER LOCATION	SESSION ROOM 1: GILLESALEN	SESSION ROOM 2: SWEDENBORG
08:00–08:50	Registration		
09:00–10:15		**OPENING SESSION** CHAIR: KATHLEEN F. JONES	
		Local organizers	
		Paul Mitten, Chairman of IWAIS	
		Determination of ice deposits thickness on overhead power lines conductors by location method, Renat Minullin, Kazan State Power Engineering University (26)	
		Coatings for protecting overhead power network equipment in winter conditions, Masoud Farzaneh, Université du Québec à Chicoutimi (15)	
10:15–10:45	BREAK		
10:45–12:15		**SESSION 2** CHAIR: MASOUD FARZANEH	
		Research Condition and Capacity of Xuefeng Mountain Natural Icing Testbase (XMNIT), Jiang Xingliang (61)	
		Meteorological data for assessing climatic loads on overhead lines. Report from Cigre WG B2.28, Svein M. Fikke, Meteorological consultant (36)	
		Back to the basics: Wetting, Icing and Ice adhesion, Lasse Makkonen, VTT Technical Research Centre of Finland (2)	
12:15–13:30	LUNCH		
13:30–15:00		**ANTI- / DE-ICING,COATINGS** CHAIR: PAUL MITTEN	**ICING MEASUREMENTS, MODELLING AND FORECASTING** CHAIR: SVEIN M. FIKKE
		Optical Fiber Temperature Characteristic of OPGW during DC Ice Melting, Zhigao Meng, The State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, Chongqing (65)	Analysis of the effect of climate change on the reliability of existing overhead transmission lines, Luc Chouinard, McGill Unviersity (1)
		Passive acoustic signal sensing approach to detection of ice on the rotor blades of wind turbines, Eugen Mamontov, Foundation Chalmers Industrial Technology (Stiftelsen Chalmers Industriteknik), Gothenburg, Sweden (21)	A Research of Icing Forecasting Algorithm Using Genetic Algorithm and Fuzzy Logic, Xin-bo Huang, College of Electronics and Information, Xi'an Polytechnic University, P.R. China (11)

		Study on Icing characteristics of Bundle Conductors under Xuefeng Mountain Natural Icing Testbase, Quanlin Wang, The State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, Chongqing (67)	Verification of Icing-model in Finland, Karoliina Hämäläinen, Finnish Meteorological Institute (FMI), FI (13)
		On Self-cleaning and Anti-ice Performance of Double-layer-SAMs Coatings with Enhanced Corrosion Resistance on an Al Alloy Substrate, Shahram Farhadi, NSERC/Hydro-Quebec/UQAC Industrial Chair on Atmospheric Icing of Power Network Equipment (CIGELE) and Canada Research Chair on Atmospheric Icing Engineering of Power Networks (INGIVRE), Université du Québec à Chicoutimi, QC, Canada (55)	
15:00–15:30	**BREAK & POSTER PRESENTATIONS**		
15:30–17:00	• Wet-snow activity research in Italy, Matteo Lacavalla, RSE SpA, IT (6) • Testing six wet snow models by 30 years of observations in Bulgaria, Dimitar Nikolov, National Institute of Meteorology and Hydrology - Bulgarian Academy of Sciences (NIMH-BAS), Bulgaria (33) • Effect of alkyl chain length on the hydro/icephobic properties of SAMs coatings on aluminum alloy 6061 surfaces, Faranak Arianpour, NSERC / Hydro-Quebec / UQAC Industrial Chair on Atmospheric Icing of Power Network Equipment (CIGELE) and Canada Research Chair on Atmospheric Icing Engineering of Power Networks (INGIVRE), www.cigele.ca Université du Québec à Chicoutimi, Chicoutimi, QC, Canada (53) • How the "Steric effects" Affect Ice Repellency, UV stability and Corrosion Resistance of Dissimilar SAMs Coatings on a AA2024 Alloy, Shahram Farhadi, NSERC/Hydro-Quebec/UQAC Industrial Chair on Atmospheric Icing of Power Network Equipment (CIGELE) and Canada Research Chair on Atmospheric Icing Engineering of Power Networks (INGIVRE), Université du Québec à Chicoutimi, QC, Canada (54)	**ANTI- DE-ICING, COATINGS** **CHAIR: SHIGEO KIMURA**	**ICING MEASUREMENTS, MODELLING AND FORECASTING** **CHAIR: LASSE MAKKONEN**
		Development and Application of Current Transferring Smart Ice Melting method and apparatus for Bundle Conductors Transmissiuon Lines of EHV/UVU, Xingliang Jiang, The State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, Chongqing (62)	Usage of automated information system for icing control on OHL 110-500 kV, Eugeniy Satsuk, Platov South Russian State Polyechnic University (Novocherkassk Polytechnic Institute), Novocherkassk, Russia (41)
		Hydrophobic and anti-ice properties of homogeneous and heterogeneous nanoparticle coatings on Al 6061 substrates, Faranak Arianpour, NSERC / Hydro-Quebec / UQAC Industrial Chair on Atmospheric Icing of Power Network Equipment (CIGELE) and Canada Research Chair on Atmospheric Icing Engineering of Power Networks (INGIVRE), www.cigele.ca Université du Québec à Chicoutimi, Chicoutimi, QC, Canada (56)	Ice detection methods and measurement of atmospheric icing, Matthew Wadham-Gagnon, Canada (40)
		Influence of Shed Structure on Icing Characteristics of Composite Insulator Based on Natural Icing Testbase, Yang Pan, The State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, Chongqing (66)	Observations and modeling of sea splash icing, Kathleen Jones, CRREL, USA (3)
		Research on icing behavior and ice adhesion testing of icephobic surfaces, Heli Koivuluoto, Tampere University of Technology, FI (49)	
18:30	**MINGLE & CONFERENCE DINNER, MASOUD FARZANEH AWARD BY UNIVERSITY OF QUÉBEC IN CHICOUTIMI** **MÅRTEN AJNE ABOUT THE SECRET LIFE OF ICE**		

WEDNESDAY JULY 1

	OUTSIDE SESSION ROOMS	SESSION ROOM 1: GILLESALEN	SESSION ROOM 2: SWEDENBORG
08:30–10:30		**OX2 - DEPLOYMENT OF LARGE SCALE WIND ENERGY IN ICING CLIMATES** **CHAIR: GÖRAN RONSTEN**	
		Lessons learned from "Large scale, cost effective deployment of wind energy in icing climates", Göran Ronsten, OX2 & WindREN (59)	
		Innovations in F-LOWICE real-time forecasts of wind power and icing effects, Erik Gregow, Finnish Meteorological Institute, FI (17)	

		Development of operational forecasting for icing and wind power at cold climate sites, Øyvind Byrkjedal, Kjeller Vindteknikk (46)	
		Vestas de-icing system, Francisco Fernandez, Vestas (71)	
10:30–11:00	**BREAK & POSTER PRESENTATIONS**		
11:00–12:30	• What we learned – Adaption and development of measurement technique and camera supervision for icing conditions, Bengt Norén, In Situ Instrument AB (58) • Wind, Ice and Snow Load Impacts on Infrastructure and the Natural Environment (WISLINE), Harold Mc Innes, The Norwegian Meteorological Institute (32) • Controller for Surface heating, Rolf Westerlund, HoloOptics (57) • Influence Analysis of Transmission Lines Insulator on the Conductor Iceshedding, Xin-bo Huang, College of Electronics and Information, Xi'an Polytechnic University, P.R.China (9)	**OX2 & ICING IN WIND ENERGY** **CHAIR: HELENA WICKMAN**	**ICING ON POWER LINES** **CHAIR: SERGEY CHERESHNYUK**
		Siemens de-icing system, Diego Levati, Siemens (72)	A severe in-cloud icing episode in Iceland 2013-2014 – Weather pattern background, Árni Jón Elíasson, Landsnet, IS (48)
		Experiences from studies of icing and production losses due to icing in OX2's Vindpilot project, Stefan Söderberg, WeatherTech Scandinavia, SE (29)	Wet snow icing - Comparing simulated accretion with observational experience, Árni Jón Elíasson, Landsnet, IS (44)
		Modelling icing conditions for a selection of Swedish wind farms during winter 2014–2015, Heiner Körnich, SMHI, SE (31)	Comparison of measured and simulated icing in 29 test spans during a severe icing episode, Egill Thorsteins, IS (45)
		Probabilistic forecasting of icing and production losses, Jennie Persson Söderman, Uppsala University, SE (28)	Automated Icing Monitoring System on the teritorry of the Czech and Slovak Republic, Jaroslav Šabata, EGÚ Brno, a.s. (70)
12:30–13:30	**LUNCH**		
13:30–15:00		**ICING IN WIND ENERGY** **CHAIR: REBECKA KLINTSTRÖM**	**ICING ON POWER LINES** **CHAIR: JAROSLAV ŠABATA**
		Case study of ice sensor using Computational Fluid Dynamics, measurements and pictures, Marie Cecilie Pedersen, Vattenfall Vindkraft A/S, Denmark (22)	Monitoring and forecasting ice loads on a 420 kV transmission line in extreme climatic conditions, Bjørn Egil Nygaard, Kjeller Vindteknikk, NOR (39)
		Supercooled Water Wettability and Freezing on Hydrophobic Surfaces: The Role of Temperature and Topography, Golrokh Heydari, KTH, Sweden (14)	Neural network approach to characterize atmospheric ice compressive strength, Hicham Farid, CIGELE/UQAC, Canada (23)
		Effect of Surface Roughness of Wind Turbine Blade on its Ice Accretion, Jian Liang, The State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, Chongqing (64)	Multichannel radar monitoring of ice on power lines, Renat Minullin, Kazan State Power Engineering University (24)
		3-D Numerical Simulation of MWs Wind Turbine Blade's Icing, Qin Hu, The State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, Chongqing (68)	Collapse of an Arctic Power Line due to strong Wind Gusts during Wet Snow Accumulation, Knut Harstveit, Kjeller Vindteknikk, Norway (34)
15:00–15:30	**BREAK & POSTER PRESENTATIONS**		
15:30–17:00	• Expansion of the ice deposition monitoring network in Germany, Bodo Wichura, German Meteorological Service, Climate and Environment Consultancy Potsdam, Germany (51) • The Numerical Analysis for jump height of multi-two-spans at different intervals of overhead transmission lines, Yong-can Zhu, School of Electro-Mechanical Engineering, Xidian University, Xi'an, P.R. China (12) • Development of snow accretion simulation method for electric wires in consideration of snow melting and shedding, Kazuto Ueno, Central Research Institute of Electric Power Industry, Japan (19)	**ICING ON POWER LINES AND CONDUCTORS/INSULATORS/ FLASHOVER** **CHAIR: BRIAN WAREING**	
		Technology radar monitoring of overhead power lines when detecting ice formations, Renat Minullin, Kazan State Power Engineering University (25)	
		Research on describing the icing level of porcelain and glass insulator based on icing thickness of the equivalent diameter, Zhijin Zhang, The State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, Chongqing (69)	

	• Effect of icephobic coating on ice protection of ultrasonic anemometer with stack-type transducers, Shigeo Kimura, Kanagawa Institute of Technology (20)	Analysis of radar equipment indications and weight sensors indications during detecting ice deposits on power lines, Renat Minullin, Kazan State Power Engineering University (27)	
		Experimental research on the icing progress of insulators, Yuyao Hu, The State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, Chongqing (63)	
17:30–19:00	**IWAIS IAC COMMITTEE MEETING**		
18:00–19:30	**UPPSALA BY FOOT**		
19:30–22:00	**IWAIS IAC COMMITTEE DINNER**		

THURSDAY JULY 2

		SESSION ROOM 1: GILLESALEN	SESSION ROOM 2: SWEDENBORG
09:00–10:30		**HSE & SENSORS, EQUIPMENT AND MACHINERY CHAIR: BODO WICHURA**	
		Numerical Study of Atmospheric Ice Accretion on Wind Turbines, Muhammad Virk, Atmospheric Icing Research Team, Narvik University College, Norway (7)	
		MuVi Graphene – Hybrid Atmospheric Icing Sensor, Umair Mughal, Atmospheric Icing Research Team, Narvik University College, Norway (8)	
		Methods for evaluating risk caused by ice throw and ice fall from wind turbines and other tall structures, Rolv Erlend Bredesen, Kjeller Vindteknikk, NO (38)	
		Icing forecast in GIS Meteo system, Yury Yusupov, MapMakers Group Ltd. (43)	
10:30–11:00	**BREAK & POSTER PRESENTATIONS**		
11:00–12:30	• Comparison of three different antiand de-icing techniques based on SCADA-data, Sandra Kolar, Uppsala Universitet/OX2 (52) • Review of icing related failures of wind masts in Bulgaria, Dimitar Nikolov, National Institute of Meteorology and Hydrology - Bulgarian Academy of Sciences (NIMH-BAS), Bulgaria (42) • The recognition and detection technology of ice-covered insulatorsunder complex environment, Xin-bo Huang, College of Electronics andInformation, Xi'an Polytechnic University, Xi'an, P.R.China (10)	**CONDUCTORS / INSULATORS / FLASHOVER CHAIR: XINGLIANG JIANG**	**TESTING FACILITIES, ICING ON MASTS, TOWERS AND BUILDINGS CHAIR: ALAN B. PEABODY**
		Anti-icing tests on La Farga CAC copper, Lluis Riera, La Farga, Spain (5)	Icing Measurements at Berlin TV Tower: A case study of a falling ice situation on 23rd December 2012, Bodo Wichura, German Meteorological Service, Climate and Environment Consultancy Potsdam, Germany (50)
		Relation between test span measured ice loads and conductor size, Brian Wareing, United Kingdom (4)	Investigation of Using Icephobic Coatings on a Cable Stayed Bridge, Douglas Nims, University of Toledo, Toledo, USA (37)
		Comparison of ice accumulation on simplex and duplex conductors in parallel overhead transmission lines in Iceland, Pétur Thór Gunnlaugsson, IS (47)	Isotopic Mass Balance Measurements of Spray Ice, Toshihiro Ozeki, Hokkaido University of Education (30)
		Advanced test methods for full-scale ice tests of DC insulators strings intended for ±350 kV, Andreas Dernfalk, STRI (18)	A prediction method of slide snow/ice load applied to roofs, Xuanyi Zhou, State Key Laboratory of Disaster Reduction in Civil Engineering, Tongji University, Shanghai, China (60)
12:30–13:30	**LUNCH**		
13:30–15:00		**SESSION 16 - CLOSING SESSION CHAIR: MATTHEW WADHAM GAGNON**	
		Ripples on Icicles, Lasse Makkonen, VTT (16)	

		Fault statistics on overhead transmission lines in Russia because of icing, Sergey Chereshnyuk, Research and Development Center at Federal Grid Company of Unified Energy System (R&D Center @ FGCUES), Moscow, Russia (35)	
15:00–15:30	BREAK		
15:45–17:45	TRAVEL TO NYNÄSHAMN		
18:35–22:00	BOAT TO GOTLAND		

FRIDAY JULY 3

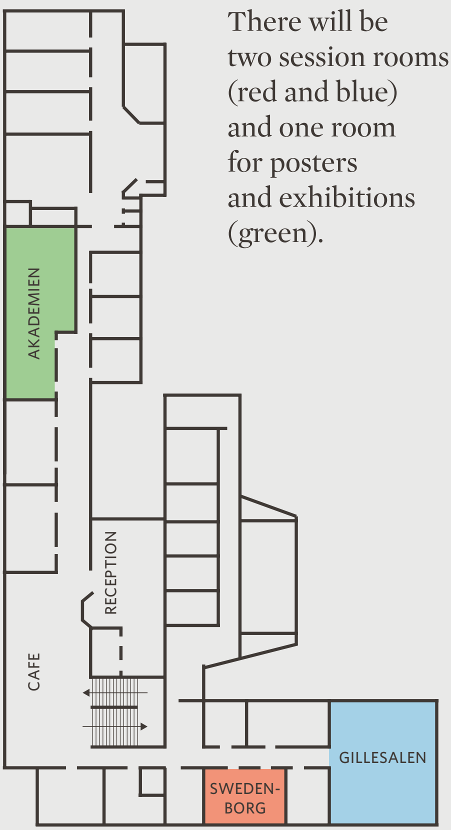
	ACTIVITY	LOCATION
09:00–16:00	SMART GRID GOTLAND	GOTLAND

SATURDAY JULY 4

	ACTIVITY	LOCATION
09:00–17:00	VISIT TO N. GOTLAND	FÅRÖ

SUNDAY JULY 5

	ACTIVITY	LOCATION
09:00–16:00	VISIT TO S. GOTLAND	NÄSUDDEN
18:00	DEPARTURE FOR VISBY HARBOR	VISBY
19:10–22:30	BOAT TO NYNÄSHAMN	VISBY
23:30	ARRIVAL TO C STOCKHOLM	STOCKHOLM



There will be two session rooms (red and blue) and one room for posters and exhibitions (green).

R&D areas/s: 07. Icing on power lines

Determination of ice deposits thickness on overhead power lines conductors by location method

Renat Minullin, Kazan State Power Engineering University

Minullin R.G.(RU), Kasimov V.A.(RU), Yarullin M.R.(RU)

Ice accretion on phase conductors of overhead lines may lead to damages of wires and towers. Monitoring of ice formation is necessary to prevent these damages. One of methods of ice formation monitoring is pulse location method [1]. Pulse device is connected to high frequency channel of transmission line. It works by sending a probe pulse into line and then receiving pulse after reflection from obstacle of surge impedance, such as end of line, tap or short circuit. Then reflected signal is analyzed and its parameters are determined (attenuation and delay).

Ice and rime accretion on wires change pulse distribution terms: decrease the speed of propagation of radar signals and increase attenuation of radar signal due to the dielectric properties of ice. Thus, the formation of ice and rime on the wires add attenuation and delay of the reflected signal.

First, effect of icing and rime deposits on the parameters of the reflected signal is determined. To do this, the modal model of high-frequency signals propagation into power lines was used [2]. In the first approximation, we can use only fundamental mode for the determination of ice attenuation and delay of the high-frequency signal. According to the model, ice attenuation and delay parameters are functions of deposition (the complex permittivity, temperature, radius and length), the line parameters (wire radius, the number of wires, impedance) and the signal frequency.

Next, inverse problem is solved to determine ice deposits thickness by changing attenuation and delay. However, there are many solutions for solving the inverse problem for the obtained values of attenuation and delay of radar signals. For example, the ice with small thickness on the entire line length or the ice with large thickness in single span may produce the equal values of delay and attenuation. According to the results of field observations the most probable length of wire icing is determined. The resulting length is fixed for the calculation and then ice thickness is determined.

Furthermore, the line may be split into separate location sections. This division can be made by using obstacle of surge impedance (already presented or specially made in line). For each section of line the ice thickness is calculated by averaging over length of separate section instead of averaging over the entire line length [3]. This increases the accuracy of the radar method.

Thus, the system of radar monitoring allows to determine the thickness of the ice deposits. This system gives command to melt ice upon reaching the critical values of the ice thickness.

1. Minullin RG, Lukin EI, Sukhomyatkin MO et al. Specifics of Detecting Ice Coatings on Electric Power Lines Using Radar Probing. Russian Electrical Engineering. New York: Allerton Press, Inc., 2011. Vol. 82 (No. 5). P. 237.

2. Kostenko M.V., Perel'man L.S., Shkarin Y.P. Volnovyye protsessy i elektricheskiye pomehi v mnogoprovodnyh liniyah vysokogo napryazheniya [Wave processes and electrical noises in high voltage lines]. Moscow: Energy, 1973. (rus)

3. Kasimov V.A., Minullin R.G. Metodika opredeleniya tolshchiny stenki gololednyh otlozheniy vdol' provodov vozdushnyh liniy elektroperedachi pri ih lokatsionnom zondirovanii [Method of determining the thickness of ice deposits on wires of overhead power lines by radar location method]. Kazan: Energetika Tatarstana [Power Engineering of Tatarstan]. 2014. No. 2 (34). Pp. 56-61. (rus)

Web site:

Short biography: Minullin Renat Gizatullovich is professor of physics and mathematics. He is a head of research laboratory at Kazan State Power Engineering University. He has developed a novel technique to detect icing and failure of overhead power lines which has no analogy in the field. Minullin R.G. and his team carry out research, both fundamental and applied, on transmission of electromagnetic waves in conducting wires. He developed unique software and hardware appliances to control ice accretion and wire breakage. These appliances that are installed in active power lines in several regions of Russian Federation since 2009 operate in continuous automatic mode and transmit the data to the central server. When ice accretion is detected, the duty operator receives an alert and gives command to melt the ice to prevent power lines from damage.

BACK

R&D areas/s: 08. Conductors / Insulators / Flashover

Coatings for protecting overhead power network equipment in winter conditions

Masoud Farzaneh, Université du Québec à Chicoutimi

Masoud Farzaneh (University of Quebec in Chicoutimi, Canada) Convenor CIGRE WG B2-44

One of the major problems in cold climate regions is ice and snow accretion on various power network equipment such as conductors and insulators. This may lead to major power outages, as observed during recent winter storms in Europe, Asia and North America. Advanced superhydrophbic and icephobic coatings can potentially benefit the electric power industry in reducing the risk of flashovers on insulators under contamination and icing conditions as well as the risk of mechanical problems caused by various phenomena related to ice or snow accretion on conductors, ground wires and support structures.

This presentation is an overview of the coatings that have been assessed by the CIGRE Working Group B2.44 for protecting and securing overhead power network equipment during winter conditions. In some cases, these coatings can also provide protection against corrosion. This working group also aims to recommend methods for testing and characterizing various properties of these coatings. In addition to their hydrophobic and icephobic properties, these coatings may allow the reduction of corona noise level and related interferences but this has not been confirmed yet. Most of them are applicable to other structures affected by icing, such as wind turbines.
Such coatings should be able to withstand the environmental stresses to which the equipment is exposed for the duration of their expected lifetime. They should also be able to withstand the wear and tear associated with the handling, installation and maintenance of the equipment involved. Also, the application of the coating should not, in any way, negatively affect the performance of the system. On the basis of these and some others anticipated stresses, a few key questions formulated in the Technical Brochure to facilitate the introduction of new coating technologies to the power system will be covered in this presentation.

Web site: http://www.uqac.ca/

Short biography: Professor Masoud Farzaneh is Director-founder of the CENGIVRE International Research Center, Chairholder of the Canada Research Chair on Atmospheric Icing Engineering of Power Networks in cold climate regions at University of Quebec in Chicoutimi (UQAC). Throughout his career, he has raised more than 55 million dollars in contracts and subsidies. He authored or co-authored around 600 technical papers, as well as 3 books and 14 book chapters related to power transmission issues in cold climate regions. Two of these books have been translated in Chinese. He has so far trained more than 125 postgraduate students and postdoctoral fellows. Since 2012, he was successively VP Technical, VP Administrative and President of IEEE Dielectrics and Electrical Insulation Society (DEIS). Presently, he is Chair of the Nominations and Appointments Committee of IEEE DEIS, member of the Editorial Board of IEEE Transactions on Dielectrics and Electrical Insulation, and chair of the PES/DEIS Joint Task Force on selection of insulators under icing conditions. He is also member of CIGRÉ Canada Executive Committee, Convenor of CIGRE WG B2.44 on coatings for protection of overhead lines during winter conditions. He is Fellow of IEEE, Fellow of The Institution of Engineering and Technology (IET) and Fellow of the Engineering Institute of Canada (EIC). His contributions and achievements in research and teaching have been recognized by the attribution of a number of prestigious prizes and awards at national and international levels. See also http://masoudfarzaneh.ca/

BACK

R&D areas/s: 10. Testing facilities

Research Condition and Capacity of Xuefeng Mountain Natural Icing Testbase (XMNIT)

Xingliang Jiang, Jiang Xingliang

JIANG Xingliang, ZHANG Zhijin, HU Jianlin, HU Qin
The State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University， Chongqing 400030， China

After the big ice-storm in early 2008 happened in South China, Chongqing University began to set up a typical natural icing testbase. Based on an overall survey in China, we found that Xuefeng Mountain has a very severe and typical icing condition, in which the icing duration can last almost 150 days each year, and the maximum wind speed can reach 35 m/s, and over 200 days is heavily foggy. Also the minmum temperature is not less then 10 °C, but the ice on structures, such as conductors, wind turbine blades, etc. is very much severe. It is a typical microclimate and microrelief icing area. From July 2008 now on, We spend a lot of manpower and material resources for its construction. After more than six years of construction, It has already very good conditions for investigating all kinds of atmospheric structures icing performance in natural icing environment. We have set up a special 10 kV high voltage power lines, and established 500kV AC and ±800kV DC testing power apparatuses, and set up simulation transmission lines. In coming summer, we will set up a 300 kWs Wind Turbine forboth its icing investigation and the backup supply of the testbase.
Furthermore, it has a good living conditions and communication conditions. He is a nice natural testbase for studying atmospheric structure icing, based on the testbase, we can cooperate with counterparts at home and abroad in this field. Based on the investigation and research, we have achieved a lot of scientific achievements.

Web site: http://international.cqu.edu.cn/

Short biography: None provided

BACK

R&D areas/s: 07. Icing on power lines

Meteorological data for assessing climatic loads on overhead lines. Report from Cigre WG B2.28

Svein M. Fikke, Meteorological consultant

Svein M. Fikke (Meteorological consultant, NO)

The purpose of this report is to summarize new information relevant for assessing climatic loads on electric overhead lines. Such information has appeared in several publications from Cigré SCB2, as well as from other sources, after the publication of the Technical Report IEC 61774 “Overhead lines – Meteorological data for assessing climatic loads” in 1997. WGB2.28 was given the task to: “compile and restructure updated meteorological knowledge for the purpose of application in international standards, especially on: Turbulent wind enhancement behind steep terrain, Application of numerical weather prediction models, and Measurements and observations of ice loads on overhead line components Probably the most important reason for reviewing meteorological data and assessment procedures concerning climatic loads and other adverse weather impacts on electric power overhead lines, is the rapid developments in data availability for the atmosphere, better knowledge of physical processes relating to cloud physics and precipitation, and the capacities of modern computers. These factors have dramatically improved the reliability of modern weather forecasts. However, the same factors have also enhanced the ability to describe details in adequate weather parameters in local topography down to spatial scales relevant to the span length of electric power transmission lines, even in rough and complex terrain. In particular this is valid for the assessments of ice loadings on structures.

Web site:

Short biography: I am a meteorologist and have almost 40 years of experience with extreme weather laodings on different kinds of outdoor structures, especially on electric overhead lines. I have been likewise involved in related national and international committees and working groups on such topics. Nowadays I try to find more time to spend with grandchildren.

BACK

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 09. Anti- / de-icing, coatings, 12. Other topics related to icing

Back to the basics: Wetting, Icing and Ice adhesion

Lasse Makkonen, VTT Technical Research Centre of Finland

Lasse Makkonen (VTT, Finland)

Back to the basics: Wettability, icing and ice adhesion
Icing in the wet growth regime is caused by a water film or droplets, the dimensions and dynamics of which depend on the external forces and on the wettability of the surface material. The rate of freezing of the drops during sliding depends on their shape [1,2], i.e. their dynamic contact angles. Furthermore, bouncing of impacting drops [3,4] and shedding of runback water [5,6] are related to the receding contact angle.
Many experimental studies on the critical external force that cause water to be removed from various surfaces have been made [5,7-13]. However, the fundamentals of wetting have not been resolved. When a drop slides on surface, its contact angle at the advancing and receding side of the drop no longer corresponds to the static contact angle. The difference between these contact angles is called the contact hysteresis, and it determines the critical tilt angle explicitly. Studies have been made on the contact angles and their relation to runback icing [3,6,14,15] and ice adhesion [16-24], but no theory for the contact angle hysteresis exists.
In this paper, the problem of the contact angle hysteresis is solved by a first principles theory. The theory originates from the recent novel interpretation [25] of the basis of the wetting theory: the Young's equation. Good agreement with experimental data is demonstrated. Implications of the theory to runback icing are discussed, and it is shown that the relations between the contact angles and the work of adhesion are complicated, but solvable by the theory. This removes many misunderstandings in the literature and shows that hydrophobicity and icephobicity should not be defined in a simple way.
References
1. K. Fumoto and H. Yamagishi, 2005. Proc., 11th IWAIS) Montreal, 13-16 June 2005, 6 p.
2. P. Tourkine, M. Le Merrer and D. Quere, 2009. Langmuir 25, 7214-7216.
3. V. Bahadur, L. Mishchenko, B. Hatton, J.A. Taylor, J. Aizenberg and T. Krupenkin, 2011. Langmuir 27, 14143-14150.
4. C. Antonini, F. Villa, I. Bernagozzi, A. Amirfazli and M. Marengo, 2011. Langmuir 29, 16045-16050.
5. A.J.B. Milne and A. Amirfazli, 2009. Langmuir 25, 14155-14164.
6. D. Mangini, C. Antonini, M. Marengo & A. Amirfazli, 2015. Cold Regions Sci. Technol. 109, 53-60.
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R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 09. Anti- / de-icing, coatings, 12. Other topics related to icing

Web site:

Short biography: Icing model developer and surface physicist. Have presented 29 papers at IWAIS so far.

BACK

R&D areas/s: 07. Icing on power lines, 09. Anti- / de-icing, coatings

Optical Fiber Temperature Characteristic of OPGW during DC Ice- Melting

Zhigao Meng, The State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, Chongqing

MENG Zhigao, JIANG Xingliang, ZHANG Zhijin, HU Jianlin, SHU Lichun
State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, 400044, China

Atmospheric ice accumulation on optical fiber Ground wire (OPGW) will affect the safe and stable operation of power grid. The use of DC ice-melting is one of the effective measures to prevent OPGW from its icing accident. However, the unreasonable selection of ice-melting current maybe result in too high temperature to hurt the optical fiber. Therefore, it is necessary to study the temperature characteristics of OPGW during ice-melting. The temperature distribution of OPGW during the ice-melting is calculated with the finite element method in this paper. The temperature variation of optical fiber is obtained according to the temperature distribution, and the calculation results are verified by the ice-melting tests in the artificial climatic chamber. Results show that the temperature of optical fiber keeps rising during DC ice-melting, and the increase rate of temperature gradually slows down. The temperature of the optical fiber reaches its maximum value at the end of the ice-melting process. The maximum temperature is greatly influenced by ice thickness and ice-melting current, and less affected by ambient temperature, while it almost remains unchanged with the variation of wind speed.

Web site: http://international.cqu.edu.cn/

Short biography: None provided

BACK

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change)

Analysis of the effect of climate change on the reliability of existing overhead transmission lines

Luc Chouinard, McGill Unviersity

Luc Chouinard (McGill University, Canada)
S.N. Rezaei (McGill University, Canada)
S. Langlois (Université de Sherbrooke)

Climate change is anticipated to have an impact on the operation of overhead transmission and distribution lines through impacts of extreme weather events. The changes in the frequency and intensity of wind and ice storms may have a considerable effect on the applied loads and can consequently change the probability of structural failure of different components of the line. This study examines the reliability of transmission lines under a range of assumed changes in the mean and standard deviation of climatic variables affecting transmission lines such as wind speed and ice thickness. This sensitivity study provides useful information required to improve the capacity of transmission lines and mitigate the long-term risks from the effects of a changing climate.

Web site:

Short biography: Participated in several previous IWAIS conférences.
Research interests: modelling of wind and icing hazards, development of design criteria, reliability analysis of structures.

BACK

R&D areas/s: 09. Anti- / de-icing, coatings, 11. Icing in wind energy

Passive acoustic signal sensing approach to detection of ice on the rotor blades of wind turbines

Eugen Mamontov, Foundation Chalmers Industrial Technology (Stiftelsen Chalmers Industriteknik), Gothenburg, Sweden

* Eugen Mamontov, Department of Research and Development, Foundation Chalmers Industrial Technology, Gothenburg, Sweden
* Viktor Berbyuk, Department of Applied Mechanics, Chalmers University of Technology, Gothenburg, Sweden

In cold seasons, irregular layers of atmospheric ice (AI) are usually accreted on the rotor blades of wind turbines. These layers can cause unexpected downtimes and increase the maintenance cost reducing the efficiency. AI presents an unpredictable mixture of crystalline and amorphous ices including such forms as dense snow frozen to the surface, soft rime, hard rime, clear ice, and glaze (e.g., [1], [2]). The parameters of the AI-layer e.g., the thickness, mass volumetric density, porosity, elastic moduli, viscosities, and stress-relaxation time) vary significantly, from a half on order to a few orders, depending on the parameter and type of AI (e.g., [1]-[5]).

To solve the icing problem for wind turbines, the ice-detection and de-icing systems are needed. The ice-detection systems (IDSs) should not only detect the AI-layer on the blade skin but also provide the data allowing identification of the AI-layer parameters, which are sufficient for the cost-efficient de-icing. The identification method is, thus, in the focus of the IDS development, which deals with the following main features.

(1) The operational load in a blade creates irregular space-time distributions of acoustic variable (e.g., strain, stress, and displacement) which depend on the acceleration, deceleration, and speed of rotation of the rotor, the blade-pitch angle, the wind, the presence of the AI layer on the skin, and other factors. The corresponding experimental data are well documented (e.g., [6, Figs. 6-9], [7, Fig. 8 and Fig. 10(b)]).

(2) The blade skin is a layer of a complex, curvilinear shape, which, in the course of the turbine operation, varies in space and time. This feature is also well documented (e.g., [6], [7]).

(3) The AI stress-relaxation time can be in an interval of a few orders (e.g., [3]-[5]).

(4) The AI-layer parameters should be identified by means of an appropriate acoustic model from the data of the sensors, which are located on the inner surface of the blade skin and wirelessly controlled in the real-time mode by a computer and gateways.

The present work develops an acoustic model and method for identification of four of the AI-layer parameters: the thickness, mass density, bulk-wave speed, and stress-relaxation time. Due to Point (1), the identification method presumes passive rather than active sensing. The method is based on measurements of the acoustic accelerations at different points on the inner surface of the skin. The challenge in Point (2) is met by the generalizing the thin-planar-disk approximation introduced in [8] from a single solid layer to the system of the blade-skin/AI layers. The features in Points (3) and (4) are allowed for by a generalization of the viscoelastic model developed in [8] and preceded in [9] to the two-layer system. The model is based on a partial integro-differential equation for the non-equilibrium component of the average normal stress. The proposed identification method is computationally efficient and suitable for the use indicated in Point (4). It extends the scope of the structural health monitoring techniques.

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Web site:

R&D areas/s: 09. Anti- / de-icing, coatings, 11. Icing in wind energy

Short biography: * Ph.D. degree: Mathematics / Differential Equations & Math. Physics, 1988, Lomonosov Moscow State University, Moscow, Russia
* Associate Professor (or Docent), 2002, Chalmers University of Technology, Gothenburg, Sweden
* Profession: Senior Researcher / R&D Manager
* Working experience in the profession: 38 years including 22 years at universities and 21 years at industrial companies
* Current position: Senior Researcher, Division of Research and Development, Foundation Chalmers Industrial Technology (Stiftelsen Chalmers Industriteknik), Gothenburg, Sweden
* Leadership in multi-disciplinary R&D: 3.5-year heading the R&D activities of an innovative company (2008-2011); 4.5-year heading teams in the national and European Commission R&D projects at universities (2003-2008); 3.75-year membership in the Executive Committee of one of the European Commission R&D project (2004-2008); 3-year senior function in the national team in the European Commission R&D project at a university (2001-2004)
* Style of management: competence-based management
* Invited lectures: 16
* Supervised, co-supervised, or guided Ph.D. students: 5
* Publications: more than 70 papers in peer-reviewed journals and peer-reviewed international conference proceedings, one book, one USA patent, and two popular-science articles
* Reviewer at peer-reviewed scientific journals or scientific databases: more than 12
* Field of competence in the wide sense: complex systems (analysis, methodologies, theories, and informatics)
* Methods of the field of competence: mathematical methods (qualitative and quantitative, analytical and computational, determinate and stochastic) including techniques for theoretical support of experiments or measurements
* Focus of the field of competence: development of constructive frameworks for either solving problems, unsolved before, or much more efficient solving problems, solved before, by means of systems approach and the above methods

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change)

A Research of Icing Forecasting Algorithm Using Genetic Algorithm and Fuzzy Logic

Xin-bo Huang, College of Electronics and Information, Xi'an Polytechnic University, Xi'an 710048, P.R.China

Yu-xin WANG(College of Electronics and Information, Xi'an Polytechnic University, Xi'an 710048, P.R.China)(Corresponding Author), Yong-can ZHU(School of Electro-Mechanical Engineering, Xidian University, Xi'an 710071, P.R.China), Hong-bo LI(College of Ele

According to the icing forecasting problems of transmission line, an icing forecasting fuzzy system was optimized by using genetic algorithm to get a better results. Firstly, a combined fuzzy rules base was established by using a learning algorithm combined with the expertise fuzzy rules in the field data. Secondly, the parameters of icing forecasting model such as the input-output domain fuzzy division、combined fuzzy rule base and membership function, etc. were optimized by genetic algorithm, moreover, the theory mix of genetic algorithm and fuzzy logic was studied and discussed further. Finally, the monitoring data acquired from transmission line online monitoring system on Guizhou Grid of China in 2014 was selected to compare the predicted effects of icing forecasting model before and after optimization.
keywords - transmission line; icing; icing forecasting; genetic algorithm; fuzzy logic

Web site: http://en.xpu.edu.cn/

Short biography: Xin-bo Huang was born in Shandong Province, China, in May 1975. He received the B.S. and M.S degrees in automation from Qingdao Technological University, Qingdao, China, in 1998 and 2001, respectively. He received the Ph.D. degrees in automation from XiDian University, Xi'an, China, in 2005. Since July 2005, he has been a teacher at Xi'an Polytechnic University, and since December 2008, he has been a full Professor with the School of Electronics Information at Xi'an Polytechnic University. From October 2005 to March 2008, he was a post-doctor in the State Key Laboratory of Electrical Insulation and Power Equipment and the School of Electrical Engineering at Xi'an Jiaotong University, engaged in the snow and ice warning system on transmission lines. Since May 2009, he was a post-doctor at South China University of Technology, engaged in the transmission conductor galloping monitoring and mechanism. His current research interests include the online monitoring technology and condition maintenance of power equipment, the wireless network sensor. He has published more than 50 journal articles and conference papers, and 4 monographs. He may be reached at hxb1998@163.com.
Dr. Huang received the 2011 new century excellent talent support plan of China Ministry of Education (MOE), 2010 teacher of the year award in China's "textile light" for teachers, 2009 Hong Kong SangMa research grants award, and several other awards and prizes from Chinese Government.
Yu-xin WANG is currently working toward the M.S. degree with the College of Elctronics and Information, Xi'an Polytechnic University, Xi'an, P.R.China. He research interests include ice growth forecasting on transmission line and artificial intelligence. He may be reached at wangyuxin_ac@sina.com.

BACK

R&D areas/s: 07. Icing on power lines, 10. Testing facilities

Study on Icing characteristics of Bundle Conductors under Xuefeng Mountain Natural Icing Testbase

Quanlin Wang, The State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, Chongqing

WANG Quanlin, JIANG Xingliang, ZHANG Zhijin, HU Jianlin, SHU Lichun State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, 400044, China

Icing on electric transmission line is one of key factors which threaten the security and reliability of power grid with wider application of bundle conductors in UHV or EHV transmission lines. However, there is no in-depth analysis of growth characteristics of icing on bundle conductors in the natural environment so far. Most researches are based on the tests in artificial climate condition, which is much difference from natural environment for the practice engineering. In order to study the icing characteristics of bundled conductors, the icing tests on three kinds of bundle conductors have been done at Xuefeng Mountain Natural Icing Testbase (XMNIT). Based on the testing results, this paper concludes: the growth rate of icing on windward site of conductors is faster than that of leeside, and the thickness of transverse direction is about ten times as much as that of lengthways direction; The growth of icing weight is nonlinear process, which is large at preliminary stage and saturated at last period; There is obvious stratification phenomenon in the icicles of hard rime, which is quite different with icing on short conductor in the artificial simulation experiments; Through observed in the experiments, the ice shape , ice weight and ice thickness have no obvious differences among the single conductor, 3-bundle conductor and 4-bundle conductor. The conclusions can be referred by designing and selection of overhead transmission lines in the region of hard rime.
Key words: bundle conductor; icing; shape feature; ice thickness; ice weight

Web site: http://international.cqu.edu.cn/

Short biography: None provided

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change)

Verification of Icing-model, in Finland.

Karoliina Hämäläinen, Finnish Meteorological Institute (FMI), FI

Sami Niemelä (FMI, FI)

In Finland one of the most demanding environmental factor for wind energy production is the presence of icing. There are methods available to simulate and predict the icing occurrence. However, measuring of atmospheric icing is not part of FMI's (Finnish Meteorological Institute) daily routine. Moreover, the icing measurement techniques varies from detailed ice-mass measurements to simple on-off type of instruments providing very different kind of information. Therefore, the amount of homogeneous icing measurements available is quite limited. In this work we present the verification results of one icing model by using different observation types. We also study the sensitivity of the icing model for its various internal components.

We collected five different kind of measurements from three sites to validate the Icing-model. The observations available were from Puijo (deep mainland Eastern-Finland) and Luosto (Lapland) measurement stations, and in addition to those one wind turbine site at Riutunkari (west coastal are). From Puijo we had data from Labkotec's LID-3300IP and Vaisala's FD12P instruments. Labkotec data was also available from Riutunkari site. These instruments give ON-OFF type of information of icing conditions. From Luosto we have two different kind of measurements. ON-OFF data from Rosemount instrument and mass measurements form Combitech's IceMonitor. The Icing-model itself is based on ISO Standard 19494, so called Makkonen model. In this model ice is accumulated over standard cylinder. The input for the Icing-model is taken from numerical weather prediction model Harmonie. Harmonie provides wind speed, temperature and liquid water content. The Icing-model was developed for climatological research to create new Finnish Icing Atlas. With Harmonie we created weather datasets to cover the periods from which we had observations. We tested the observations from each instrument separately. According to model-observation comparison the Icing-model has the skill to detect icing events. No instrument seemed to be better than others respect to model results. Unfortunately, the model has no skill what so ever to predict ice mass accumulation correctly. One problem in ice mass comparison was that the observations were from 5m asl., but the lowest model level is at 30m height from the ground seen by the model. And in Luosto's case the observations are made at top of a hill which cannot be seen by the weather model. So, the shift is about 130m. Nevertheless, the Icing-model is suitable to predict the existence of icing events already now, but to estimate the severity of the event cannot be made jet.

At the second part of our verification work we tested how sensitive the Icing-model itself is for the input it gets from the weather model. We perturbed wind speed, temperature, liquid water content and cloud particle number concentration to understand the model sensitivity for these parameters. As a result we discovered that the results are strongly dependent on how well we forecast the wind speed, temperature and liquid water content, but not that sensitive to cloud particle number concentration. Fortunately the weather model has the skill to predict the temperature and the wind speed reliably. However, predicting the clouds and the liquid water content temporally and spatially correctly still remains as challenge.

Web site:

Short biography: Ms. Karoliina Hämäläinen is a PhD -student from Helsinki University. At the moment she is working her thesis at Finnish Meteorological Institute in Helsinki. Topic of her thesis is: Meteorological solutions to support wind power production in Finland. Her educational background is in both Engineering and Natural Sciences: Bachelor of Engineering on Energy & Environmental Technics and Master of Sciences on Atmospheric Sciences (Meteorology). During the past few years Ms. Hämäläinen has been working with Finnish Wind Atlas and Finnish Icing Atlas. Her heart is with atmospheric icing and she likes to knit warm woolen socks at her private time.

BACK

R&D areas/s: 09. Anti- / de-icing, coatings, 12. Other topics related to icing

On Self-cleaning and Anti-ice Performance of Double-layer-SAMs Coatings with Enhanced Corrosion Resistance on an Al Alloy Substrate

Shahram Farhadi, NSERC/Hydro-Quebec/UQAC Industrial Chair on Atmospheric Icing of Power Network Equipment (CIGELE) and Canada Research Chair on Atmospheric Icing Engineering of Power Networks (INGIVRE), Université du Québec à Chicoutimi, QC, Canada

1) Shahram FARHADI (Industrial Chair on Atmospheric Icing of Power Network Equipment (CIGELE), UQAC, Canada)
2) Masoud FARZANEH (Industrial Chair on Atmospheric Icing of Power Network Equipment (CIGELE), UQAC, Canada)
3) Stephan SIMARD (Aluminum Technol

In cold climate countries such as Canada, the USA etc., outdoor structures including transmission lines and telecommunication networks are exposed to ice and/or snow accretions which are sometimes the source of several types of damage and malfunctions. Superhydrophobic coatings were introduced and developed over the past decades as a passive technique to reduce or prevent ice accumulation on outdoor structures. At the same time, corrosion protection of metallic substrates such as aluminum and its alloys is another essential issue when they are used in environments in close contact with water or other aggressive molecules. The present study, therefore, aims at systematically studying a double-layer SAMs coating terminated with surface alkyl groups that are expected to reduce ice adhesion and corrosion rates on an Al surface. More precisely, thin films of 1,2-bis-trioxymethyl-silyl-ethane [C14H34O6Si2] and octadecyltrimethoxysilane C18H37Si(OCH3)3 were deposited layer by layer on etched Al alloy (AA2024-T3) substrates. The first layer was used as an under-layer expecting to improve the anti-corrosive performance for the top-layer providing surface water and ice repellency (surface hydrophobization). The prepared coated samples demonstrated good superhydrophobic and self-cleaning properties providing a static water contact angle of CA > 155º and a hysteresis angle of CAH ≤ 5º. The low CAH causes the water droplets to roll off the surface thus easily carrying away surface contamination by water droplets passing by. The coating stability was studied by immersing the coated samples into water, with basic and acidic conditions (different pH), showing gradual loss of superhydrophobicity over time. In the meantime, while bare mirror-polished and as-received Al showed average ice detachment shear stress values of ~270 ± 20 kPa and ~370 ± 30 kPa, respectively, their counterparts coated samples showed reduced values of ~182 ± 15 kPa. This reduction is ascribed to the presence of engineered micro-/nano-hierarchical surface asperities along with applying low surface energy top-layer on the sample surfaces. The ice-releasing performance, however, gradually decreased over repeated icing/de-icing cycles. Potentiodynamic polarizations studies revealed that the corrosion resistance of modified aluminium alloy improved remarkably compared to the unmodified samples. Meanwhile, salt spray exposure tests demonstrated that while extensive corrosion appeared on bare Al after only 8 cycles of salt spray exposure, trace of corrosion was observed for the double-layer SAMs coating after 81 cycles of exposure.
Keywords: Superhydrophobicity; Self-cleaning; Anti-corrosive performance; Nanostructured aluminum; Double-layer coating; Durability; Ice Repellency; Wetting hysteresis.

Web site: http://cigele.ca/

Short biography: I have a 5-year work experience as an analytical, researcher (R&D) and quality control chemist in pharmaceutical and petrochemical companies as well as 6-year academic experience as a full-time MSc and PhD student in Canada. The subject of my PhD study is "Developing nanostructured coatings for protecting surfaces of aluminum alloys (series 2000 and 6000) against corrosion and ice accumulation" in collaboration with Aluminum Technology Center (NRC-ATC) in Quebec, Canada. I have published over 20 articles including refereed journal papers, refereed conferences with published abstracts and scientific reports in the field of corrosion, hydro-/super-hydrophobic and anti-icing coatings.

Personal interest: Corrosion, Coating and surface engineering, Sport, Music, Cinema and Painting.

BACK

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 07. Icing on power lines

WET-SNOW ACTIVITY REASERCH IN ITALY

Matteo Lacavalla, RSE SpA, IT

Pietro Marcacci, RSE SpA, IT

The power grid infrastructure is vulnerable to some extreme meteorological phenomena and this could create some difficulties in the safe management of the power system. The wet-snow accretion on OHL (OverHead Lines) is well-known to the Transmission and Distribution System Operators (TSO&DSO). The problem affects much of Europe, with an annual number of wet-snow type steadily increasing over the total number of snowfalls. The problem imposes a greater attention to this phenomenon, either through a focused weather forecast both through active and passive mitigation strategies. RSE has developed WOLF (Wet snow Overload aLert and Forecasting) for OHL warning on the transmission power grid. The weather forecast system is already being tested at the Italian TSO. WOLF together with wet-snow load, provides an estimation of the ant-icing current necessary to keep OHL free of wet-snow sleeve formations, supporting operators in adopting mitigation active strategies. In synergy with WOLF, an automatic station named WILD (Wet Snow - Ice Laboratory Detection) has been installed in the municipality of Vinadio in the west Alps, at an altitude of 950 m. aslm, for the verification of the forecasts system. Through WILD measurements, it is possible to analyse in detail the weather conditions most critical for the wet-snow sleeve formation and, at the same time, to make the "tuning" of the parameters in the models of accretion and anti-icing. A prototype of an active anti-icing circuit is able to maintain snow-free the surface of a typical cable in any condition of wet-snowfall and a rotating system allows to measure and compare the sleeve accretion on different type of conductors. In the terms of the passive mitigation, a qualitative test is being carried out at WILD station on innovative conductors materials provided by Italian TSO, characterized by different surface hydrophobic and ice-phobic treatments. The wet-snow accretions on new cables are compared, although qualitatively, in the same weather conditions with those on conventional conductors. This experimentation may be an important test to get a selection of materials to be used in the areas most exposed at wet-snow risk.

Web site: http://www.rse-web.it

Short biography: I've been working as meterologist in RSE Company since 2011. I'm interested in weather forecast, especially in extreme weather phenomena as wet-snow storm and strong thunderstorms. I like skiing and walking in the mountains.

BACK

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change)

Testing six wet snow models by 30 years of observations in Bulgaria

Dimitar Nikolov, National Institute of Meteorology and Hydrology - Bulgarian Academy of Sciences (NIMH-BAS), Bulgaria

Dimitar Nikolov (NIMH-BAS, BG)
Lasse Makkonen (VTT, FI)

Six simple wet snow accretion models are applied for simulations of well documented historical severe wet snow events in Bulgaria for the period 1969-1998. The data base consists of information about the diameters and masses, and thereof about the densities, of wet snow depositions in cases of damages on power lines. These measurements were taken soon after each of the damage. For all cases, it is checked if the meteorological conditions correspond to the wet snow accretion criterion of Makkonen (1981). The models used in this study are: the model of Admirat and Sakamoto (Admirat et all., 1986a and b, Admirat and Sakamoto, 1988a), the model of Finstad et al. (1988), two model suggestions of Sakamoto and Miura (1993), the model of Makkonen (1989) and its improvement (Makkonen and Wichura, 2010) and the one with the latest suggestion for the sticking efficiency of snow by Björn Egil Nygaard et al (2015).
The estimated density of the wet snow depositions varied between 400 and 700 kg/m3 and these measured values are used in the calculations instead of the experimental relationships proposed in some of the models. Working with known densities allows us to make conclusions for the approximations of the sticking efficiency and the snow concentration in air. The models are tested with two data sets – the original one consisting of standard three and six hourly synoptic measurements and its transformation into hourly values.
The sensitivity of some of the models to the meteorological parameters is also demonstrated.

Web site:

Short biography: I work at the National Institute of Meteorology and Hydrology in since 1998.
My higher education is from University of Sofia, Faculty of Physics with MSc in Physic with specialty Meteorology.
My PhD is from the National Institute of Meteorology and Hydrology - Bulgarian Academy of sciences.
The title of my PhD is "Icing of technical equipment in Bulgaria and other European regions".
My main professional interests are in the field of snow and icing, ice and snow loads, snow and ice storms.

BACK

R&D areas/s: 09. Anti- / de-icing, coatings

Effect of alkyl chain length on the hydro/icephobic properties of SAMs coatings on aluminum alloy 6061 surfaces

Faranak Arianpour, NSERC / Hydro-Quebec / UQAC Industrial Chair on Atmospheric Icing of Power Network Equipment (CIGELE) and Canada Research Chair on Atmospheric Icing Engineering of Power Networks (INGIVRE), www.cigele.ca Université du Québec à Chicoutimi, Chicoutimi, QC,

1) F.arianpour, NSERC / Hydro-Quebec / UQAC Industrial Chair on Atmospheric Icing of Power Network Equipment (CIGELE), QC,Canada
2)R.Jafari, Industrial Chair on Atmospheric Icing of Power Network Equipment (CIGELE), UQAC, CANADA
3) M.Farzaneh, NSERC / H

In cold climate countries, ice and wet-snow accretions on overhead power transmission lines can be a source of damage and malfunctions which may lead to mechanical or electrical failures. Reducing or preventing ice accumulation on surfaces can be accomplished by applying icephobic coatings. The application of self-assembled monolayer (SAMs) coatings is one of the most successful approaches to chemically transform otherwise hydrophilic surfaces into hydrophobic ones. The SAMs through a combined process of adsorption, hydrolysis, and polymerization can lead to a spontaneously assembled surface with low surface energy. In this paper, the hydro/icephobic properties of SAMs of trichloro (octadecyl) silane (C18H37Cl3Si, OD) and trichloro (octyl) silane (C8H17Cl3Si, OT) on a polished Al alloy were studied. The contact angle (CA) values for coatings of OD and OT after 12 hours of immersion time (IT) were ~140o and ~120o, respectively. The contact angle hysteresis (CAH) for OD sample was ~38o and for OT sample was ~55o after 12 hours of immersion time. The larger and smaller obtained values of CA and CAH were ~140o and, ~38o respectively, for OD sample. The ice-repellent behavior of the prepared coatings was also evaluated by accumulating artificial glaze ice on coated surfaces via spraying supercooled water microdroplets in a wind tunnel at subzero temperature (-10 oC). The ice adhesion reduction factor (ARF) for OD and OT samples demonstrated that the ice adhesion strength values are ~1.24 and ~1.05 times smaller than those obtained on a polished Al sample, respectively. The shear stress of ice detachment values of the OT sample were not observed to be as small as those obtained in the case of the OD sample. It was shown that the properties of hydro-/ice-phobic for OD sample was more improved compared to the OT sample. This behavior could be explained by the reduction of the molecular reactivity caused by the steric effect in case of the OT sample on a polished Al surface. The surface morphology of the surfaces was analyzed by scanning electron microscopy (SEM). The SEM micrographs of coated surfaces demonstrated the presence of a rough structure at micro/nano-scale on the mirror polished Al substrate.

Web site:

Short biography: • 6-months (full-time) as summer probationary working in chemical laboratory of Farabi pharmaceutical company.
• 3-year academic experience as full-time M.Sc. student in Canada (Full-time research study).
• 3-year teaching assistant of chemical fundamental and chemical engineering courses in university of Quebec at Chicoutimi.
• First ranked student in university during all four years of my B.Sc.
• Diploma of mathematics and physics, B.Sc. in applied chemistry and M.Sc in engineering (chemical engineering and nanotechnology).
• MsOffice (Word, Excel, Power Point), Internet, Chem. Office-Ultra software and Origin 6.0.
• Familiar with UV-Vis spectroscopy, Jones reductor, High-performance liquid chromatography (HPLC), Viscometer, Gas Chromatography (GC), Chemical vapor deposition (CVD), IR spectroscopy, Gas Chromatography (GC), Atomic Absorption, Fluor-meter, Polarizing microscope, Flash point, Contact angle goniometer, Atomic force microscopy (AFM), Centrifuge adhesion test machine, X-ray photoelectron spectroscopy (XPS), Scanning electron microscope (SEM/EDX), UV accelerator, TDS (Total Dissolved Solids) meter and Spin and dip-coater and pH-meter.
PhD of Engineering (surface engineering and nanotechnology,"ELABORATION OF COMPOSITE AND CHEMICALLY HETEROGENEOUS ICE-PHOBIC COATINGS")
University of Québec at Chicoutimi, Québec, CANADA
I have about 25 publication and conference papers.

R&D areas/s: 09. Anti- / de-icing, coatings

Personal interest: Dance, music, sport, paint, travelling

R&D areas/s: 09. Anti- / de-icing, coatings, 12. Other topics related to icing, Corrosion

How the "Steric effects" Affect Ice Repellency, UV stability and Corrosion Resistance of Dissimilar SAMs Coatings on a AA2024 Alloy

Shahram Farhadi, NSERC/Hydro-Quebec/UQAC Industrial Chair on Atmospheric Icing of Power Network Equipment (CIGELE) and Canada Research Chair on Atmospheric Icing Engineering of Power Networks (INGIVRE), Université du Québec à Chicoutimi, QC, Canada

1) Shahram FARHADI (Industrial Chair on Atmospheric Icing of Power Network Equipment (CIGELE), UQAC, Canada)
2) Masoud FARZANEH (Industrial Chair on Atmospheric Icing of Power Network Equipment (CIGELE), UQAC, Canada)
3) Stephan SIMARD (Aluminum Technol

Ice adhesion on outdoor structures is an important issue in cold climate countries. Passive approaches to the problem, e.g. anti-icing or icephobic coatings that inhibit or retard ice accumulation on surfaces, are gaining in popularity. The development of ice-releasing coatings on metallic structures, e.g. Al alloys, is closely related to anti-corrosive protection of that metal, since they must be durable enough when placed in humid environments. In the present study, icephobic stability against UV-irradiation and anti-corrosive performance of three dissimilar alkyl-terminated SAMs thin films on a AA2024 substrate were investigated. The samples were prepared following "wet-chemistry" technique by depositing three alkylsilane-based SAMs of Triethoxy(octyl)silane [CH3(CH2)7Si(OC2H5)3, 8C], Octadecyltrimethoxysilane [C18H37Si(OCH3)3, 18C], and Trichlorooctadecylsilane [(CH3(CH2)17SiCl3, 18C+Cl] on the Al substrate. The influences of "Steric effects" on coating formation and performance, their hydrophobicity and durability versus different pH and/or against UV-irradiation were studied by means of contact angle measurements, demonstrating gradual loss of hydrophobicity over time. Glaze ice was artificially deposited on the coated surfaces by spraying supercooled water micro-droplets (~65μm) in a wind tunnel at subzero temperature (-10oC) to simulate most severe natural atmospheric icing. All samples demonstrated initially the shear stress of ice detachment values of ~ 1.68 to 2 times lower than as-received Al surfaces. However, following successive icing/de-icing cycles, different degree of coating degradation was observed. In addition, surface hydrophobicity was studied after icing/de-icing tests to study their stability over ice releasing, showing decreases in contact angle values. Lose of hydrophobicity and increase of ice adhesion were indeed dramatically and completely different for coated samples with 8C and 18C+Cl SAMs compared to 18C SAMs thin films. This is due to the reason that the 18C SAMs was the most ordered thin film among the other two, which is due to the significant influence of the "steric effects". Meanwhile, potentiodynamic polarization revealed that the corrosion resistance of the coated sample with 18C SAMs is slightly improved if compared to the 8C, 18C+Cl and bare samples. The "Cyclic Corrosion Test" showed that while extensive corrosion appeared on bare samples after only 8 cycles of salt spray exposure, early stage corrosion was observed for the 8C, 18C and 18C+Cl coated samples after 12, 18, 9 cycles of exposure, respectively.
Keywords: Steric effects; Self-assembling; UV-irradiation; Ice adhesion strength; Potentiodynamic polarization; Cyclic Corrosion Test; Coating stability.

Web site: http://cigele.ca/

Short biography: I have a 5-year work experience as an analytical, researcher (R&D) and quality control chemist in pharmaceutical and petrochemical companies as well as 6-year academic experience as a full-time MSc and PhD student in Canada. The subject of my PhD study is "Developing nanostructured coatings for protecting surfaces of aluminum alloys (series 2000 and 6000) against corrosion and ice accumulation" in collaboration with Aluminum Technology Center (NRC-ATC) in Quebec, Canada. I have published over 20 articles including refereed journal papers, refereed conferences with published abstracts and scientific reports in the field of corrosion, hydro-/super-hydrophobic and anti-icing coatings.

Personal interest: Corrosion, Coating and surface engineering, Sport, Music, Cinema and Painting.

BACK

R&D areas/s: 07. Icing on power lines, 09. Anti- / de-icing, coatings

Development and Application of Current Transferring Smart Ice-melting method and apparatus for Bundle Conductors Transmissiuon Lines of EHV/UVU

Xingliang Jiang, The State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, Chongqing

JIANG Xingliang, ZHANG Zhijin, HU Jianlin, HU Qin
The State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, Chongqing 400030, China

After the big ice-storm in early 2008 happened in South China's power gird, China has invested a lot of manpower and material resources for research of powser grid icing and preventing mehod. Through extensive research and practice, the power grid has proposed dc ice-meliting method in service transmission lines, and developed both stationary and mobile dc ice-melting apparatuses, and hundreds of stationary and mobile dc ice-melting apparatuses have been installed in substations. Although dc ice-melting apparatus is effective in ice-melting practice of power gird, but it need to stop power supply during ice-melting and last several hours, and the apparatus is very heavy and high cost. If a large area of ice disaster like 2008 occur again, this method and the installed apparatus can not satisfy the engineering needs still. Especially with the development of next generation power grid of high reliability and intelligence, the ice-melting with power cuts do not meet the requirements of the development of the power grid at all. Based on the characteristic of EHV and UHV transmisison which use bundle conductors, we proposed current transferring ice-melting method for bundle conductors transmissiuon Lines of EHV/UHU, and developed a kind of smart ice-melting apparatus. The developed smart ice-melting apparatus has been tested at Xuefeng Mountain Natural Icing Testbase, and passed the detection and measurement of the National Quality Inspection Center. The results show that current transferring ice-melting method and the apparatus is effective and is of broad prospects for preventing EHV/UHV transmission lines from ice disaster.

Web site: http://international.cqu.edu.cn/

Short biography: None provided

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 05. Sensors, equipment and machinery - standards, 06. Icing on masts, towers and buildings, 07. Icing on power lines, 08. Conductors / Insulators / Flashover

Usage of automated information system for icing control on OHL 110-500 kV

Eugeniy Satsuk, Platov South Russian State Polyechnic University (Novocherkassk Polytechnic Institute), Novocherkassk, Russia

A. Bytkin (Novocherkassk, RU)

Automated information system for icing control (AISIC “Blais®”) on OHL consists of equipment being installed directly on OHL towers (measure stations) and equipment installed on control centre (data reception and processing station). System has almost unlimited possibility for the increase of quantity of the measure stations and quantity of measured parameters. System usage gives possibility of icing detection on OHL’s conductors and execution of de-icing procedures.
Measure stations are located on OHL in the points most “interesting” from the icing point of view and consist of:

- microprocessor-based hardware;
- icing sensors on conductors and ground-wires;
- automatic meteorological stations with sensors of air temperature and humidity, wind speed and direction;
- conductor’s temperature sensor;
- video camera;
- transmitting unit;
- Combined power supply unit, including accumulator, solar battery, charging unit.

Measure stations could transmit data through different communication channels:

- radio channel;
- GSM channel;
- GPRS channel;
- satellite channel;
- Ethernet;
- Fiber-optic communication line.

Different system versions make it possible to use all available communication channels in the region where the system being installed. Possible usage of two communication channels make it possible to create a net with communication channels reservation. Thus in the case of main channel lost the reserved channel will be automatically used.
Currently in South Grids and Kuban Backbone Grids successfully being used AISIC “Blais®”, which integrates in an entity information space more than 300 measure stations and more than 20 data reception and processing stations. AISIC “Blais®” successfully being used also in other grids all over Russia. Totally are installed more than 400 measure stations and more than 30 data reception and processing stations.

Web site: http://www.npi-tu.ru/index.php?id=226

Short biography: 1992 graduated in electric power systems at Platov South Russian State Polyechnic University (Novocherkassk Polytechnic Institute), Novocherkassk, Russia.
2011 postdoc in tecnical science;

BACK

R&D areas/s: 09. Anti- / de-icing, coatings

Hydrophobic and anti-ice properties of homogeneous and heterogeneous nanoparticle coatings on Al 6061 substrates

Faranak Arianpour, NSERC / Hydro-Quebec / UQAC Industrial Chair on Atmospheric Icing of Power Network Equipment (CIGELE) and Canada Research Chair on Atmospheric Icing Engineering of Power Networks (INGIVRE), www.cigele.ca Université du Québec à Chicoutimi, Chicoutimi, QC,

1)F. Arianpour, Industrial Chair on Atmospheric Icing of Power Network Equipment (CIGELE), UQAC, QC, Canada
2)R. Jafari, Industrial Chair on Atmospheric Icing of Power Network Equipment (CIGELE), Canada
3)M. Farzaneh, NSERC / Hydro-Quebec / UQAC Industria

Atmospheric icing occurs when supercooled water drops or snow particles come into contact with the surfaces of exposed structures. Ice and/or wet-snow adhesion on outdoor structures and equipment is a serious problem for regions subjected to extreme weather conditions in winter due to ice/snow build-ups. Prevention of ice accretion on surfaces requires reduction of ice adhesion strength. Icephobic coatings reduce ice and wet-snow accumulation on such surfaces. In order to develop icephobic coatings, various groups of materials or surface treatments can be considered. However, low surface energy heterogeneous coatings (HCs) have drawn less attention. These types of coatings are a very attractive alternative because they show lower ice adhesion as compared to homogeneous coatings. In this study, chemically homogeneous and heterogeneous nanoparticles coatings of low surface energy materials on Al surface were studied. Experimental work has indeed demonstrated the presence of the heterogeneity effect on an Al surface by applying different hydrophobic functions (C-H and C-F). For the homogeneous coatings with PE-spin and PTFE-spin on a polished Al surface, the CA values were ~100o and ~98o, respectively. A significant enhancement of CA values (~134o) was observed for the heterogeneous coating of PE-PTFE. The CAH value is smaller for PE-PTFE (~32o) than for homogeneous PE-spin (~46o) and PTFE-spin (~56o) coatings. Ice adhesion reduction factor (ARF) for PE-spin and PE-PTFE samples demonstrated that ice adhesion strength values are ~1.14 and ~1.32 times smaller than those obtained on a polished Al sample, respectively. The surface morphology of the surfaces was analyzed by scanning electron microscopy (SEM) and atomic force microscopy (AFM). The chemical composition of the surfaces was analyzed by X-ray photoelectron spectroscopy (XPS). The SEM and AFM analysis of the coated surfaces demonstrated the presence of a rough structure at micro/nanoscale on the mirror polished Al substrate.

Web site:

Short biography: • 6-months (full-time) as summer probationary working in chemical laboratory of Farabi pharmaceutical company.
• 3-year academic experience as full-time M.Sc. student in Canada (Full-time research study).
• 3-year teaching assistant of chemical fundamental and chemical engineering courses in university of Quebec at Chicoutimi.
• First ranked student in university during all four years of my B.Sc.
• Diploma of mathematics and physics, B.Sc. in applied chemistry and M.Sc in engineering (chemical engineering and nanotechnology).
• MsOffice (Word, Excel, Power Point), Internet, Chem. Office-Ultra software and Origin 6.0.
• Familiar with UV-Vis spectroscopy, Jones reductor, High-performance liquid chromatography (HPLC), Viscometer, Gas Chromatography (GC), Chemical vapor deposition (CVD), IR spectroscopy, Gas Chromatography (GC), Atomic Absorption, Fluor-meter, Polarizing microscope, Flash point, Contact angle goniometer, Atomic force microscopy (AFM), Centrifuge adhesion test machine, X-ray photoelectron spectroscopy (XPS), Scanning electron microscope (SEM/EDX), UV accelerator, TDS (Total Dissolved Solids) meter and Spin and dip-coater and pH-meter.
• English, French, Persian (Farsi).
PhD of Engineering (surface engineering and nanotechnology,"ELABORATION OF COMPOSITE AND CHEMICALLY HETEROGENEOUS ICE-PHOBIC COATINGS)
Personal interest: Dance, music, sport, paint, travelling

BACK

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 05. Sensors, equipment and machinery - standards, 10. Testing facilities, 11. Icing in wind energy

Ice detection methods and measurement of atmospheric icing

Matthew Wadham-Gagnon, Canada

Nigel Swytink-Binnema (TCE, CA),
Cédric Arbez (TCE, CA),
Kossivi Tete (TCE, CA)

The ability to reliably and accurately detect the presence of ice on a structure is of interest for wind energy, aerospace, power transmission and transportation. Some ice detection sensors and methods are designed to detect the presence of meteorological icing (i.e. the duration of active ice accretion), others instrumental icing (i.e. the duration of the presence of ice on the instrument). In some cases, additional information such as severity (ice thickness) or intensity (rate of accretion) can be obtained from the sensor and/or method.

Recent work has shown that certain specialised ice sensors have reliability issues, particularly at severe icing sites [1]. This paper presents a thorough comparison of ice detection sensors and methods in more moderate icing conditions.

A comprehensive case study is ongoing at the TechnoCentre éolien's (TCE) test site based in Rivière-au-Renard, Quebec, Canada, aimed at comparing the capabilities of specialised ice sensors (Goodrich 0872F1 Ice Detector, Combitech IceMonitor and Labkotec LID-3300IP) to other ice detection methods derived from sensors providing data such as cloud base height, relative humidity, solar radiation, wind speed (from heated and unheated anemometers) and temperature. Cameras were also installed to provide validation of the presence of ice on the test site and a comparison benchmark for all the other sensors and methods.

Meanwhile, ice accretion models often require liquid water content (LWC) and mean volume diameter (MVD) of droplets in the atmosphere [2]. These parameters are usually estimated or derived from weather forecast models. This paper also presents measurements of LWC and MVD made by a Microwave Rain Radar (MRR) installed at the TCE test site.

The presence of meteorological icing as well as an estimation of ice accretion based on LWC from the MRR will be discussed and compared to the other ice detection sensors and methods.

References:

[1] Wickman, H., 2014. Evaluation of field tests of different ice measurement methods for wind power, WinterWind 2014 Conference, Sundsvall, Sweden

[2] ISO. Atmospheric Icing of Structures. Standard ISO 12494:2001(E). Geneva, Switzerland, 2001

Web site: http://www.eolien.qc.ca

Short biography: Matthew Wadham-Gagnon has developed his engineering expertise internationally over the last 10 years. He has been managing projects related to wind energy in cold climate at the TechnoCentre éolien (TCE) since 2011. Prior to joining the TCE, he developed skills in structural analysis and design of composite structures as well as composite processing. Matthew has a Master's degree in Mechanical Engineering.

BACK

R&D areas/s: 08. Conductors / Insulators / Flashover, 10. Testing facilities

Influence of Shed Structure on Icing Characteristics of Composite Insulator Based on Natural Icing Testbase

Yang Pan, The State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, Chongqing

PAN Yang, HU Jianlin, JIANG Xingliang, ZHANG Zhijin, HU Qin
State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, Chongqing 400030, China

The shed structure of composite insulator has much influence on icing and icing flashover voltage. To study the influence of the shed structure on icing, an icing test was performed at the natural icing test station on the Xuefeng Mountain in Hunan, using eight 220 kV composite insulators with different shed structures. The ice type is mixed-phase ice, and the icing characteristics are as follows: the icicles grow in the windward direction along the edge and the surface of the sheds; in the mid-to-late icing period, the ice on the two sides of the windward side is much thicker than that in the middle, which may easily bridge the adjacent sheds; the ice on the leeward side is much thinner than that on the windward side, homogeneous distributed. By analyzing the icing characteristics of composite insulators in different shed structure, this paper gets the following conclusions: the composite insulators with larger upward inclination have better resistance to icing; the ice thickness increases significantly when there are edges under the sheds; the ice on the two sides of the windward side is thinner when the diameter of larger shed is smaller, but easier to bridge the sheds; the risk of ice bridging the adjacent sheds can be decreased by increasing the diameter ratio of sheds and the distance between sheds; multiple (more than 3) small to medium sheds may be arrayed between large ones, which can avoid the ice bridging the larger sheds.
Key words ： natural icing test; mixed-phase ice; composite insulator; shed structure; icing characteristics

Web site: http://international.cqu.edu.cn/

Short biography: None provided

BACK

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 06. Icing on masts, towers and buildings

Observations and modeling of sea splash icing

kathleen jones, CRREL, USA

Keran Claffey, CRREL, USA

Stationary offshore structures are subject to icing from sea spray and from run up and splash. Sea spray is created by the bursting of bubbles in whitecaps and, at very high wind speeds, by water sheared from the crest of waves by the wind. The relatively large drops in this spindrift can result in significant ice accretion on any offshore structure in cold temperatures with wind speeds greater than 20 m/s. For offshore structures with significant area at the waterline, waves running up on the side of the structure create large quantities of splash even at lower wind speeds. The relatively warm splash keeps ice from forming on the structure near the ocean surface even in subfreezing temperatures. The water content in the splash decreases with elevation and if the air is cold enough there may be sufficient cooling to freeze some or all of the splash. In this paper we present observations of splash icing on a mast on Mt. Desert Rock in January-February 2014. We also develop a simple model of run up and splash based on wave tank experiments and field observations. We compare the icing profile on the mast with model results using local observations of wind speed, air and water temperature, and significant wave height and period.

Web site:

Short biography: Ms. Jones' is a research physical scientist at the Cold Regions Research and Engineering Laboratory in Hanover, New Hampshire. Her primary focus is loads on structures due to atmospheric icing from sea spray, freezing rain, and supercooled clouds.
Education:
M.S.E. Civil Engineering, University of Washington, Seattle, Washington
M.S. Geophysics, University of Washington
B.S. Earth and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Massachusetts
Personal interests:
Nordic skating, road biking, skate skiing, gardening

BACK

R&D areas/s: 09. Anti- / de-icing, coatings, 10. Testing facilities

Research on icing behavior and ice adhesion testing of icephobic surfaces

Heli Koivuluoto, Tampere University of Technology, FI

Christian Stenroos (Tampere University of Technology, FI), Riku Ruohomaa (Tampere University of Technology, FI), Giovanni Bolelli (University of Modena and Reggio Emilia, IT), Luca Lusvarghi (University of Modena and Reggio Emilia, IT), Petri Vuoristo (Ta

On-going climate change, opening of new logistic routes, energy and mineral resources as well as increasing tourism feed the growing activity in cold climate regions. One of the major challenges for operations in these areas is ice and snow accretion. Icing reduces safety, operational tempo, productivity and reliability of logistics, industry and infrastructure. Surface engineering provides one sustainable approach to icing problems. Currently, several passive anti-ice mechanisms adoptable to coatings are known but further research is required to proceed to practical applications.
For ice testing, an icing wind tunnel was designed and constructed with capability to simulate the ice accretion by in-cloud mechanism (glaze and rime icing) and precipitation icing. The wind tunnel is placed in a climatic room with temperature range from 0 to -40 °C. Icing conditions can be varied as volume median diameter of water droplets from 25 μm to 1 mm, a liquid water content between 0 and 4.2 g/m3 and flow velocity up to 25 m/s. After accretion, the adhesion of the ice is measured with centrifugal ice adhesion test. This test equipment is based on description by Laforte and Beisswenger (Ref. 1). In centrifugal ice adhesion test, the plate with iced area is rotated with a constant acceleration rate until the ice detaches. Detachment is observed by acceleration sensor. The iced test plate is weighted right before and after the test to measure the mass of detached ice. When adhesion area is measured and the speed of rotation at the moment of detachment is known, the maximum adhesive shear strength can be calculated. Finite element simulations confirm that the largest shear and normal stresses concentrate at the ice-plate interface, where adhesive failure will occur. This minimises the risks of cohesive failure events, which would act as confounding factors on the test results.
Icing wind tunnel and centrifugal ice adhesion test equipment enable the evaluation and development of anti-ice and icephobic coatings for e.g., wind turbine applications but also other growing players in arctic environment e.g. oil, extractive and logistic industries. This research is focused on the evaluation of different icing conditions (rime and glaze ice) and their influence on the icing properties of various surfaces.
(Ref. 1) C. Laforte, A. Beisswenger, Icephobic Material Centrifuge Adhesion Test, International Workshop on Atmospheric Icing of Structures (IW AIS) XI, Montreal, June 2005

Web site:

Short biography: Senior Research Fellow at Tampere University of Technology, Department of Materials Science, Laboratory of Surface Engineering. Research topics are icephobic surfaces, icing properties, coating properties and thermal spraying.

BACK

R&D areas/s: 01. R&D programs, overviews, 03. Icing measurements, modelling and forecasting (incl. climate change), 09. Anti- / de-icing, coatings, 11. Icing in wind energy

Lessons learned from "Large scale, cost-effective deployment of wind energy in icing climates"

Göran Ronsten, OX2 & WindREN

Göran Ronsten (WindREN, SE)

De-icing systems from major wind turbine manufacturers are slowly starting to become commercially available, a situation far from that when OX2's wind pilot project was initiated in 2008. The market size of wind turbines in icing climates has been difficult to determine, primarily due to the lack of studies of mapping of icing. During a five-year period, the Swedish Energy Agency has been spending some 30 MEuro on studies of wind farms located in cold climates and the development of wind energy technologies adapted for icing climates. The activities include synoptic icing measurements, mapping of icing, de-icing of wind turbine blades and the evaluation of performance and loads with respect to icing. OX2's wind pilot project has engaged, among others, four meteorological institutes and four different suppliers of de-icing systems during several years from 2008 to 2015. Results and comparisons will be presented by the project manager.

Web site: http://ox2.com/

Short biography: Mr. Goran Ronsten holds a Master in Aeronautical Science from the Royal Institute of Technology (KTH, 1981-1986) in Stockholm and a Master in Business Administration (MBA) from Stockholm School of Economics (SSE, 2006-2207). He's been engaged in wind energy related research with The Aeronautical Research Institute of Sweden (FFA) from 1985 to 2000 and The Swedish Defence Research Agency (FOI) from 2001 to 2006. Ronsten has been the Swedish representative to IEA RD&D Wind's Task 19 - Wind Energy in Cold Climates since 2002 and participated in COST 727 - Atmospheric Icing of Structures 2004-2009. Since 2008 until 2015, Ronsten has been OX2's external project manager for the wind pilot project "Large scale, cost-effective deployment of wind energy in icing climates". Ronsten is the secretary and O&M manager of the Swedish Wind Energy Coop.

BACK

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 11. Icing in wind energy

INNOVATIONS IN F-LOWICE REAL-TIME FORECASTS OF WIND POWER AND ICING EFFECTS

Erik Gregow, Finnish Meteorological Institute, FI

Ben C. Bernstein (Leading Edge Atmospherics, USA)
Erik Gregow (Finnish Meteorological Institute, FI)
Ian Wittmeyer (Leading Edge Atmospherics, USA)

In recent years, numerous systems have been developed for the diagnosis and prediction of wind power and the effects of icing conditions thereon. These include two systems developed in partnership between Leading Edge Atmospherics ("LEA") and the Finnish Meteorological Institute ("FMI") called "LOWICE" and "F-LOWICE". LOWICE and F-LOWICE, respectively, produce diagnoses and forecasts of icing and wind power. As part of the Swedish Energy Agency's Wind Pilot Program, LOWICE, F-LOWICE and forecast systems from several other agencies were run over Sweden for several icing seasons.

Output from these systems have been compared with observations of temperature, wind speed, power and icing at wind farms and the results have proven that these systems provide reasonably realistic information. Of course, the systems are not perfect and errors and biases have been identified. Among the LEA-FMI systems, the LAPS-analysis based diagnostic system LOWICE clearly outperformed the HIRLAM-forecast based F-LOWICE system, especially in terms of temperature and wind speed. Such errors cascade into systematic errors and biases in wind power, icing and the effects of icing on the wind power predictions.

In an effort to improve F-LOWICE forecasts for the final season of the Wind Pilot Program, an improvement to the real-time F-LOWICE system was put in place. The first 6 hours of HIRLAM model output was compared to both a) turbine-observations and b) LOWICE diagnoses of temperature and wind speed at the wind farms of interest. Temperature differences, wind speed differences and ratios were calculated. These were used to calculate corrections to raw HIRLAM fields, which were applied to forecast hours 7-48, covering the remainder of the forecast run. Comparisons between observations and both the original and adjusted output at longer forecast times (12+ hours) have been made. Although statistics have not yet been calculated (they will be before the conference), visual inspection of daily output has shown that predictions of temperature, wind speed, icing and iced power were significantly improved.

Web site: http://fmi.fi

Short biography: Erik Gregow has worked for many years on the development and real-time applications of mesoscale numerical models, including LAPS and MM5/WRF. For the last 5 years, FMI's LAPS model has been used as the backbone of the LAPS-LOWICE diagnostic system, with the specific application of real-time diagnosis/estimation of winds, icing and the effect of icing on wind power at numerous wind farms across Sweden.

BACK

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 11. Icing in wind energy

Development of operational forecasting for icing and wind power at cold climate sites

Øyvind Byrkjedal, Kjeller Vindteknikk

Johan Hansson (Kjeller Vindteknikk)

Based on icing measurements from 12 meteorological stations in Sweden a methodology for calculating icing from meso scale model data has been developed over the past 5 years. Operational data from seven wind farms in cold climate regions in Sweden (total of 272 MW and 111 individual turbines) have in addition been utilized to devlop a state-of-the-art model for estimating production losses due to icing (IceLoss). It is shown that the method is able to realistically describe the buildup of ice at the wind farm sites both regarding the timing of icing situations and melting and sublimation of the ice.
Operational forecasting of energy production, icing and production losses due to icing has been carried out for the seven wind farms which all experiences losses due to icing. Two of the wind farms are equipped with heated blades. For some of these wind farms the forecasts has been in operation since 2012. The forecast simulations are run 4 times daily, each with a lead time of 48 hours.
Icing has been identified from the turbines using an algorithm described by Davis et al (2015). The periods where icing has been identified from the operational data has been compared with the forecasted icing periods. Verification of the model shows that 70-80% of the cases identified as icing from the turbines are predicted with a low false alarm rate of 3-5%. For 60% of the observed icing cases the model predicted the timing of the meteorological icing within +/- one hour from when it was detected to influence the turbines energy production.
The power forecasts with and without losses due to icing is compared to the hourly production data from the wind farm. It is evident that the accuracy of the forecasts is improved when the power losses caused by icing are taken into account resulting in a reduction of the mean absolute error (MAE) of the hourly values from the forecast by up to 40 % when the power losses due to icing are included. The correlation coefficient between forecasted and actual power is increased by approximately 0.15. The results show that the number of cases when the power is over predicted is reduced when including power losses due to icing, while the cases of under predicting the power losses is somewhat increased.
The work has been supported by the project "Large scale, cost effective wind energy development in icing environments" which is financed through the Swedish Energy Agency
References:
Neil N. Davis, Øyvind Byrkjedal, Andrea N. Hahmann, Niels-Erik Clausen, Mark Zagar (2015): Ice detection on wind turbines using the observed power curve, submitted to wind energy

Web site: http://www.vindteknikk.com

Short biography: Byrkjedal has been working in Kjeller Vindteknikk for the past 8 years, and holds the position of R&D manager. Byrkjedal has a background as a meteorologist and holds a phd in meteorology from the University of Bergen, Norway.
He has been working in the field of meteorological icing during the past 8 years, and has lead the development of the Norwegian wind- and icing atlases and has also created wind and icing atlases for Sweden and Finland. Byrkjedal has also developed a methodology to estimate power losses due to icing based on operational power data from several Swedish wind farms.

BACK

R&D areas/s:

Vestas de-icing system

N. N., Vestas

Web site:

Short biography:

BACK

R&D areas/s: 01. R&D programs, overviews, 05. Sensors, equipment and machinery - standards, 06. Icing on masts, towers and buildings, 12. Other topics related to icing

To be completed

Björn Östberg, In Situ Instrument AB

To be completed

Web site:

Short biography: To be completed

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 04. Icing climates - standards, 07. Icing on power lines

Wind, Ice and Snow Load Impacts on Infrastructure and the Natural Environment (WISLINE)

Harold Mc Innes, The Norwegian Meteorological Institute

Bjørn Egil Nygaard (Kjeller Vindteknikk, Norway)
Jón Egill Kristjánsson (University of Oslo, Norway)
Roy Rasmussen (National Center for Atmospheric Research, USA)
Ole Einar Tveito (The Norwegian Meteorological Institute, Norway)
Jan Erik Haugen (The Norwe

Atmospheric icing is a major weather hazard in many mid- to high-latitude locations in the winter, including Norway. There are mainly three types of atmospheric icing; in-cloud icing due to (supercooled) liquid cloud droplets at sub-freezing temperatures; icing due to supercooled rain droplets, and icing caused by wet snow or sleet at temperatures just above freezing point. In-cloud icing and icing caused by wet snow have together with strong wind caused damage to overhead powerlines in Norway at several occasions, leaving people without electricity and the power companies with large expenses.
In order to investigate future ice and snow loads, an extensive knowledge about such loads in the present climate is required. We will provide this by improving the description of the cloud microphysical processes that occur in particular in cold clouds, as this is essential for ice modelling. Our choice of model is the operational limited area atmospheric forecast model system used at MET Norway, the non-hydrostatic AROME model at 2,5 km resolution, which is run in forecast mode four times per day using ECMWF forecasts as initial and boundary conditions. The AROME model with improved cloud micro physics will be combined with routines for ice accretion in order to produce an icing climatology for present climate. The data will be verified against measurements of ice loads on power lines as well as measurements of cloud water. The next step is then to apply AROME to downscale data from climate models in order to produce a future icing climatology.
As damage often is caused by icing accompanied with heavy wind, wind loads in present as well as future climate will be investigated in the project. Techniques for downscaling wind data from AROME in complex terrain will be studied in order to provide a dataset for wind in both present and future climate. Wind may also cause damage to forests such as up-rooting and stem breakage, and we will hence combine wind, icing and snow damage data for forests with the dataset for wind in order to produce a risk model for forest damage for both present and future climate.
The WISLINE project will provide tools for calculating climate loads as well as datasets for present and future climate. Data will be made available for the public in order to support the design of infrastructure in a changing climate as well as protection of environment.

Web site:

Short biography: My academic background is meteorology with a PhD in arctic mesoscale weather systems from 2011 and M.Sc in Greenland lee cyclones from 1997. Since 2011 I have been working with data quality control and wind and ice loads on infrastructure at the Norwegian Meteorological Institute. I am currently leader of WISLINE which involves several institutions that are involved in work on climate loads. Before I started my PhD work in 2008, I worked with models and observational studies of urban and industrial air pollution at The Norwegian Institute for Air Research .

R&D areas/s: 05. Sensors, equipment and machinery - standards

Controller for Surface heating

Rolf Westerlund, HoloOptics

Rolf Westerlund (HoloOptics, SE)

Ice on surfaces used by man or vehicles are a big public health hazard. Accidents are fervent every year. To counter this, a large number of surface heating systems are installed all over the northern hemisphere. The size may varies between some 10 m2 up to several 1 000 m2. This description refers to Sweden, but relate to many other countries with similar conditions.
I Sweden there are some 70 000 surface heating systems, most of them small. Smaller systems normally use direct electric heating and the larger uses district heating. Installed capacity is between 100 and 300 W/m2. The energy consumption is dependent on many factors, including the meteorological conditions and the performance of the control system.
Often the heater is on at times without any needs due to poor control systems. By using a smart control system large energy saving are possible.

Web site:

Short biography: Rolf Westerlund is SEO for HoloOptics International AB. The company is producing equipment used to measure icing on structures. The company is also involved in several energy savings projects.

R&D areas/s: 07. Icing on power lines

Influence Analysis of Transmission Lines Insulator on the Conductor Ice-shedding

Xin-bo Huang, College of Electronics and Information, Xi'an Polytechnic University, Xi'an 710048, P.R.China

Guan-hua XU(College of mechanical and Electrical Engineering, Xi'an Polytechnic University, Xi'an 710048, P.R.China), Yong-can ZHU(School of Electro-Mechanical Engineering, Xidian University, Xi'an 710071, P.R.China), Ming-jin LIAO(College of Electronics

Conductor strenuous exercise will be caused by the ice-shedding. It is easy to cause the occurrence of electrical or mechanical accident of transmission line. Therefore, Conductor-insulator finite element model has been established through the ANSYS, and it is the analysis of the dynamic characteristics for the wire type, material properties and the length of the insulator string under different ice shedding. The influence of insulator has been separately analyzed from the jump height, unbalanced tension etc. for the conductor ice-shedding. The results showed that: It I type insulator on ice-shedding unbalanced tension impact is about 0.9 times smaller than the V type insulator. It is not significant for ice-shedding unbalanced tension effects about the composite and ceramics materials. The ice-shedding jump height will be unchanged for the V type or I type insulator with the length increase of insulator string, but ice-shedding unbalanced tension will be decreased. The related results provide a reference for the subsequent study on conductor ice-shedding and lines structure design.
Keyword: icing; ice-shedding; FEM; insulator; ice-shedding jump height; unbalanced tension

Web site: http://en.xpu.edu.cn/

Short biography: Xin-bo Huang was born in Shandong Province, China, in May 1975. He received the B.S. and M.S degrees in automation from Qingdao Technological University, Qingdao, China, in 1998 and 2001, respectively. He received the Ph.D. degrees in automation from XiDian University, Xi'an, China, in 2005. Since July 2005, he has been a teacher at Xi'an Polytechnic University, and since December 2008, he has been a full Professor with the School of Electronics Information at Xi'an Polytechnic University. From October 2005 to March 2008, he was a post-doctor in the State Key Laboratory of Electrical Insulation and Power Equipment and the School of Electrical Engineering at Xi'an Jiaotong University, engaged in the snow and ice warning system on transmission lines. Since May 2009, he was a post-doctor at South China University of Technology, engaged in the transmission conductor galloping monitoring and mechanism. His current research interests include the online monitoring technology and condition maintenance of power equipment, the wireless network sensor. He has published more than 50 journal articles and conference papers, and 4 monographs. He may be reached at hxb1998@163.com.
Dr. Huang received the 2011 new century excellent talent support plan of China Ministry of Education (MOE), 2010 teacher of the year award in China's "textile light" for teachers, 2009 Hong Kong SangMa research grants award, and several other awards and prizes from Chinese Government.
Guan-hua XU is currently working toward the M.S. degree with the College of mechanical and Electrical Engineering, Xi'an Polytechnic University, Xi'an, P.R.China. His research interests include the establishment of finite element analysis and 3D model. He may be reached at xuguanhua0123@163.com.

R&D areas/s: 09. Anti- / de-icing, coatings, 11. Icing in wind energy

Siemens Wind Power De-icing system

Diego Levati, Siemens Wind Power A/S, DK

Operation of wind turbines in cold climates requires a well-functioning de-icing technology that is both technically and commercially fit.
Since the 1990's, Siemens Wind Power has been a leading innovator in de-icing technology. Starting with prototype installations in 1996 during the Bonus era, to operating more than 300 turbines in harsh icing conditions around the globe. Thereby, proving the de-icing system to be a vital part of large scale, cost efficient deployment of wind energy in icing conditions.
Market potential for de-icing systems is high, as a well-functioning de-icing system is a must in Scandinavia and North America, and is requested for many other projects where there are safety regulations such as Belgium, Austria, and Germany.
For continuous de-icing innovation and increased customer benefit, future research into ice characteristics and behavior is necessary to standardized methods of describing icing conditions, increase de-icing efficiency, and warrant the additional performance

Web site: http://www.energy.siemens.com/hq/en/renewable-energy/wind-power/

Short biography: Diego Levati - Strategic Product Development&Performance Manager at Siemens Wind Power.
More than 5 year experience in the industry working with technology development and lifecycle management. Main focus on transformation of market requirements with increased focus on customer value into roadmap planning.
Responsible for product development related to increase the performance of Onshore and Offshore wind turbines.
Area of responsibility covering: environmental, loads, noises and grid
Master degree in mechanical engineering from Politecnico Milano IT
MBAs from SDA Bocconi, Milano IT and Harvard University, Cambridge MA USA

BACK

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 04. Icing climates - standards, 07. Icing on power lines

A severe In-cloud Icing Episode Mid-winter 2013-2014 in Northern and Northeastern Iceland

Árni Jón Elíasson, Landsnet, IS

Einar Sveinbjörnsson (Veðurvaktin, IS)

A severe in-cloud icing episode from mid-winter 2013-2014 that lasted more than a month is analyzed. A weather pattern characterized by frequent and repeated low pressure tracks aligning from west to east south of Iceland towards the British Isles. As the systems passed slowly or became quasi stationary large amounts of precipitation, humidity and relatively mild air circulated towards the eastern part of Iceland as the wind direction was almost uniform between E and NE. As a result in-cloud icing accumulated in large quantities.

In the affected area, of elevation interval from 350 to 700m in N- and NE-part of Iceland, the TSO of Iceland operates many test spans for icing accumulation. Some of the test spans in the area collapsed as well as other structures such as telecommunication towers and transmission lines. The data from the test spans in this time interval are analyzed.

Former observations in the test spans and experience of operating overhead transmission lines in the area were also reviewed. Measurements from 1974 were explored in order to look for similar events. Data from ECMWF reanalysis were analyzed for the period from 1961 to 2013. So-called Hovmöller analysis method of the large scale pattern of the 500 hPa pressure level near Iceland is imposed for estimating the anomaly of the winter of 2013-14 compared to more than 50 seasons from 1961.

Web site:

Short biography: Árni Jón Elíasson is a geographer. He has participated all IWAIS workshops since 1988 and presented many papers with colleagues. Responsible for running ice test spans for power companies in Iceland since 1977.

BACK

R&D areas/s: 11. Icing in wind energy

Experiences from studies of icing and production losses due to icing in OX2's Vindpilot project

Stefan Söderberg, WeatherTech Scandinavia, SE

Magnus Baltscheffsky (WeatherTech Scandinavia, SE)

Atmospheric icing can have a profound effect on wind power production. In certain conditions ice can accrete on the blades of a wind turbine and change its aerodynamic properties resulting in lower output power and possibly increased loads. In order to mitigate the risks of icing having a large financial impact on wind farm developments it is necessary to understand the atmospheric conditions that result in ice accretion on the blades and to asses the climatological aspects of these conditions.
WeatherTech Scandinavia has taken part in Ox2's Vindpilot project with the goal to increase understanding of atmospheric icing on wind turbines and to develop models and tools to assess and forecast icing conditions. In this work a tool chain has been developed including an icing model and a production loss model which we will be presented and discussed in some detail.
Through the course of Ox2's Vindpilot project it has become clear that measuring icing with good accuracy is challenging. However, careful analysis of SCADA data has proven to be a good measurement of production losses due to icing. Studying SCADA data can also provide new insights of how production losses due to icing vary within a wind farm. This will be demonstrated by visualising and filtering SCADA data together with weather data in a topographic context for wind farms in cold climate.

Web site:

Short biography: Dr. Söderberg has extensive experience in boundary layer meteorology and numerical modelling in complex terrain. He has been working with atmospheric numerical models since 1999 and holds an MSc in meteorology from Uppsala University and a PhD in dynamic meteorology from Stockholm University. After working for 7 years as a scientist at the Department of Meteorology, Stockholm University, his interest in renewable energy and wind power in particular, brought him back to Uppsala in 2006 where he founded WeatherTech Scandinavia. Dr. Söderberg is currently a senior consultant and researcher at WeatherTech Scandinavia specialized in wind resource and icing climate studies.

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 07. Icing on power lines

Wet snow icing - Comparing simulated icing with observational experience

Árni Jón Elíasson, Landsnet, IS

Sigurjón Páll Ísaksson (EFLA, IS), Hálfdán Ágústsson (Reiknistofa í vedurfræði, IS), Guðmundur M. Hannesson (EFLA, IS), Egill Thorsteins (EFLA, IS)

Icing accumulation models and numerical atmospheric models are powerful tools which can aid in assessing ice loading for overhead powerlines. This paper presents an analysis of how well an icing model captures wet-snow accumulation in several wet-snow icing areas in Iceland, based on a comparison of simulated icing maps with data from a detailed database containing historical icing events on overhead powerlines.

The wet-snow icing maps were prepared using a cylindrical accretion model and simulated atmospheric data as input. The necessary weather parameters, i.e. wind speed, temperature, precipitation rate and snowflake liquid water fraction, were derived by simulating the state of the atmosphere with the ARW/WRF model at horizontal resolution of 3 km for the period 1994-2011. Five different icing maps were prepared; one map containing accumulation without considering icing direction, i.e. vertical cylinder, and four maps taking different accretion directions into account, i.e. at 45° intervals using the horizontal cylinder approach.

The Icelandic icing database is unique as it contains a systematic registration of all known icing events on overhead lines in Iceland since 1977 and most events since 1950. Many different icing events are registered each year as well as total of 3700 records of icing on line sections in these events. Most of the records are for wet-snow icing and contain an estimate of icing diameter.

The main focus of the analysis is on how well observed icing in areas prone to icing, as well as in complex terrain, is reproduced by the spatial distribution and the magnitude of the predicted wet-snow accumulation. Experience has shown that in areas with severe wet-snow icing, accumulation on overhead lines is strongly sensitive to their direction with respect to the main icing direction. This emphasises that the directional influence of accumulation must be taken into account, as is done here.

Web site:

Short biography: Árni Jón Elíasson is a geographer. He has participated all IWAIS workshops since 1988 and presented many papers with colleagues. Responsible for running ice test spans for power companies in Iceland since 1977.

BACK

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 11. Icing in wind energy

Modelling icing conditions for a selection of Swedish wind farms during winter 2014/2015

Heiner Körnich, SMHI, SE

Esbjörn Olsson, Heiner Körnich, Per Undén (all SMHI, SE)

A meso-scale atmospheric model has been used to calculate icing conditions and corresponding power production losses for some Swedish wind farms for a couple of winter seasons. The model used, is called Harmonie/Arome, which has the ability to simulate weather processes with a very high horizontal resolution. Output from this model is used in a second stage to calculate ice loads using a slightly modified version of the Makkonen ice accretion model. Icing rate and ice load together with wind speed is then fed into a third stage to get an estimate of the power production losses. For a comparison, observed production losses are calculated using derived power curves, observed wind speed and actual power production at each wind turbine. Also the observed wind speed and temperature are compared to the modelled values. The model describes often the timing of the icing events rather well, but there is a rather big uncertainty in the predicted ice loads. This also means that the predicted power production losses can differ rather much from the observed during intense icing episodes. The icing season will be summarized and compared to earlier seasons. The method used to calculate power production losses with the model data can also be used to produce real time areal forecasts. This approach has been tested during this winter and some sample maps will be shown.

Web site: http://www.smhi.se/forskning/forskningsomraden/analys-prognos

Short biography: Heiner Körnich holds a PhD in atmospheric sciences from the University of Rostock, Germany, and he is the head of the meteorological research group at SMHI since May 2012. He has wide experience in numerical weather prediction, data assimilation, and climate modelling.

BACK

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 07. Icing on power lines

Comparison of measured and simulated icing in 29 test spans during the extreme icing winter of 2013-1014 in Iceland

Árni Jón Elíasson, Landsnet, IS

Hálfdán Ágústsson (Reiknistofa í vedurfræði, IS), Guðmundur M. Hannesson (EFLA, IS), Egill Thorsteins (EFLA, IS)

This paper presents an analysis of simulated in-cloud icing and a comparison of the results with detailed field measurements from 29 test spans at 19 test sites in Iceland for a period of 99 days during the winter of 2013-2014.
The state of the atmosphere is simulated with the ARW/WRF-model at a horizontal resolution of 9, 3 and 1 km. The icing simulations are applied as post-processing, employing the simulated atmospheric data as input and an icing model for both a vertical and a horizontal cylinder, i.e. taking wind direction into account. The simulations are compared with detailed observations of the ice load and temperature, made at 29 test spans. The ice accretion was extensive and more or less continuous from December to March in North- and East-Iceland, with two intense accretion periods from mid-December to mid-January, and again in February to early March. The maximum ice load measured in a test span was 47 kg/m, the greatest total accumulation in a span during the period was
186 kg/m/winter and the total accumulation at the 29 test spans was 1300 kg/m/winter.
Model results are presented as icing maps and time-series of icing at locations of test spans, as well as summaries of total accretion loads and intensities at the spans. Results are highly sensitive to the performance of the atmospheric model, while the timing of individual icing periods is nevertheless on average correctly captured. Small and medium size accretion events are generally better captured than more extreme events which are often underestimated. In addition to investigating the performance at individual test spans, results from all spans have been aggregated in a novel method which removes the complicating effect of differential ice-shedding and allows for an overall comparison of the observed and simulated ice accumulation. The icing model is forced to shed ice in unison with the observations, and total simulated accretion is compiled for each span during periods when accretion is actually observed. This comparison reveals that on average simulated accretion is somewhat weaker, in particular during extreme accretion periods.

Web site:

Short biography: Árni Jón Elíasson is a geographer. He has participated all IWAIS workshops since 1988 and presented many papers with colleagues. Responsible for running ice test spans for power companies in Iceland since 1977.

BACK

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 11. Icing in wind energy

Probabilistic forecasting of icing and production losses

Jennie Persson Söderman, Uppsala University, SE

Heiner Körnich (SMHI, SE), Esbjörn Olsson (SMHI, SE), Hans Bergström (UU, SE), Anna Sjöblom (UU, SE)

Next-day forecasts of icing on wind turbines are needed for the estimation of wind power production and safe operations. Forecasts are uncertain owing to uncertainties in the meteorological initial conditions and model formulations, in the employed ice growth models, and in the production loss models. Therefore, in order to forecast the risk for icing conditions it is necessary to develop a probabilistic forecasting system.

In this study we examine the contribution of the meteorological uncertainties to the icing and production loss forecasts using the mesoscale ensemble prediction system HarmonEPS. It is based on the numerical weather prediction model Harmonie/AROME. The ensemble prediction system consists of 11 members and has been run for up to +42 hours for a two week period in the winter 2011/2012 with a horizontal resolution of 2.5 km over a Swedish domain of 1100x1600 km2. Meteorological parameters forecasted by each ensemble member are used as input to the icing model, generating an ensemble of the icing intensity and ice load. The production losses due to the icing are estimated from the icing intensity and ice load with an empirical model.

For the verification we use meteorological observations from twelve stations where five stations provide also production data of the wind turbines. We examine the skill and spread of the ensemble prediction system concerning meteorological parameters at the height of wind turbine nacelles. It is found that the ensemble mean provides generally more skilful forecasts than a single forecast member. The reliability of the ensemble spread as a measure of the meteorological forecast uncertainty is assessed. The study demonstrates the benefit of using an ensemble forecasting system for predicting icing and production losses of wind turbines.

This study is supported by the Swedish Energy Agency (Energimyndigheten) under the project number 37279-1.

Web site:

Short biography: I have a M.Sc. in meteorology from Uppsala University. Last summer I started my PhD position about forecasting of icing on wind turbines and the following production losses, with the main focus on the applicability of probabilistic forecasts.

BACK

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 07. Icing on power lines

Automated Icing Monitoring System on the teritorry of the Czech and Slovak Republic

Jaroslav Šabata, EGÚ Brno, a.s.

Petr Lehký (EGÚ Brno, a.s.), Lubomír Zeman (EGÚ Brno, a.s.)

Ice load on overhead lines is a major concern of the distribution utilities as it is influences their operational reliability significantly. The real-time information about actual ice load and also the knowledge of its recent development can be, in some situations, crucial for the dispatchers and their fast reaction.

Building of automated icing monitoring system started in the Czech Republic in 1999, when first monitoring stations were put in operation on overhead lines. In recent years (2011-2012) new generation of monitoring stations were deployed on south part of Czech Republic and west part of the Slovak Republic. Within next two years more than twenty monitoring stations will be installed in other parts of the Czech Republic.

The paper will describe performance of these ice monitors, their present deployment and also intended future development of the whole monitoring system.

Web site: http://www.egubrno.cz/

Short biography: Fields of research: measurement of ice loads on OH lines, Dynamic Line Rating. Personal interest: MTB, climbing, skiing and some other "ings"

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 11. Icing in wind energy

Case study of ice sensor using Computational Fluid Dynamics, measurements and pictures

Marie Cecilie Pedersen, Vattenfall Vindkraft A/S, Denmark

Marie Cecilie Pedersen, Industrial PhD (Vattenfall Vindkraft A/S, Kolding, Denmark and Department of Energy Technology, Aalborg University, Aalborg, Denmark)
Henrik Sørensen, Associate Professor (Department of Energy Technology, Aalborg University, Aalb

During the past years, operating wind turbines in cold climate has shown to be a challenging affair. Some reasons are ice accretion on the wind turbines leading to changes in lift and a reduction in the performance of the wind turbine. Icing on the blade also challenges the structure leading to blade fatigue in some cases. Another challenge is ice shedding during operation and during start-up of the turbines after an ice event. This study focuses on the production losses and how to improve the current in-house methodology for production loss assessment. The hypothesis of this study is to improve the current ice model by a model based on Computational Fluid Dynamics (CFD). The need for such CFD-based ice model designed for wind turbines has also been mentioned in the most recent work within the field [1]. The well know ice model by Makkonen [2], which is used in the in-house model will be replaced by Messinger's model [3] originally developed for the aircraft industry, solved by using the Finite Volume Method on the boundary of the geometry. By using CFD, the ability to study icing in micro-scale is enabled and by adding the accumulated ice to the existing geometry the changes in lift and drag can be investigated. By using a multiphase model the CFD model is able to represent the actual conditions, which the wind turbine is facing at the site. On this basis the ice build-up can be simulated by adding the ice model to the CFD platform and from the calculated mass flux of ice, displace the grid to obtain the new "iced geometry". Grid displacement and the design and type of mesh has shown to be a central part of the development of the model.
A well know challenge when modelling icing on wind turbines is to get a measure of the actual amount of ice on the wind turbine blade. Camera pictures have been used for this purpose and provides an acceptable qualitative measure of the ice load. To ensure a reliable framework for the model validation this work presents a case study of an ice sensor located close to the reference wind farm. The ice sensor is installed on a met mast, from where pictures and measurements of the ice load is available. Thus, this case study of the ice sensor forms the basis of a more general CFD based icing model for a wind turbine blade, by the establishment of a reliable, well documented and validated model frame work.
Keywords: wind energy, Computational Fluid Dynamics, ice accretion, multiphase flow
References:
[1] Davis, Neil N. Icing Impacts on Wind Energy Production, Technical report, Technical University of Denmark (DTU), The Department of Wind Energy, January 6, 2015, PhD Thesis.
[2] Makkonen, L. Models for the growth of rime, glaze, icicles and wet snow on structures Philosophical Transactions: Mathematical, Physical and Engineering Science Vol. 358, No. 1776, Ice and Snow Accretion on Structures, p. 2913-2939, November 2000.
[3] Messinger BL. Equilibrium temperature of an unheated icing surface as a function of air speed, Lockheed Aircraft Corporation, I.A.S., Los Angeles, USA, 1953.

Web site:

Short biography: Marie Cecilie Pedersen is an Industrial PhD student at Vattenfall Vindkraft A/S, Kolding, Denmark and Aalborg University, Aalborg, Denmark. She has been working with the topic of icing and wind turbines for two and a half years for Vattenfall and in January 2014 she started the industrial PhD with Vattenfall Vindkraft A/S and Aalborg University, The department of Energy Technology, which is a three year project.
The main focus of Marie's work is modelling of icing on structures by using Computational Fluid Dynamics. She will use this knowledge to extract knowledge about the impact of ice on the power production from wind turbines in cold climate.
Marie holds a Master of Science Energy technology from Aalborg University in Denmark.

BACK

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 07. Icing on power lines, 10. Testing facilities

Monitoring and forecasting ice loads on a 420 kV transmission line in extreme climatic conditions

Bjørn Egil Nygaard, Kjeller Vindteknikk, NOR

Lars Andre Moen (Statnett SF, NOR)
Finn Nyhammer (Kjeller Vindteknikk, NOR)
Rolv Bredesen (Kjeller Vindteknikk, NOR)
Øyvind Byrkjedal (Kjeller Vindteknikk, NOR)
Øyvind Welgaard (Statnett SF, NOR)

Operating electrical transmission lines in the mountainous regions of Norway is challenging in winter time. In particular, the loads caused by ice accretion on phase conductors, ground wires and insulator strings may cause severe problems in terms of mechanical damages, electrical flashovers as well as environmental safety risks due to line sag and falling ice.
During the winter seasons 2013/2014 and 2014/2015 Statnett SF, the transmission system operator in Norway, experienced cases of severe atmospheric icing causing the collapse of transmission towers and the failure of other components. One of the affected lines was an entirely new 420 kV transmission line crossing an exposed mountain area just north of the Hardanger Fjord in Norway. The measured ice load was more than double the design load, indicating that the ice loads had been significantly underestimated in the pre-construction phase. The design load had been estimated by applying the best available meteorological expertize. Today, an advanced local-scale meteorological model has been implemented as a tool to improve load estimation of the ice loads. The present paper is on a measurement test set-up intended to validate this tool in a region with extreme ice loading.
Load tension recorders with real time wireless data transmission were installed in the insulator strings in a transmission line tower, and in a test span erected parallel to the line. Heated web cameras and wind sensors were installed, and all data was made available through an online database. Calibrated WRF-based icing forecasts were prepared four times per day, including predictions of accumulated ice mass on a reference object, simplex phase conductors, and duplex phase conductors (bundles).
In this paper/presentation we provide an overview of the equipment and instruments used for measuring and monitoring the icing conditions at this particular site. We present measurement results and experiences gained through the 2014/2015 winter season, which turned out to be one of the most severe icing seasons of the last 4 decades. One of the main questions we attempt to answer through these measurements is how extreme ice loads are distributed on simplex phase conductors compared to duplex phase conductors. Finally we present plans and ideas for improved and extended measurements for the coming winter seasons. We invite the audience of the workshop to discuss these ideas and share similar experiences.

Web site: http://www.vindteknikk.no

Short biography: Bjørn Egil K. Nygaard holds a phD in meteorology from the university of Oslo from 2013. Since 2005 he has specialized in atmospheric icing modeling using mesoscale numerical weather prediction models, with particular focus on ice loads on electrical power lines. Since August 2013 Nygaard has been employed at Kjeller Vindteknikk AS, where he is currently leading the company's activities on meteorological analyses for operation and construction of electrical power grids. Nygaard has been actively involved in several research projects within this field, and he has attended all IWAIS workshops since Yokohama 2007.

BACK

R&D areas/s: 09. Anti- / de-icing, coatings

Supercooled Water Wettability and Freezing on Hydrophobic Surfaces: The Role of Temperature and Topography

Golrokh Heydari, KTH, Sweden

Golrokh Heydari (KTH, Sweden) : presenter
Eric Tyrode (KTH, Sweden)
Maziar Sedighi Moghaddam (KTH and SP, Sweden)
Mikael Järn (SP, Sweden)
Mikko Tuominen (SP, Sweden)
Per M. Claesson (KTH and SP, Sweden)

Implication of hydrophobic, in particular superhydrophobic, surfaces as ice-phobic surfaces has received significant interest in the last decade. However, few works have explored the influence of temperature on the interaction of water with these surfaces that could be critical for the performance as anti-icing or de-icing materials. Moreover, there is a remaining debate on how surface chemistry and topography would affect the wetting by supercooled water and subsequent heterogeneous ice nucleation. In this work, we focus on this issue by investigating the temperature-dependent contact angle of micro-liter sized water droplets and also temperature and delay of ice nucleation from the supercooled water droplets placing over hydrophobic surfaces with similar chemistry but variation in topography. Furthermore, we address the gap utilizing multi-scale rough hydrophobized wood surfaces with different chemistries. Our data demonstrate that due to condensation and frost formation a transition in wetting state of superhydrophobic surfaces could occur at low temperatures whereas this is not the case for smooth hydrophobic surfaces. Moreover, we showed that kinetics of heterogeneous ice nucleation is not significantly affected by surface topography but it could be the most delayed on flat hydrophobic surfaces. Utilizing the wood samples we illustrate a positive effect of multi-scale roughness on reducing the penetration of supercooled water into surface depressions, and also enhancing the freezing delay at low degrees of supercooling.

Web site:

Short biography: I got my master in Polymer Engineering-Coating Technology from Tehran Polytechnic in 2006. After graduation I worked for 4 years in R&D department of a pioneer manufacturer of marine & industrial coatings. In 2010, I started my Ph.D. in KTH, Division of Surface and Corrosion Science. My project is founded by TopNANO. SP of Sweden was leading the project together with industrial and research partners. In this PhD project we focus on fundamental aspects of interaction of water with surfaces at sub-zero temperatures and the surface parameters affecting the strength of ice adhesion.

BACK

R&D areas/s: 07. Icing on power lines

Neural network approach to characterize atmospheric ice compressive strength

Hicham Farid, CIGELE/UQAC, Canada

H. Farid (1), M. Farzaneh (1), A. Saeidi (1), F. Erchiqui (2)
(1) NSERC/Hydro-Quebec Industrial Reaearch Chair on Atmospheric Icing of Power Network Equipment (CIGELE), and Canada Research Chair on Engineering of Power Network Atmospheric Icing (INGIVRE)

Atmospheric icing of structures is a phenomenon that hampers human activities in northern regions. Coupled with weather conditions such as wind and temperature fluctuations, accumulated ice on power transmission conductors and ground wires can fall off or shed, leading sometimes to serious damage. Characterizing the compressive strength of atmospheric ice is very important to understand the ice shedding phenomenon from conductors and wires. For this purpose, an experimental study was undertaken to study the behavior of atmospheric ice under compression, and under various environmental and structural parameters.
Ice was accumulated in the closed loop wind tunnel of CIGELE at University of Québec in Chicoutimi in order to simulate the natural processes of atmospheric icing, under different temperatures (-20oC, -15oC and -5oC). Wind speed inside the tunnel was set at 20 m/s, mean volume droplet diameter at 40 µm, and a water liquid content at 2.5 g/m3. Each type of ice was tested at the same temperature at which it had been accumulated. A tomographic analysis was carried out on a small specimen (cylinder of 1-cm diameter × 2-cm length) at each temperature level, in order to quantify the porosity, and to determine the grain size and their distribution.
A neural networks approach was used to model the compressive strength of atmospheric ice as a function of strain rate and temperature. Four strain rates (10-4s-1, 10-3s-1, 10-2s-1 and 10-1s-1,) and three temperatures (-20°C, -15°C and -5°C) were considered. The obtained results show the capability of this model to reproduce the compressive behavior of atmospheric ice under different conditions.

Web site: http://www.cigele.ca/

Short biography: PhD Student in civil engineering,
Working in research and development in many laboratories and with many nationalites, in my research experience, i had the ability to switch between different fields such as polymers, metalic alloys, biocmaterials, and ice. i like to link different fields together to bring new methods and solutions for engineering problems.

BACK

R&D areas/s: 11. Icing in wind energy

Effect of Surface Roughness of Wind Turbine Blade on its Ice Accretion

Jian Liang, The State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, Chongqing

LIANG Jian, SHU Lichun, HU Qin, HU Jianlin, JIANG Xingliang
The State Key Laboratory of Power Transmission Equipment & System Security and New Technology,
Chongqing University, Chongqing 400030, China

The wind turbine blades' icing often occurs under cold climates when the blades suffer from super-cooling droplets. Ice on blades changes the airfoil profile, reducing the efficiency of wind turbine. In this paper, the icing characteristic of the miniature horizontal-axis rotating wind turbine blade under different surface roughness is experimentally studied by establishing the platform of ice wind tunnel in artificial climate chamber. A simulation is performed to reflect the flow field characteristics of the blade profile under different surface roughness and different icing conditions. By measuring the ice mass, ice thickness and ice type of the blades under different surface roughness, it is found that Rough surface significantly increases the ice mass of blades; Ice mass of blades hardly changes under different roughness of rough surface, but the more rough surface leads to a more non-uniform distribution of ice on blades; Surface roughness cannot change the ice type of blades. Simulation results also show that surface roughness can change the flow field of the blade profile. Based on the results, a method of improving the local surface roughness is proposed to keep the blade profile.
Key words: wind turbine blade, surface roughness, flow field, ice mass, ice type, CFD.

Web site: http://international.cqu.edu.cn/

Short biography: None provided

BACK

R&D areas/s: 07. Icing on power lines

Multichannel radar monitoring of ice on power lines

Renat Minullin, Kazan State Power Engineering University

Minullin R.G.(RU), Goryushin Yu.A.(RU), Chereshnyuk S.V.(RU), Kasimov V.A.(RU), Yarullin M.R.(RU)

One of the methods for early detection of ice on power lines is the location method, which has been developed in the Kazan State Power Engineering Uni-versity (KGEU) for more than 15 years, since 1998 [1] The proposed method of radar detection of ice is unique and has no analogues in the world. During this period, theoretical and experimental work has been done, methods and ap-paratus of sensing power lines have been developed, and methods of interpre-tation of the results of sensing ice deposits detection have been established.

"Location method" makes it possible to determine the occurrence of icing on a transmission line by comparing the propagation time of the reflected sig-nals and their amplitudes in the presence and in the absence of icing for-mations.

Hardware-software of the ice monitoring complex consists of the follow-ing components:

- radar sensing device;
- commutation device;
- a computer with a wireless modem and operator interface;
- Central server.

Commutation device is designed for connection of wires of one of 16-air lines substation to the output/input of the radar sensing.

The computer controls the operation of device transmits data to the cen-tral server, and forms the operator interface.

The central server performs the functions of the archiver.

Currently, employees of KSPEU designed and manufactured a small se-ries of radar systems for sensing power lines, which have been used successful-ly to control icing on existing power lines.

In 2012, employees KSPEU together with employees of JSC "NPO" Electronics named after V.I. Shimko " by the order from OAO" UES FGC " designed, manufactured and tested a prototype of an autonomous and auto-matic system of ice monitoring for 16 channels. The complex has a pen-and-wall mounted and rack-mount version.

Control of icing on power lines is carried out since 2009 in seven lines of 35-110 kV substation "Bugulma-110" (the Volga region), on four lines of 110 kV substation "Kutlu Bukash" (Volga), and from 2013 on three lines of 110 kV substation "Shkapova "(Ural) and on the line of 330 kV substation" Baksan "(North Caucasus). The complex operates in continuous an automatic sensing mode and transmits data to the control center KSPEU. Data on depos-its of ice can be transmitted via the GSM channel or the Internet to a control position without distance limitations, providing a convenient interface to moni-tor the dynamics of the icing on the wires of transmission lines and the dynam-ics of melting ice deposits on the wires.

At all substations we have performed preliminary diagnosis of the condi-tion of controlled transmission lines , defined their configuration, measured eta-lon reflectograms, identified channels and high-frequency interfering into tech-nological communication, set the modes of probing and took measures to iso-late reflected pulses from interference.

To summarize, we have developed and put into operation locating sys-tems to detect icing formations on the35-330 kV overhead lines. Complexes can reliably monitor the dynamics of the ice formation on the wires and clearly define the beginning of time required for melting ice deposits.

1. Minullin R.G., Petrushenko Yu.Ya., Fardiev I.Sh. Sounding of Air Power Transmission Lines by the Location Method // Russian Electrical Engi-neering. New York: Allerton Press, Inc., 2008. Vol. 79 (№ 7). PP. 389–396.

Web site:

Short biography: Minullin Renat Gizatullovich is professor of physics and mathematics. He is a head of research laboratory at Kazan State Power Engineering University. He has developed a novel technique to detect icing and failure of overhead power lines which has no analogy in the field. Minullin R.G. and his team carry out research, both fundamental and applied, on transmission of electromagnetic waves in conducting wires. He developed unique software and hardware appliances to control ice accretion and wire breakage. These appliances that are installed in active power lines in several regions of Russian

R&D areas/s: 07. Icing on power lines

Federation since 2009 operate in continuous automatic mode and transmit the data to the central server. When ice accretion is detected, the duty operator receives an alert and gives command to melt the ice to prevent power lines from damage.

R&D areas/s: 11. Icing in wind energy

3-D Numerical Simulation of MWs Wind Turbine Blade's Icing

Qin Hu, The State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, Chongqing

HU Qin, YANG Shuang, SHU Lichun, JIANG Xingliang
The State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, Chongqing 400030, China

This work presents 3-D numerical simulation of ice accretion on a 5 MW horizontal axis wind turbine operating under icing conditions. The two-phase flow is simulated with Fluent and the ice layer is calculated using Matlab. Spanwise flow may be ignored in the present 2-D simulation of the two-phase flow around blade. Thus, the results of 3-D simulation can offer more complete information of droplet trajectories. The air flow is calculated by the Moving Reference Frame (MRF) model. The rotating speed and the wind speed are set for a reasonable range of tip speed ratio. Based on the distribution of air flow field, Eulerian-Lagrangian method is suitable to track water droplets to estimate the local collision coefficient. The droplets trajectories are solved using the Discrete Particle Model (DPM), and the impingement characteristic of droplets can be obtained. The ice mass and ice shape is calculated base on the local collision coefficient. The results show that the downwind side of blade is almost covered with ice, while there is barely ice appeared on the leeward side of blade. Most ice deposit on the leading edge of blade, and the ice layer of blade tip is much thicker than the blade root. Slowing the rotating speed can reduce the ice accretion. The distribution of ice can be a useful reference for anti-icing and de-icing.
Key Words: wind turbine, droplet trajectory, ice accretion, 3-D, numerical simulation

Web site: http://international.cqu.edu.cn/

Short biography: None provided

BACK

R&D areas/s: 07. Icing on power lines

Collapse of an Arctic Power Line due to strong Wind Gusts during Wet Snow Accumulation

Knut Harstveit, Kjeller Vindteknikk, Norway

Bjørn Egil Nygaard, Kjeller Vindteknikk, Norway
Rolv E. Bredesen, Kjeller Vindteknikk, Norway

High voltage overhead lines in the Nordic climate are generally exposed to atmospheric icing. There have been several serious damages as a result of icing combined with strong winds. In the lowland areas, the ice is typically formed through wet snow icing.
The 31st of December 2004 an overhead line northwest of Tromsø in the Arctic part of the country broke down at several sites. The line is typically situated along a fjord at the lee-side of steep mountains. The event is well documented by photos and notes.
Wind and temperature data from the weather station Fakken 30 km west of the line showed very strong winds, gusting to 41 m/s from the west. Fakken, as well as the broken line are situated at the lee – side of very steep and irregular mountains, up to 900 m asl. The data show temperatures which are typical for wet snow conditions varying between 0 and +2°C during the event.
Precipitation is measured at a local weather station located close to the line route. This station measured large precipitation amounts during the storm. Such local and high precipitation amounts are most probably due to a spillover effect, i.e. the precipitation intensity is increased above the mountain top and blow further down-stream to the line area at the lee side of the island. The mountain area west of Fakken and west of the line are very similar. Large amounts of wet snow are blowing perpendicularly to the power line causing rapid wet snow accumulation on the line conductors. The strong wind at the iced line induces strong forces, resulting in several broken power line poles. The exact location of the damages indicates that both wind and precipitation are strengthened at the lee side of steep and irregular mountains.
The weather event is modeled using a high resolution meteorological model (WRF model). Simulations are carried out at a horizontal grid resolution of 500 m x 500 m, and the results are used to draw maps showing wind, precipitation, and accumulated ice loads. The ice loads are computed using the method described in Nygaard et al. 2013 (http://dx.doi.org/10.1175/JAMC-D-12-0332.1)
The Eurocode for wind actions with national annex treating gust strengthening at the lee side of steep terrain is studied, and the damaged sites are compared to this annex. In addition to this specific power line load project, the work is also part of a research project using mesoscale WRF simulations combined with topographic parameters to map risk zones for wind gust strengthening in complex and steep terrain.

Web site: http://www.vindteknikk.no

Short biography: Ph.D, 25 years experience at Norwegian Met Office, 7 years at KVT. Atmospheric Icing, Extreme Wind Statistics, General Wind Statistics

BACK

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 04. Icing climates - standards

Expansion of the ice deposition monitoring network in Germany

Bodo Wichura, German Meteorological Service, Climate and Environment Consultancy Potsdam, Germany

Long-term ice deposition measurements were carried out at up to 35 stations in the east part of Germany during 1965-1990. In 1991 the number of locations with ice deposition measurements was reduced to a total number of five (Arkona, Chemnitz, Zinnwald, Kahler Asten and Hohenpeißenberg). Since 2005 additional ice deposition measurements have been available from a meteorological mast (three heights 10 m, 50 m and 90 m above ground) at Falkenberg, near the Meteorological Observatory Lindenberg of German Metorological Service (DWD).
The severe wet snow incident in November 2005 in the northwest part of Germany (Münsterland area) as well as the results of the European COST action 727 “Measuring and forecasting atmospheric icing on structures” gave convincing reasons for an expansion of the ice deposition monitoring network in Germany. Therefore, DWD started a project to implement the expansion. The poster gives a review about the ongoing project.

Web site: http://www.dwd.de

Short biography: Bodo Wichura studied meteorology at the Humboldt University of Berlin. After his diploma in 1991 he worked until 2000 as research assistant in different projects (experimental turbulence research, hydrology of lakes, polar research and micrometeorology) at the German Meteorological Service in Potsdam, the Ludwig-Maximilians-University of Munich, the Institute for Applied Freshwater Ecology in Brandenburg, the Alfred Wegener Institute for Polar and Marine Research in Potsdam and at the University of Bayreuth. He was the station leader of the German Arctic station in Ny-Ålesund (Spitsbergen) from 1997 to 1998. He is been working as senior scientist and expert of Technical Meteorology (Wind Power Meteorology, Wind-, Ice- and Snow Loads) for the German Meteorological Service in Potsdam since 2001. He received his PhD in micrometeorology in 2009 at the University of Bayreuth.

BACK

R&D areas/s: 07. Icing on power lines

The Numerical Analysis for jump height of multi-two-spans at different intervals of overhead transmission lines

Yong-can Zhu, School of Electro-Mechanical Engineering, Xidian University, Xi'an 710048, P.R. China

Xin-bo HUANG(College of Electronics and Information, Xi'an Polytechnic University, Xi'an 710048, P.R.China) （Corresponding author), Xin-xin ZHENG(College of Electronics and Information, Xi'an Polytechnic University, Xi'an 710048, P.R.China), Yu-xin WANG(Co

Ice-shedding is the typical fault inducement. The decreasing of the electric clearance and increasing of the dynamic tension are usually caused by ice-shedding vibration of overhead transmission lines. Wire flashover, fittings damaged, or even wire breakage, tower collapses may be occurred if the ice-shedding vibration is serious which pose a serious threat to the safe operation of power equipment. According to different parameters of transmission line such as spans, span length, ice thickness, a finite element analysis model of wire-insulator was established by ANSYS, and the simulation of Ice-shedding from overhead transmission lines was adopted by additional force method. Then, the jump height of multi-two-spans at different intervals can be got. The result shows that the amplitude of jump height decreased when the same time of Ice-shedding on multi-two-spans was equivalent to unilateral strain tower. The jump height of second Ice-shedding spans was the maximum amplitude when the vibration cycle of multi-two-spans interval was about 5/8, and it could exceed first Ice-shedding spans. Besides, it was great impact on spans coupling such as the weight of the ice, spans, span length, damp and other factors, the more weight of the ice and spans number the less damp, span length and level. Thus, the jump height of first Ice-shedding spans can easily passed by second Ice-shedding spans.
keywords -Transmission line, ice-shedding, jump height, ice-shedding interval, spans coupling

Web site: http://en.xidian.edu.cn/

Short biography: Yong-can ZHU was born in Henan Province, China, on October 1986. He received the B.Eng. and M.Eng. degrees in automation from Xi'an Polytechnic University, Xi'an, China, in 2009and 2012, respectively. He is currently pursuing the Ph.D. degree in electro-mechanical engineering from Xidian University , Xi'an, China. His research interests include the online monitoring technology and condition maintenance of transmission lines.
Xin-bo Huang was born in Shandong Province, China, in May 1975. He received the B.S. and M.S degrees in automation from Qingdao Technological University, Qingdao, China, in 1998 and 2001, respectively. He received the Ph.D. degrees in automation from XiDian University, Xi'an, China, in 2005.
Xin-xin Zheng is currently working toward the M.S. degree with the College of Electronics and Information, Xi'an Polytechnic University, Xi'an, P.R.China. She research interests include the mechanism study on ice growth forecasting on transmission line. She may be reached at minyunchen1067@163.com.
Yu-xin WANG is currently working toward the M.S. degree with the College of Electronics and Information, Xi'an Polytechnic University, Xi'an, P.R.China. He research interests include ice growth forecasting on transmission line and artificial intelligence. He may be reached at wangyuxin_ac@sina.com.

BACK

R&D areas/s: 07. Icing on power lines, 12. Other topics related to icing

Development of snow accretion simulation method for electric wires in consideration of snow melting and shedding

Kazuto Ueno, Central Research Institute of Electric Power Industry, Japan

Kazuto Ueno, Central Research Institute of Electric Power Industry (CRIEPI), Japan
Yuzuru Eguchi (CRIEPI),
Takashi Nishihara (CRIEPI),
Soichiro Sugimoto (CRIEPI),
Hisato Matsumiya (CRIEPI)

In order to quantitatively clarify the process from the start of snow accretion to overhead transmission lines until snow shedding, we have developed a numerical code, SNOVAL Ver.3 (Snow accretion simulation code for overhead transmission lines). SNOVAL consists of meteorological data as input, a snow accretion model, a thermodynamic model for snow melting, and a snow shedding model. In the snow accretion model, dynamic effect of an electric wire rotation by external moments due to gravitational and aerodynamic forces on snow deposit is considered. The shape of accreted snow produced by SNOVAL is not necessarily to maintain cylindrical shape as in simple cylindrical accretion models. In contrast to the existing snow accretion models in which the snow deposit is always oriented normal to the wind speed, SNOVAL is applicable to snow accretion on electric wires under calm to strong wind from any direction. In the thermodynamic model with heat exchanges between the air, electric wire and snow deposit, the liquid water content in the snow deposit is introduced by taking into account the melting of snow deposit as well as the melting of snowflakes before impact. The sticking efficiency and density of the accreted snow in the snow accretion model are parameterized based on the liquid water content and the shape of accreted snow. In the snow shedding model, the adhesive force between the surface of electric wire and ice granules is estimated as a function of the liquid water content. Wet snow shedding is numerically evaluated based on the balance of forces and its related moments exerted on the accreted snow. SNOVAL is applied to wet snow accretion to conductor samplers supported by wires, and the quantitative comparisons between numerical and observational results are made.

Web site: http://www.denken.or.jp/en/index.html

Short biography: I am a visiting researcher at the Central Research Institute of Electric Power Industry (CRIEPI) since 2013. I engage in a ten-year research project from 2007 to 2016 on damage to overhead transmission facilities caused by severe snowstorms in Japan. This project is conducted in cooperation with electric power companies. My current work uses a combination of field observations, numerical modeling and simulation studies for snow accretion on overhead transmission lines. My research interests are in multiphase systems with phase transition under fluid flow which couples thermodynamics and fluid dynamics.

BACK

R&D areas/s: 07. Icing on power lines

Technology radar monitoring of overhead power lines when detecting ice formations

Renat Minullin, Kazan State Power Engineering University

Minullin R.G.(RU), Yarullin M.R.(RU), Kasimov V.A(RU)

When using a locating method of ice formation, information about the appearance of ice is given by probing pulses reflected from any inhomogeneity of the wave resistance of the line (hereinafter - heterogeneity) on it. Inhomogeneities are represented by the ends of lines or branches from them and high-frequency chokes.
Ice formation on the wires is heterogeneous dielectric which reduces the speed of the signal along the line and causing its additional attenuation due to dielectric losses of electromagnetic wave energy that is used for heating the layer of ice coating. "Location method" makes it possible to determine the occurrence of icing on a transmission line by comparing the propagation time of the reflected signals and their amplitudes in the presence and in the absence of icing formations.
When probing the line by the pulsed radar, the set of reflected pulses forms a trace. The appearance of ice deposits on the line causes a change of the trace. The more the characteristic of the line resistance will change under the influence of the thickness of the ice deposits due to changes in the dielectric constant between the wires of the line, the greater the increase in the pulse delay $\Delta\tau$ and decrease in the amplitude ΔU will be.
We have developed a technology for radar sensing of power lines with icing. It consists of the following steps:
1. Trial reflectograms are taken on controlled lines. These reflectograms are digitally processed using the averaging method. This also requires determining the optimal number of averages of the reflectogram necessary for sustainable and reliable separation of the reflected pulse signals from the noise. The found optimal number of averages reflectogram is then used in the normal sensing mode to determine the number of pulses in the probe pack.
2. The length of the line and its configuration (presence a tap off line with their parameters to determine the sensing range) are determined by using the pulse reflectometer. To determine the amplitude of the probe pulse, the attenuation of the line is found. The shape of the reflected pulses from the end of the power line and the point of attachment a branch off line and their ends are determined. The reflectogram, which will be used as an etalon, is taken.
3. The interference environment in the controlled line is studied in detail. The frequencies of interfering signals are determined. Interfering signals are removed using the method of digital signal processing (spectral analysis method).
4. The mode of measurements is defined. The amplitude and duration of the probe pulse, the number of pulses in the series, a range of sensing and the sensing period are specified on the radar monitor and the etalon reflectogram entered into the memory.
5. Test reflectogram are taken and sensing modes are adjusted for their optimization.
6. Values obtained by measuring the delay $\Delta\tau$ and the pulse amplitude ΔU are translated into the weight or thickness of the ice deposits. If the line consists of several radar areas, then the weight and thickness of the ice is calculated for each of them separately.
7. The calculated values of ice deposits are transferred to the screen controller mains, where they are displayed in a format easy to read. The results of these data are used to make decisions on the need for melting ice deposits on wires of power lines.
1. Minullin R. G., Lukin E. I., Sukhomyatkin M. O. et al. Specifics of Detecting Ice Coatings on Electric Power Lines Using Radar Probing. // Russian Electrical Engineering. New York: Allerton Press, Inc., 2011. Vol. 82 (№ 5). P. 237.

Web site:

Short biography: Minullin Renat Gizatullovich is professor of physics and mathematics. He is a head of research laboratory at Kazan State Power Engineering University. He has developed a novel technique to detect icing and failure of overhead power lines which has no analogy in the field. Minullin R.G. and his team carry out research, both fundamental and applied, on transmission of electromagnetic waves in conducting wires. He developed unique software and hardware appliances to control ice accretion and wire breakage. These appliances that are installed in active power lines in several regions of Russian

R&D areas/s: 07. Icing on power lines

Federation since 2009 operate in continuous automatic mode and transmit the data to the central server. When ice accretion is detected, the duty operator receives an alert and gives command to melt the ice to prevent power lines from damage.

BACK

R&D areas/s: 08. Conductors / Insulators / Flashover

Research on describing the icing level of porcelain and glass insulator based on icing thickness of the equivalent diameter

Zhijin Zhang, The State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, Chongqing

Zhang Zhijin, Jiang Xingliang, Zheng Qiang, Hu Jianlin, Hu Qin
The State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, 400044, China

The configure of insulator is more complex than that of conductors, and the ice shape and distribution on the surface of insulator are much different from conductors. It can not accurately characterize the insulator icing level with only ice quality during the ice process of insulator and there is difference with the general method of conductor icing characterization. Taking the typical ceramic and glass insulators as the research object, the paper studied equivalent diameter based on insulator configure parameters and experimented icing of insulator in the Xuefeng Mountain Natural icing Teatbase studied the equivalent diameter of the insulator icing thickness, and compared to verify the insulator equivalent diameter method and standard rotating wire icing thickness. The results of the study show that:
(1) Based on the equal area method, the numerical calculation formula of the equivalent diameter of the insulator is put forward, and the equivalent diameter of insulator has a relationship with the insulator structure parameters, the diameter and the area of insulator is greater, the greater of the equivalent diameter of insulator;
(2) The natural environment of insulator icing in the windward and leeward is obvious difference, and the icing time, weather parameters, structure of insulator may influence on icing level of insulators
(3) The ice thickness of equivalent diameter of insulator is given based on equal volume of ice, and the ice covered insulator is more serious, the equivalent diameter of insulator ice thickness is thicker;
(4) There is no difference for the varying rule of ice thickness changes with the ice time between the equivalent diameter of insulator with standard rotating wire. Therefore, it is acceptable using the icing thickness of the equivalent diameter describing the icing level of porcelain and glass insulator.
Key Words: Insulator, equivalent diameter, natural icing, icing level, icing thickness, describing method

Web site: http://international.cqu.edu.cn/

Short biography: None provided

BACK

R&D areas/s: 01. R&D programs, overviews, 05. Sensors, equipment and machinery - standards, 09. Anti-/ de-icing, coatings

Effect of icephobic coating on ice protection of ultrasonic anemometer with stack-type transducers

Shigeo Kimura, Kanagawa Institute of Technology

Kengo Sato(National Research Institute for Earth Science and Disaster Prevention)
Hiroshi Morikawa(Meteorological Research Institute for Technology)
Jarmo Hietanen(Vaisala Oyj)
Yoichi Yamagishi(Kanagawa Institute of Technology)
Tetsuya Kojima(Meteorologic

In cold climates, ultrasonic anemometers with stack-type heated transducers sometimes record extraordinarily higher instantaneous wind speeds than average wind speed during short periods in long series of measurements. A successive record of wind speed measured at a high sampling frequency indicates that those high-speed winds are not gusts because they suddenly jump from the speeds fluctuating around a certain value to a far higher speed and immediately return to almost the same value before the events of sharp increase.
We have identified the cause of such abnormal measurement by repeatedly performing snowing wind tunnel tests; it is because of the formation of ice-bridge on transducers. The surface of a transducer is heated by an electric heating element in the longitudinal center. However, very narrow upper and lower parts of the transducer remain unheated because of inner structural constraints. Therefore, ice or snow accretion may occur on the upper part when the anemometer operates under icing or snowing conditions. When the condition is prolonged, the accretion grows downward and covers the transducer like a canopy. In the central part of the transducer, the temperature is kept constant at a certain positive value even in subzero environments such that snowflakes colliding with the surface melt upon impact. The meltwater runs down along the surface to the unheated lower end and then to the upper arm. Because the upper arm of the anemometer is unheated, water begins to freeze on the surface immediately below the transducer. As water continuously flows down and freezes, the ice grows upward. As a result, the accretions of ice growing downward from the upper end and upward from the lower end meet each other at the center of the transducer. However, because the middle region of the transducer is heated and maintained at a prescribed temperature regardless of ambient conditions, the ice melts and forms a gap at the interface between the ice and the transducer surface. Consequently, an ice bridge is formed, and it disturbs the normal transmission of ultrasonic waves between the transducers. Based on this finding, we applied a superhydrophobic coating to the unheated upper arm in order to accelerate the removal of molten water by wind force. The results from a snowing wind tunnel test showed that the coating imparted a low-wettability characteristic to the upper arm for preventing ice growth, and measurements could be taken without any missing or unusual data.
In the present research, to further verify the effectiveness of coating on icing prevention, another snowing wind tunnel test was conducted using the same anemometer with extended superhydrophobically coated areas including the transducer, lower arm, and top cover of the body. Prior to the test, an acoustic impedance analysis was performed using a covering of silicon rubber to examine the transmissivity of the ultrasonic waves through the coating film and the ice deposit on the transducer. Moreover, an immersion test of the covering that was inherently attached to the transducer was carried out in accordance with the guidance of the Japanese Industrial Standard (in a short duration only for the wind tunnel test) in order to evaluate the influence of paint thinner on the covering.

Web site:

Short biography: S. Kimura is a professor at Kanagawa Institute of Technology, Kanagawa Japan. He received the Ph.D. in aeronautics from Tokyo University.

BACK

R&D areas/s: 07. Icing on power lines

Analysis of radar equipment indications and weight sensors indications during detecting ice deposits on power lines

Renat Minullin, Kazan State Power Engineering University

Minullin R.G.(RU), Kasimov V.A.(RU), Yarullin M.R.(RU)

In the ice detecting radar method, locator pulses are fed into power line through coupling filter and coupling capacitor when there is a line trap. Ice accretion decreases the amplitude and increases the delay of locator pulses reflected from the end of the line [1, 2].
The technique of converting values of reflected pulse amplitude and delay into equivalent weight of ice deposits on wires was developed. This technique allows us to compare the results of measurements obtained by location and weight methods on a comparable basis by weight ice deposits.
Radar method and weight sensors method were compared, based on measurements on the 330 kV line in the North Caucasus and on the 110 kV line in the Urals for the period from 2013 to the present time. Experiments have shown that the dynamics of weight change of wires with icing is objectively determined by the radar equipment and by the weight sensor. However, there are differences in the details of their readings, since these devices have different operating principles. Radar equipment detects all ice deposits, because the line is monitored along its entire length. The weight sensor monitors icing only in a single span near the sensor while other spans are not controlled.
According to indications of weight sensors masses of ice deposits on phase conductors do not coincide with each other. This reduces the credibility to weighing method and complicates determining the critical mass of ice deposits that can cause an accident on the power lines, as well as it creates uncertainty in making operational decisions about the beginning of the melting of ice deposits. Radar method has no such drawbacks.
Radar method can reliably monitor in real time the dynamics of icing on wires, allows clearly identifying the starting time of ice melting, which is necessary to prevent wire breakage on power lines. In addition, radar method allows monitoring ice melting process.
Radar method has the following advantages compared to the method of weighing conductors that are currently used in rare cases on some power lines:
1) pulse signal simultaneously serves as a sensor and a carrier of information about icing on wire, so there is no need to install separate sensors and data transmitters on wires, which would have collected data from sensors and then transmit data to control center, so is used small, simple and cheap structure of the equipment;
2) it ensures control of the entire line, not just a single span;
3) installation of radar equipment does not require intervention in the power line structure, because radar equipment is placed in the indoor substation, which increases reliability and simplifies its exploitation for operating personnel;
4) commissioning of radar equipment takes a few minutes if the power line has a high-frequency channel;
5) it is possible to monitor all lines outgoing from the substation using periodical switching.

1. Minullin R.G., Fardiev I.Sh., Petrushenko Yu.Ya., Mezikov A.K., Korovin A.V. et al. Location method for the detection of the appearance of glaze ice on the wires of power transmission lines. //Russian Electrical Engineering. New York: Allerton Press, Inc., 2007. Vol. 78. № 12. PP. 644–648.
2. Minullin R.G., Petrushenko Yu.Ya., Fardiev I.Sh. Sounding of Air Power Transmission Lines by the Location Method // Russian Electrical Engineering. New York: Allerton Press, Inc., 2008. Vol. 79 (№ 7). PP. 389–396.

Web site:

Short biography: Minullin Renat Gizatullovich is professor of physics and mathematics. He is a head of research laboratory at Kazan State Power Engineering University. He has developed a novel technique to detect icing and failure of overhead power lines which has no analogy in the field. Minullin R.G. and his team carry out research, both fundamental and applied, on transmission of electromagnetic waves in conducting wires. He developed unique software and hardware appliances to control ice accretion and wire breakage. These appliances that are installed in active power lines in several regions of Russian Federation since 2009 operate in continuous automatic mode and transmit the data to the central server.

R&D areas/s: 07. Icing on power lines

When ice accretion is detected, the duty operator receives an alert and gives command to melt the ice to prevent power lines from damage.

BACK

R&D areas/s: 08. Conductors / Insulators / Flashover, 10. Testing facilities

Experimental research on the icing progress of insulators

Yuyao Hu, The State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, Chongqing

HU Yuyao， JIANG Xingliang， ZHANG Zhijing， WANG Quanlin， PAN Yang
The State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, Chongqing 400030, China

The environmental parameters can be controlled and the ice test is not limited by season in the artificial climate chamber. Therefore, the experimental research on the icing progress of insulators is mainly carried out in the artificial climate chamber. However, there are considerable differences between the icing formed under artificial environment and that formed under natural environment. To explore the characteristics of the icing growth under natural environment, the different type of insulators were suspended on glaze tower at Xuefeng Mountain Natural Icing Test Base and the key factors affecting the icing growth were analyzed. The research results indicate that icing is influenced by many factors, such as the meteorological parameters, the arrangement positing and structure of insulator. The lower of temperature and the greater of wind speed, the large more icing accretion on the surface of insulator will be. The ice mass of insulators and the thickness of insulator surface grow nonlinearly with the increasing of time, while the growing degree of ice thickness slows down with the increasing of time. Icing of insulators arranged on the windward side is somewhat more serious than that arranged on the leeward side. Under natural condition, ice mainly exits on windward side of insulator and there is almost no ice on leeward side.
Keywords: natural icing test base; insulator; icing; icing growth; mass of ice; thickness of ice

Web site: http://international.cqu.edu.cn/

Short biography: None provided

R&D areas/s: 01. R&D programs, overviews, 05. Sensors, equipment and machinery - standards, 07. Icing on power lines, 10. Testing facilities, 11. Icing in wind energy

Numerical Study of Atmospheric Ice Accretion on Wind Turbines

Muhammad Virk, Atmospheric Icing Research Team, Narvik University College, Norway

Muhammad Virk (NUC, NO)
Umair N Mughal (NUC, NO)

Atmospheric icing on wind turbines has been recognized as a hindrance to the development of the wind power in the Arctic and alpine regions, where the uncertainty surrounding the effect of icing on energy production may prevent otherwise good wind resources from being utilized. A variety of problems due to icing on wind turbines occur such as complete loss of power production, reduction of power due to disrupted aerodynamics, overloading due to delayed stall, increased fatigue of components due to imbalance in the ice load and damage or harm caused by the uncontrolled shedding of the large ice chunks. Experimental analyses of such issues are costly; therefore in this research work, efforts are focused to numerically simulate and analyse the effects of both operating and geometric parameters on resultant rate and shape of ice accretion on wind turbine. Numerical modelling of rate and shape of ice accretion on the wind turbine blades is a complex coupled process that involves the air flow, droplet & surface thermodynamics. In this research work numerical analyses were carried out to understand the atmospheric ice growth on the wind turbine blade profiles and its resultant effect on its performance. Numerical study showed that an increase in blade profile size reduces the atmospheric ice accretion at leading edge, both in terms of local mass and ice thickness. Results show an increase in the ice growth with the increase of droplet size; whereas change in atmospheric temperature significantly affects the shape of accreted ice. Streamlined ice shapes were observed for low temperatures, whereas horn shape ice accretion was found at higher temperatures.

Web site: https://www.linkedin.com/profile/view?id=148457923&trk=hp-identity-photo

Short biography: Muhammad Shakeel Virk is presently working as Professor and leading the cold climate/atmospheric Icing related research activities at Narvik University College. His research background and experience is multi-field, where he has done research in areas including cold climate, renewable energy systems, complex flows, structural analyses and micro fluidics. Presently he is author of 85 journal papers and international conference proceedings.

BACK

R&D areas/s: 01. R&D programs, overviews, 05. Sensors, equipment and machinery - standards, 10. Testing facilities, 11. Icing in wind energy

MuVi Graphene – Hybrid Atmospheric Icing Sensor

Umair Mughal, Atmospheric Icing Research Team, Narvik University College, Norway

Umair N Mughal (NUC, NO)
Muhammad S.Virk (NUC,NO)

Due to increasing human activities in cold regions, atmospheric icing is considered as hazard for safe operations. Hence, development of new techniques to detect and measure atmospheric ice accretion on structures is required. Presently, there is no ice sensor commercially available that can detect and measure all important icing parameters such as: icing rate, melting rate, load and type simultaneously. A prototype modular hybrid atmospheric icing sensor has recently been designed & developed by Atmospheric Icing Research Team of Narvik University College, in order to facilitate the atmospheric icing measurement problems in Cold Region. This modular sensory unit of MuVi-Graphene is potentially capable to deliver all of the mentioned icing parameters and has successfully been tested at Cryospheric Environmental Simulator, Japan in both icing and snow conditions. This paper is aimed to highlight the design details and testing of this prototype sensor.

Web site:
https://www.linkedin.com/profile/view?id=71810394&authType=NAME_SEARCH&authToken=0kDs&locale=en_US&srchid=1484579231427113024371&srchindex=1&srchtotal=11774&trk=vsrp_people_res_name&trkInfo=VSRPsearchId%3A1484579231427113024371%2CVSRPtargetId%3A71810394%2CVSRPcmpt%3Aprimary%2CVSRPnm%3A

Short biography: Mr. Mughal is working as researcher at Atmospheric Icing Research Team of Narvik University College, where he is also managing the COLDTECH-RT3 project. His main area of research is atmospheric icing sensor, where as in addition to this, he hold good expertise in numerical simulations, structural analysis, vibrations and aerodynamics.

BACK

R&D areas/s: 02.Health, Safety and Environment (HSE), 03. Icing measurements, modelling and forecasting (incl. climate change), 06. Icing on masts, towers and buildings, 07. Icing on power lines, 11. Icing in wind energy

Methods for evaluating risk caused by ice throw and ice fall from wind turbines and other tall structures

Rolv Erlend Bredesen, Kjeller Vindteknikk, NO

Helge Ausland Refsum (Lloyd's Register Consulting, NO)

IceRisk, a state-of-the-art method for assessing site specific risk caused by ice fall or throw from turbines or other tall structures, has been developed in close collaboration between Kjeller Vindteknikk and Lloyd's Register Consulting. The method consists of a detailed meteorological simulation resulting in maps of ice throw probability zones and safety distances for the considered site, followed by a risk assessment approach based on the Norwegian Directorate for Civil Protection (DSB) guidelines for acceptable risk outside industrial facilities. The approach results in a map showing safety zones, i.e. what type of activities are acceptable within the vicinity of the wind turbine or similar installation.
Guidelines for acceptable risk levels, both for facility operating personnel and for third parties, are proposed. The calculated risk for any specific site may take into account local risk reducing measures, and calculate individual risk for different exposure, such as pedestrians and vehicle passengers, separately.
The IceRisk methodology has so far been applied for met masts, tall towers, power lines and wind turbines in Norway. Since 2013, validation work has been performed by ongoing inspections on and around a 209 m telecom mast at Tryvann, Oslo.
During the winter of 2013-2014, the telecom mast experienced extreme icing conditions and both the mast and area surrounding the mast were inspected. Based on the inspections we consider the model as qualitatively validated yielding highly realistic zones for ice fall. A quantitative comparison between the number of ice pieces and larger craters found on the ground in given areas against the calculated probability maps was also found favourable with a logarithmic decrease in the number of strikes per square meter with distance. The kinetic energy of impact is an important parameter in the risk assessment; this could however not be directly compared.
A warning system, coupled to automated forecasts of risk zones for the following 48 hours, was installed before the winter 2014-2015. A total of 6 separate cases with dangerous amounts of ice were forecasted during the winter, which resulted in warnings issued. After each episode, inspections were performed before the warning system was de-activated.
The IceRisk model is linked to a hindcast archive with time series of meteorological parameters such as icing, wind speed, wind direction and temperature from the last 35 years. This archive was used to define the periods of icing and the associated ice amount in the structure. Ice cubes (rime ice) with a weight of more than 150 g falling from the mast were considered dangerous, as the impact energy can exceed 40 Joules. The furthest drift distance for a dangerous ice piece at Tryvann was calculated to be 1.5 times the height of the construction.
For wind turbines, IceRisk calculates the impact position and impact energy of the ice pieces released from various positions on the blades. Heavier ice pieces can be thrown further than light pieces, however light pieces may drift longer distances in strong winds. When ice that has built up on a turbine blade is released it can be thrown hundreds of meters in the worst cases. Calculations with the IceRisk model suggest that safety distances are dependent on the local wind conditions and may in the worst cases with modern turbines exceed the general rule of 1.5 * (H+D), where H is hub height and D is the rotor diameter. If the turbine is located at an elevated position compared to the surrounding, we also recommend adding the overheight, dZ, to H in the above formula for screening purposes.

Web site: http://www.vindteknikk.com/

Short biography: Rolv Erlend Bredesen holds a M. Sc. In Computational Science and Engineering from the University of Oslo from 2005. In 2004 and 2005 he was an exchange student at the University of Washington, USA studying mesoscale modeling with WRF (Weather Research and Forecasting) model. His main expertise is within fluid mechanics, computer programming, and wind farm development. He has long experience in applying WRF to wind farm development and lately he has gained experience in ice loss and ice risk analysis for wind farms.

R&D areas/s: 02.Health, Safety and Environment (HSE), 03. Icing measurements, modelling and forecasting (incl. climate change), 06. Icing on masts, towers and buildings, 07. Icing on power lines, 11. Icing in wind energy

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 05. Sensors, equipment and machinery - standards

Icing forecast in GIS Meteo system

Yury Yusupov, MapMakers Group Ltd.

Icing often becomes a natural disaster, especially when the diameter of accretion reaches several centimeters. Overhead transmission lines and other constructions are most exposed by the event, that could lead to abruption of wires and even fall of steel towers. So considering negative consequences it is evident that the forecast of these events should be as accurate as possible.
The problem of icing forecast is the problem of most accurate precipitation and temperature stratification forecasts. In GIS Meteo technology mesoscale nonhydrostatic hydrodynamic WRF-ARW model with 3d-VAR data assimilation system and horizontal resolution 2 km is used for short-term forecasting and nowcasting. On obtaining model results bias correction is used for minimizing surface data errors. Beside that GIS Meteo technology gives possibility to overlap model data, observations data, satellite data and meteorological radars data. Weather forecaster, using all these possibilities, could adjust model forecast to work out the most accurate forecast of hazard atmospheric events.
GIS Meteo is an interactive, real-time tool primarily designed for use in meteorologist's operational work. It can be also successfully used in related areas, such as agrometeorology, hydrology, oceanology, etc. GIS Meteo creates meteorological maps using data provided by various databases, such as meteorological real-time database, satellite images, and others. GIS Meteo has a simple and friendly user interface for working with maps, graphs, diagrams and etc. GIS Meteo includes a great number of components, realizing various numeric methods, for instance, trajectory calculations, calculation of frontal areas, clouds, precipitation, thunderstorms, turbulences, icing, jet streams, fire danger and many others. GIS Meteo was successfully certified in Roshydromet and recommended for using in all its regional meteo services.
The elements of abovementioned technology were tested in Sochi region during meteorological support of XXII Winter Olympic Games in 2014.

Web site: http://www.gismeteo.ru/

Short biography: Director of Research and Development department at MapMakers Group Ltd.

BACK

R&D areas/s: 11. Icing in wind energy

Comparison of three different anti- and de-icing techniques based on SCADA-data

Sandra Kolar, Uppsala Universitet/OX2

Sandra Kolar (Uppsala Universitet/ OX2, Sweden).

Comparison of three different anti- and de-icing systems
Sandra Kolar, Uppsala Universitet/ OX2
Ice accretion on the blades of the wind turbines results in a lower energy production compared to the energy production in the same conditions with no ice, and thereby causes a loss of income for the owner of the wind turbine. In many locations the winter is the time of the year with the most wind, which makes it especially important to ensure availability of the production during this time period. Furthermore cold climate and ice could increase the costs for maintenance and insurance, increase the loads on the turbine, give rise to more noise and form a safety risk due to ice throws . It has therefore become more common for wind turbines in cold climates, like the climate in the north of Sweden, to have de- or anti-icing systems installed on the turbines.
This paper, which is a master thesis carried out during the spring 2015 in cooperation with OX2 in Sweden, evaluates the performance of three de- and anti-icing systems.
The evaluation of the production losses due to icing is based on the main outlines of the standard method (T19IceLossMethod), which IEA task 19 is currently working on. The assessment is based on 10 minute average values of SCADA-data. The parameters being used are wind speed, wind direction, ambient temperature, the power output and the state of operation of the turbine. The power output is compared to the output in conditions considered to be ice free and three types of icing events are identified. The icing events are classified as:
Type A) Loss of production
Type B) Turbine standstill due to icing or operation of the de- or anti-icing system
Type C) Ice influenced wind anemometer resulting in overproduction compared to the power curve.

Losses in the production are calculated for icing events of type A and B. The reference production during icing event C cannot be estimated since there is no knowledge about the accurate wind speed. The loss of production during ice event A is defined as the difference between the reference production according to the reference power curve and the actual output and the loss during ice event B is defined as the reference output according to the power curve together with the power input for running the de- or anti-icing system.
Since the de- or anti-icing system will result in a higher investment cost for the turbine as well as an additional cost for the operation of the system, the cost of the system must be compared to the potential cost of the ice losses. The production of the evaluated wind farm is therefore compared to the production of a wind farm without anti-icing ("reference park") located nearby in order to get a better understanding of the economical impact of the system as well as the operation of the de- or anti-icing system. The master thesis will be completed in June 2015.

Web site:

Short biography: Studying the last year at the Master programme in Energy systems engineering at Uppsala Universitet. Currnetly doing master thesis in cooperation with OX2.

BACK

R&D areas/s: 06. Icing on masts, towers and buildings

Review of icing related failures of wind masts in Bulgaria

Dimitar Nikolov, National Institute of Meteorology and Hydrology - Bulgarian Academy of Sciences (NIMH-BAS), Bulgaria

Dimitar Nikolov (NIMH-BAS, BG)

Wind energy in Bulgaria has rapidly developed since 2008 and nowadays the amount of the energy from the installed wind turbines reaches more than 650 MW. However, more of the places with high wind energy potential are often affected by icing – a fact, which has not been expected or were underestimated by the owners and operators, might be because of the southerly location of our country and the tendency of warmer winters in recent years. The first winters after 2008 were indeed relative warm and with small number of light or moderate icing events, but not the last three ones.
This paper summarizes the cases with failures of tall wind masts due to icing in different locations in the country since 2011. The review includes description of the meteorological conditions, the type of icing and assessments of the ice loads at different elevations of the masts. These assessments are based on simple approaches such the method included in ISO 12494 "Atmospheric Icing of Structures" and few others recently described in Makkonen et al. (2014). The results are compared with photos of the depositions on the damaged masts.

Web site:

Short biography: I work at the National Institute of Meteorology and Hydrology since 1998.
My higher education is from University of Sofia, Faculty of Physics with MSc in Physic with specialty Meteorology.
My PhD is from the National Institute of Meteorology and Hydrology - Bulgarian Academy of sciences.
The title of my PhD is "Icing of technical equipment in Bulgaria and other European regions".
My main professional interests are in the field of snow and icing, ice and snow loads, snow and ice storms.

BACK

R&D areas/s: 10. Testing facilities

The recognition and detection technology of ice-covered insulators under complex environment

Xin-bo Huang, College of Electronics and Information, Xi'an Polytechnic University, Xi'an 710048, P.R.China

Juqing LI(College of Electronics and Information, Xi'an Polytechnic University, Xi'an 710048, P.R.China), Ye ZHANG(College of Electronics and Information, Xi'an Polytechnic University, Xi'an 710048, P.R.China), Fei ZHANG(College of Electronics and Inf

In order to avoid the impacts of outer factors on the ice-covered insulators recognition, such as weather, seasons, outside illumination changes, acquisition time, image background and image contrast, a general algorithm which can recognize and detect the ice-covered insulator accurately in a complex environment is put forward in this paper. With the video monitoring device, the image information of insulators with or without covered ice can be acquired. The ice-covered insulator images under complex environment are regarded as the research objects. Morphological closing operation is conducted on the ice-covered insulator images firstly. Then the high frequencies in the image are removed by the Wavelet Domain. A kind of invariant background quotient image can be acquired by dividing the processed images and the original images, then after the camera calibration on the quotient images, the edge contours of insulators can be extracted using the wavelet edge detection method, and the icing thickness of insulator can be obtained by using template matching algorithm and geometric model. The method is verified in an artificial climate chamber, the results show that this method can eliminate the interference of the complex background weather, accurately identify icing insulators and calculate the insulator icing thickness. This method can be applied to recognition and detection of ice-covered insulators under complex environment.
Key Words- icing insulators; monitoring device; quotient image; contour feature; template matching; geometric model

Web site: http://en.xpu.edu.cn/

Short biography: Xin-bo Huang was born in Shandong Province, China, in May 1975. He received the B.S. and M.S degrees in automation from Qingdao Technological University, Qingdao, China, in 1998 and 2001, respectively. He received the Ph.D. degrees in automation from XiDian University, Xi'an, China, in 2005. Since July 2005, he has been a teacher at Xi'an Polytechnic University, and since December 2008, he has been a full Professor with the School of Electronics Information at Xi'an Polytechnic University. From October 2005 to March 2008, he was a post-doctor in the State Key Laboratory of Electrical Insulation and Power Equipment and the School of Electrical Engineering at Xi'an Jiaotong University, engaged in the snow and ice warning system on transmission lines. Since May 2009, he was a post-doctor at South China University of Technology, engaged in the transmission conductor galloping monitoring and mechanism. His current research interests include the online monitoring technology and condition maintenance of power equipment, the wireless network sensor. He has published more than 50 journal articles and conference papers, and 4 monographs. He may be reached at hxb1998@163.com.
Dr. Huang received the 2011 new century excellent talent support plan of China Ministry of Education (MOE), 2010 teacher of the year award in China's "textile light" for teachers, 2009 Hong Kong SangMa research grants award, and several other awards and prizes from Chinese Government.
Juqing LI is currently working toward the M.S. degree with the College of Elctronics and Information, Xi'an Polytechnic University, Xi'an, P.R.China. Her research interests include the Technology of recognition and detection of icing insulator on transmission line . She may be reached at 759553742@qq.com.

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 07. Icing on power lines, 08. Conductors / Insulators / Flashover, 09. Anti- / de-icing, coatings, 10. Testing facilities

Anti-icing tests on La Farga CAC copper

Lluis Riera, La Farga, Spain

Lluis Riera (La Farga, Spain), Brian wareing (Brian Wareing.Tech Ltd, UK)

The most significant weather loads world-wide are commonly those due to ice loads. Whilst many countries have wind loads as their major concern, in general loads due to icing, whether wet snow, rime or glaze icing, commonly dominate wind loads except in hurricane prone areas. This paper covers ice load tests at the EA Technology test site at Deadwater Fell on the England/Scotland border in the UK on two copper conductors with anti-accretion coating compared with an uncoated ACSR conductor, all provided by La Farga of Spain. In every icing incident the ACSR accreted more load than either of the copper conductors and so the anti-icing coating must have had some significant effect. Overall the tension increases on the copper conductors were only about 50% of those on the ACSR. In the worst cases, the tension increases of the copper conductors were 73% of the ACSR in rime ice and 34% in wet snow conditions.

Web site:

Short biography: To be added later

BACK

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 04. Icing climates - standards, 06. Icing on masts, towers and buildings

Icing Measurements at Berlin TV Tower: A case study of a falling ice situation on 23rd December 2012

Bodo Wichura, German Meteorological Service, Climate and Environment Consultancy Potsdam, Germany

The surrounding area of the Berlin TV Tower in the city center of Berlin has been shut by the authorities on December 23rd, 2012 due to falling ice. The case study presents results of icing measurements at 248 m height above ground level at Berlin TV tower during the event. The meteorological (pre)conditions are analysed. Furthermore, results are compared to data measured at a 100 m tower near Falkenberg (approx. 60 km southeast from Berlin TV Tower). The comparison shows a good temporal agreement of data. Due to the good temporal agreement of data as well as of very similar meteorological preconditions the dependence of ice loads on height above terrain level has been analysed using data from both sites.

Web site: http://www.dwd.de

Short biography: Bodo Wichura studied meteorology at the Humboldt University of Berlin. After his diploma in 1991 he worked until 2000 as research assistant in different projects (experimental turbulence research, hydrology of lakes, polar research and micrometeorology) at the German Meteorological Service in Potsdam, the Ludwig-Maximilians-University of Munich, the Institute for Applied Freshwater Ecology in Brandenburg, the Alfred Wegener Institute for Polar and Marine Research in Potsdam and at the University of Bayreuth. He was the station leader of the German Arctic station in Ny-Ålesund (Spitsbergen) from 1997 to 1998. He is been working as senior scientist and expert of Technical Meteorology (Wind Power Meteorology, Wind-, Ice- and Snow Loads) for the German Meteorological Service in Potsdam since 2001. He received his PhD in micrometeorology in 2009 at the University of Bayreuth.

BACK

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 07. Icing on power lines, 08. Conductors / Insulators / Flashover, 10. Testing facilities

Relation between test span measured ice loads and conductor size

Brian Wareing, United Kingdom

Brian Wareing (Brian Wareing.Tech Ltd, UK)

The 2010 draft of IEC60826 includes a parameter, gR, as the reference ice load for a 30mm diameter conductor at 10m above ground. When applying this to conductors of other sizes, the standard states that gR should be multiplied by a factor Kd. However, the IEC standard does not go below 10mm conductor diameters, is flat for 10-30mm and then has an increasing load factor for in-cloud (rime) and precipitation (wet snow) icing above 30mm diameter. Measurements have been made under rime ice and wet snow conditions at the Green Lowther and Deadwater Fell test sites operated by EA Technology in the UK on single conductor sizes from 32mm^2 Copper to 700mm^2 Araucaria i.e. 6 to 37mm diameter conductors. The site data over the last 23 years (but mainly 1991-96 and 2000-05) has been reviewed and used to produce a new relationship between Kd and conductor diameter. The results indicated that the IEC figure is not correct, especially for small conductors. All the data confirms that small conductors (≤10mm diameter) suffer significantly higher accretion rates. The assertion in IEC60826 (2010) that ice loads do not change for conductors of ≤30mm diameter is not borne out by the data. The rime ice Kd line from IEC60826 (2005) does not match up with the Deadwater data as the increase in rime ice loads with conductor size is much greater than Kd predicts. However, the wet snow Kd line is reasonably close to the Deadwater data for conductors with diameters >10mm. It is intended that this data be used to feed into the output of current UK line design software to provide ice loads and radial ice thickness for different conductor diameters.

Web site:

Short biography: Qualifications: B Sc (1st Class Hons) Physics, Ph.D, MIET, C.Eng
CEO of Brian Wareing.Tech Ltd, an Overhead Lines and Lightning Protection Consultancy. He is the author of book 'Wood Pole Overhead lines' and a contributer to 'Handbook of Renewable Energy Technology'. Involved in several Cigré working groups dealing with climatic loads on overhead lines. Member of Cigré SCB2 AG06 (Mechanical aspects of overhead lines) and convenor of Cigré SCB2 AG06 WG48 (Field experience with high temperature conductors). Currently involved in non-wood alternatives for support structures (spun concrete, composite poles etc) and the wake effects of wind turbines on overhead lines. Has run wind/ice test sites for EA Technology since 1988 and involved in development of ice maps for UK and Ireland.

R&D areas/s: 05. Sensors, equipment and machinery - standards, 06. Icing on masts, towers and buildings, 09. Anti- / de-icing, coatings

Investigation of Using Icephobic Coatings on a Cable Stayed Bridge

Douglas Nims, University of Toledo, Toledo, USA

Ahmed Abdelaal, University of Toledo, USA,
Clinton Mirto, University of Toledo,Toledo, USA,
Douglas Nims, University of Toledo, USA,
Tsun-Ming Ng, University of Toledo, USA,
Kathleen Jones, US Army Cold Regions Engineering and Research Laboratory,

Icing is a significant challenge that affects structures in many countries. Bridges are one of the examples of structures that may be severely affected by atmospheric icing. The Veterans Glass City Skyway (VGCS) is a single pylon cable stayed bridge with a main span of 375 m in Toledo, Ohio which was opened to traffic in 2007. The VGCS is owned by the Ohio Department of Transportation (ODOT). Five major icing events have occurred on the bridge which led to the closure of bridge lanes and damaged cars. Therefore, over 80 anti-icing/deicing technologies were investigated Anti-icing techniques aim to reduce the adhesion between the ice layer and the structure and prevent the potential accretion of hazardous ice layers, whereas deicing techniques aim to prevent ice buildup. In addition to considering active and passive technologies, bridge management was considered as an approach to assist the bridge operators.
Coatings are a passive anti-icing technique which would be advantageous if practical. The stay cable sheaths of the VGCS are made of stainless steel which offered aesthetic and life cycle cost advantages. However, because the stay appearance is important, in addition to preventing ice buildup, being durable enough to last through several winters, and being economical, the coating must not alter the appearance of the stays.
This paper focuses primarily on several icephobic coatings being considered. Experiments were conducted indoors at the University of Toledo (UT) icing wind tunnel on a small specimen made from the same material as the cable sheath, and outdoors at the UT Icing Experiment Station on a full scale specimen. The UT icing tunnel was used to conduct experiments with conditions similar to natural icing scenarios. Three different coatings were tested in the wind tunnel: (1) aliphatic petroleum distillates with proprietary additives, (2) epoxy polymers, silicate mesh with new melt-point-depressants, and (3) fluorocarbon polymer and aliphatic, moisture-cure, three-part polyurethane. Based on results of the wind tunnel test, one coating was selected for testing outdoors in simulated icing events.
None of the coatings tested performed the anti-icing function effectively. Under the same conditions and over the same duration, the ice layer accumulated on the coated specimen was thicker than that on the uncoated specimen. The results showed that water would bead on the coating, which did initially prevent ice from forming directly on the stainless steel surface. However, rather than running off the coating, the water droplets would freeze rapidly on top of the coating. This resulted in a craggy, uneven surface that trapped water effectively, which in-turn led to an increase in ice accumulation rate compared to no-coating. Addition, during the outdoor test it was observed that the coating would affect the appearance of the specimen over time. After a period of months, the coating turned gummy and dull.
Other techniques such as chemicals and internal heating were also tested in this project. Overall, no technique, active or passive, met the operational requirements for the bridge. Therefore, ODOT elected to instead monitor the conditions on the bridge and protect the traveling public by closing traffic lanes on the bridge when there is a risk of ice fall. An automated real time monitoring system (dashboard) was built to identify possible icing conditions. To provide necessary information for the operators during a potential icing event, the dashboard displays the conditions of the stays and provides warnings regarding the ice accumulation and ice shedding based on the understanding of the climate, weather history, current weather information from existing weather stations, and the presence of ice on the stays. In addition, new sensors were developed for monitoring the ice on the bridge stays. An overview of the local weather station on the bridge, the monitoring system and sensor development will also be presented.

Web site:

Short biography: Ms. Jones' primary focus at CRREL is loads on structures due to atmospheric icing from sea spray, freezing rain, and supercooled clouds, including making field measurements and analyzing the data, modeling, and the comparison of observations and model results. She developed a both simple and

R&D areas/s: 05. Sensors, equipment and machinery - standards, 06. Icing on masts, towers and buildings, 09. Anti- / de-icing, coatings

detailed freezing rain models for calculating ice loads from historical weather data, and then used these results in an extreme value analysis based on L-moments to map extreme ice loads from freezing rain for ASCE Standard 7. She is currently working on a model of icing on offshore structures from run up and splash.

R&D areas/s: 07. Icing on power lines, 08. Conductors / Insulators / Flashover

Comparison of Ice Accumulation on Simplex and Duplex Conductors in Two Parallel 220 kV Energized Overhead Lines in Iceland

Árni Jón Elíasson, Landsnet, IS

Pétur Þór Gunnlaugsson (ARA Engineering, IS), Árni Björn Jónasson (ARA Engineering, IS)

The paper presents results from icing measurements for more than 8 years in two parallel 400 kV energised OHTLs. The measuring site Hallormsstaðaháls is a mountain ridge, located 575 m.a.s.l. between two narrow valleys. Most of icing events at the site occurs when wind is blowing from north to northeast. The distance from the site to the east coast of Iceland is approximately 65 km in this direction. One of the OHTL has simplex conductor, 49.9 mm in diameter. The other OHTL has duplex conductor (2x39.2 mm in diameter). The measurements are made in suspension towers with load cells in one phase conductor attachment points.

Icing is frequent every year at the site which in most cases are in-cloud icing events although wet snow icing events also occurs. 300 m away from the location of the measuring towers there is a test span where icing has been measured continuously for more than 30 years. Also there is a long experience of operating 132 kV transmission line parallel to the two 400 kV lines. An automatic weather station has been operated close to the test span for 17 years.

The ice accumulation at Hallormsstaðaháls Measuring Site on simplex and duplex conductors from November 2006 to May 2015 is analysed. Diagram of icing on simplex and duplex conductors is published. Icing periods are registered and the icing accumulation rate calculated for each period. Timing of ice drops is evaluated. Icing accumulation rate on simplex and duplex conductors is investigated with regards to estimated torsional stiffness of the conductors.

Web site:

Short biography: Árni Jón Elíasson is a geographer. He has participated all IWAIS workshops since 1988 and presented many papers with colleagues. Responsible for running ice test spans for power companies in Iceland since 1977.

BACK

R&D areas/s: 06. Icing on masts, towers and buildings

Isotopic Mass Balance Measurements of Spray Ice

Toshihiro Ozeki, Hokkaido University of Education

Toshihiro Ozeki (Hokkaido University of Education, Japan)
Kyohei Yamane (Hokkaido University of Education, Japan)
Satoru Adachi (Snow and Ice Research Center, NIED, Japan)
Shigeru Aoki (Hokkaido University, Japan)

Spray ice is frozen ice formed from sea or lake spray water in cold regions and accreted on ships, offshore structures, and trees in lakeside, developing into a massive ice form. Freezing spray is the main cause of spray icing; however, spray ice accretion often occurs under intense snowfall. We investigated the contribution of snow to spray icing.

We collected samples of spray ice, snow, and water on the west coast of Hokkaido Island and in Lake Inawashiro and Lake Towada of Main Island, Japan. The structural characteristics of the spray ice were analyzed using conventional thin-section and NMR imaging. The observed layer structure in the samples depends on the growth history of the spray ice. Additionally, the spray ice was composed of two ice types with different crystal structures: granular ice with uniform, rounded smaller grains and columnar ice. The differences in ice composition may be influenced by snow accretion.

The snow mass fraction of the spray ice samples was calculated from the isotopic mass balance. The oxygen isotopic composition of the melted samples was analyzed using a standard mass spectrometer. The oxygen isotopic composition values of spray ice were higher than that of the sea or lake water supply. This difference suggests that isotope fractionation has occurred during the wet growth of spray ice. We verified the isotope fractionation during the wet growth of artificial spray ice produced in cold room experiments.

The snow mass fraction of spray ice responds to icing events and the oxygen isotopic composition values of granular ice layers tend to be lower than the other layers, suggesting the contribution of snow accumulation. High snow fractions in the samples demonstrate that snow contributed significantly to the growth of spray ice.

References

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Kawamura, T., Ozeki, T., Wakabayashi, H., Koarai, M, (2009): Unique lake ice phenomena observed in Lake Inawashiro, Japan: Spray ice and ice balls. J. Glaciol., Vol. 55, 939-942.

Web site:

Short biography: Research subjects: sea spray icing, anti-/ de-icing technique, snow accretion on trains, avalanche release mechanism, snow metamorphism.

BACK

Abstract #: 18 - Oral

R&D areas/s: 08. Conductors / Insulators / Flashover

Advanced test methods for full-scale ice tests of DC insulators strings intended for ±350 kV

Andreas Dernfalk, STRI

Andreas Dernfalk (STRI, SWE)
Johan Lundengård (STRI, SWE)
Erling Petersson (STRI, SWE)
Igor Gutman (STRI, SWE)
Kyle Tucker (Nalcor, CAN)
Sarajit Banerjee (Kinetrics, CAN)

A new ±350 kV HVDC transmission line is planned from Muskrat Falls to Soldiers Pond in Canada. Along the route, two areas were considered as potential challenges for dimensioning with respect to pollution and ice; one characterized as coastal area and another one characterized as mountainous area. Three basic possible service cases were identified to be simulated by representative laboratory testing:

1. Polluted insulator covered by rime ice
2. Polluted insulator covered by glazed ice
3. Polluted insulator covered by glazed ice accreted under full-scale voltage

The insulator string consisted of standard DC glass cap-and-pin insulators and the performance was verified by withstand test during melting phase of ice. Pollution was applied by the standard IEC procedure (IEC 61245), i.e. dipping the insulators into a standard suspension prepared from water, salt (NaCl) and kaolin. Target pollution levels (low and medium levels of pollution) were checked by measurements on sample insulators (3 units) not included in the following ice accretion and voltage test. For all test cases the ice was formed either from water similar to standard IEC rain (conductivity was approximately 100 µS/cm) or from the tap water (conductivity was approximately 200 µS/cm). During all ice applications the air temperature in the test hall was kept between -7°C and -8°C. Water was sprayed towards the four insulators without additional air flux (no wind simulation).To avoid removal of the firstly applied pollution layer, small amounts of water were first sprayed onto the insulators in a cyclic manner (using nozzles moving up and down along insulator with adjustable pause length after each sweep). After accretion of the first ice layer protecting the pollution, the pause length between each sweep was decreased, allowing for more time efficient application. The ice created was either glaze type, or rime ice. After a number of trial applications the required ice was achieved by use of different nozzles and different distances. Ice thickness and ice distribution were specified to be measured in some parts of the agreed test program. However, the visual criterion for bridging was the dominant criterion to make a decision when the target ice accretion is accomplished.

For the special case of ice accretion under voltage the same method and same number of nozzles (two per string) were initially used for the application of the first ice layer without washing off the pollution layer. For the ice accretion under voltage a certain distance was needed to prevent flashover to the equipment for ice accretion. Thus, in this case a different type of nozzles spraying larger droplets (which reach longer) were used. The nozzles were automatically moving up and down with a velocity of 0,15 m/s. One nozzle was spraying on each string. The water was pre-cooled to a temperature just above 0 degrees C. According to the test program the voltage withstand tests in all cases were performed in “melting regime” mode according to the principles of IEEE 1783. This was achieved by increase of temperature in the climate test hall after finalized ice accretion for each case. The door of the chamber was opened and additional flow of warm air was created by the fans evacuating air through the roof of the chamber. The gradient of temperature increase was in the proximity to zero degrees C about 2-3oC/h.

The following parameters were measured during the tests:

- Temperature in the climate hall
- Humidity in the climate hall
- Ice density
- Melted ice water conductivity via collection of melt water during voltage test
- Melted ice water volume via collection of melt water after voltage test
- DC test voltage
- Leakage current
- Ice temperature by non-contact IR measurements

The paper presents more details on each of testing philosophy and practical principles for all three possible service cases, mentioned in the beginning of the abstract.

R&D areas/s: 08. Conductors / Insulators / Flashover

Web site: http://www.stri.se

Short biography: Andreas Dernfalk has more than 15 years experience in high voltage technology and his specialist field covers outdoor insulation and failure cause investigations. He has been involved in the development of procedures for ice and snow testing, dimensioning and diagnostic testing of outdoor insulators, with special focus on composites. Andreas has also worked with insulation coordination and performed several studies related to conversion of OHLs from AC to DC operation. His experience also includes dielectric spectroscopy measurements on transformers.

R&D areas/s: 06. Icing on masts, towers and buildings

A prediction method of slide snow/ice load applied to roofs

Xuanyi Zhou, State Key Laboratory of Disaster Reduction in Civil Engineering, Tongji University, Shanghai, China

Xuanyi Zhou(State Key Laboratory of Disaster Reduction in Civil Engineering, Tongji University, Shanghai, China), Jialiang Li (East China Architectural Design & Research Institute Co.,Ltd., Shanghai, China), Ming Gu (State Key Laboratory of Disaster Red

The prediction of slide snow/ice loads on roofs is vital for structure design in heavy snowfall regions. Some studies have been conducted on the snow-slide loads on roofs. However, most of them do not provide a practical method for structural engineers. Current load codes and Zhou et al. (2013) established calculation methods that disregard some crucial effects of key factors. For example, these load codes generally regard the slide snow/ice load coefficient as fixed. Zhou et al. (2013) considered the effects of heat obtained from within buildings and the shielding effect of neighboring buildings, but they ignored the effects of roof slope. Hence, the study attempts to explore the effects of roof slope on slide snow/ice loads. The concept of accumulated temperature above freezing was proposed by Chiba et al. (2012). Chiba et al. believed that the data of the accumulated temperature above freezing follows log-normal distribution and summarized the relationship between snow-slide probability and the accumulated temperature above freezing. In the present study, snow sliding is closely related to the internal physical states of snowpack, which is determined by the absorption of energy by snowpack on roofs. The energy absorbed by the snowpack reflects the essence of snow slide more effectively than air temperature does. In especial, the positive energy absorbed from the surrounding environment can alter snow phases and induces further snow slide. Therefore, this study introduces the concept of accumulated positive energy similar to the accumulated temperature above freezing. The snowmelt model of Zhou et al. (2013), which mainly includes the energy and mass balance equations, is adopted to simulate the amount of some types of energy involved in the snowmelt process on roofs. In the snowmelt model for building roofs, the shielding effect of neighboring buildings is considered in the computation of short-wave radiation. The heat transfer from within the building is mainly related to the differences in indoor and outdoor temperature, as well as to the level of thermal insulation of the materials that cover the roof.

Then, the developed method is used to simulate the slide snow/ice loads on several sloped roofs of several representative regions in China. The differences in snow-slide mechanisms between the northern and southern regions were analyzed. The sliding events in the northern regions, which were uncorrelated with snowfall, were more evenly distributed than those in the southern regions. However, the sliding events in the southern regions were relatively concentrated and mainly occurred several days after snowfall. The effects of roof slope are analyzed. The mechanism of snow slide caused by change of snow energy content is discussed. Roof slope is found to affect slide snow/ice load significantly.

Keywords: slide snow/ice load, sloped roof, snowmelt model for building roofs

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Web site: http://www.tongji.edu.cn/english/

Short biography: 2010.12- present: Associate professor, State Key Laboratory for Disaster Reduction in Civil Engineering, Tongji University, Shanghai, China.
2009.12-2010.12: Assistant professor, State Key Laboratory for Disaster Reduction in Civil Engineering, Tongji University, Shanghai, China.
2008.11-2009.11: Visiting scholar, The Alan G. Davenport Wind Engineering Group of the Boundary Layer Wind Tunnel Laboratory (BLWTL), The University of Western Ontario, Ontario, Canada.
2004.03-2008.11: Assistant professor, State Key Laboratory for Disaster Reduction in Civil Engineering, Tongji University, Shanghai, China.
2000.07-2004.03: Ph. D. in Structural Engineering,Tongji University, Shanghai, China.
1997.07-2000.09: M. S. in Structural Engineering, Harbin Institute of Technology, Harbin, Heilongjiang province, China.

R&D areas/s: 06. Icing on masts, towers and buildings

1993.07-1997.09: B. A. in Civil Engineering, Changsha University of Science and Technology, Changsha, Hunan province, China.

R&D areas/s: 03. Icing measurements, modelling and forecasting (incl. climate change), 12. Other topics related to icing, ice morphology

Ripples on Icicles

Lasse Makkonen, VTT

Antony Szu-Han Chen (SAIT, Calgary, Canada), Stephen W. Morris (University of Toronto, Toronto, Canada), Lasse Makkonen (VTT, Finland)

We present the results of the first comprehensive study of the origin and dynamics of the ripple patterns that form on the exterior of icicles. We find that the main determining factor of ripple formation is water purity. Icicles grown from distilled water have no measurable ripples, while those grown from very slightly salty water have clear ripples which are first observed at the remarkably low wt/wt concentration of 10^(-5). The speed of ripple growth increases roughly logarithmically as a function of concentration. The wavelength of the ripples was always found to be very close to 1cm, independent of impurity concentration. Ripples moved upward on the icicle for low impurity concentrations and downward for larger ones. Ripple growth and dynamics were not strong effected by altering the surface tension by the addition of a surfactant. These observations are inconsistent with existing theories of ripple formation which do not account for impurities.
See
A. S.-H. Chen and S. W. Morris, New Journal of Physics, 15, 103012 (2013),
http://dx.doi.org/10.1088/1367-2630/15/10/103012
Data available online:
http://www.physics.utoronto.ca/Icicle_Atlas

Web site: http://www2.vtt.fi/people/lasse_makkonen.jsp?lang=en

Short biography: Dr. Makkonen background is in geophysics, meteorology and ice research but his approach is multidisciplinary. He is best known for his work in modeling of icing of structures with applications to power lines, communication towers, ships and wind turbines. These models are applied worldwide in the design of structures. Dr. Makkonen has published more than 230 scientific papers out of which 70 in international journals and he is an author of 11 patents.
Dr. Makkonen's present main interest is in microphysics of surface phenomena such as phase change, friction and adhesion. The applications include solidification processes in all scales, particularly as they relate to accretion of ice and snow. Another present interest area of Dr. Makkonen is the theory of extreme value analysis and its application to evaluating structural safety and strength of materials.

BACK

R&D areas/s: 01. R&D programs, overviews, 03. Icing measurements, modelling and forecasting (incl. climate change), 04. Icing climates - standards, 07. Icing on power lines

Fault statistics on overhead transmission lines in Russia because of icing

Sergey Chereshnyuk, Research and Development Center at Federal Grid Company of Unified Energy System (R&D Center @ FGC UES), Moscow, Russia

Vladimir LUGOVOI (R&D Center @ FGC UES, RU), Larisa TIMASHOVA (R&D Center @ FGC UES, RU)

During overhead transmission lines operation, technical failures can occur. Depending on the character and heaviness of failure, it is possible to distinguish accident and incident. Investigation results are formalized with the “Technical failure investigation act”. This act contains the following main sections:
- Address section – with main info on failure: day and time of failure beginning, location, damage, etc.
- Description section – with network operating conditions before failure, failure beginning and development, failure causes, damages description;
- Damaged equipment description section – with information on damaged equipment type, brand and technical parameters.

A large portion of failures are caused by impact of atmospheric (climatic) conditions. These typically are wind, icing, combined ice-wind impact, lightning, temperature impact.
In the article, it was made an attempt to assess failure rate caused by icing. The analysis of the failure rate of overhead line components (towers, conductors, ground wires, insulators and line hardware) at 110-750 kV was done for the period from 1997 till 2007.
Failure statistics analysis has showed that during the above mentioned period, 9948 event of overhead line’s components failures happened, including:
- 110 kV – 7953 (84,2%);
- 220 kV – 1185 (12,5%);
- 330 kV – 110 (1,2%);
- 500 kV – 164 (2,0%);
- 750 kV – 7 (0,1%).

Main failure causes are the following:
- outside interference (influence) (trees falling, running-down accidents, vandalism, etc.) – 26,2%;
- ice loads and combined ice-wind loads – 17,6%;
- lightning overvoltages – 15,2%;
- failures caused by technical condition of overhead line components.

So, failures caused by icing are the second cause on total quantity of OHL failures.
OHL and it’s elements failures analysis are necessary for the development of reliability improvement measures.

Web site: http://www.ntc-power.ru/

Short biography: Graduated in meteorology at Moscow State University in 2000.
February 2000 – present - senior researcher at Research and Development Center at Federal Grid Company.
The job responsibilities involve
- Methodology and guidelines development for electric power engineers
- Development of Technical Specification for Scientific Research
- Automation of scientific calculations
- Analysis of huge data bulk
- Statistical analysis of data
- Mathematical modelling and programming
- Database architecture design and programming
- Programming of dedicated software field-specific
- Participation to Commission for analysis of incidents in Electric Power network
- Field work surveying electric power objects, overhead transmission lines and substation
- Lecturing in International Conferences (CIGRE, IWAIS)
- Participation with papers and presentations in more than 20 scientific conferences within Russia and CIS
- Review of articles for confirmation of scientific novelty

R&D areas/s: 01. R&D programs, overviews, 03. Icing measurements, modelling and forecasting (incl. climate change), 04. Icing climates - standards, 07. Icing on power lines

- Development of projects using geographical information systems (GIS)
- Document filling for tender participation
- Project dedicated Team setting up
- Assignment and supervision of work to a team of executors
- Project management of work developed over a time spam of many years
- Academic networking

BACK