

18th NORDIC
PROCESS CONTROL
WORKSHOP 2013
Oulu Finland



NORDIC PROCESS CONTROL (NPC)



PROCEEDINGS

18th Nordic Process Control Workshop

22 – 23 August 2013

University of Oulu

Oulu, Finland

Editors: Jenő Kovács, Matias Hultgren



OULUN YLIOPISTO
UNIVERSITY of OULU

CONTENTS

CONTENTS	2
WELCOME	3
ABOUT THE ORGANIZER	4
ABOUT THE NPCW	5
NPC AWARD	6
CONFERENCE PROGRAM	7
PARTICIPANTS.....	8
TUTORIAL DAYS	9
SCIENTIFIC PROGRAM	10
TECHNICAL VISIT.....	13



WELCOME

Welcome to the 18th Nordic Process Control Workshop!

Welcome to the University of Oulu!

Welcome to Oulu, the capital of Northern Finland!

The Nordic Process Control Workshop (NPCW) is organized for the 18th time in Oulu, the hub of Northern Finland. The workshop provides an excellent possibility for academics, postdoctoral researchers, PhD researchers and industrialists to discuss the progress of advanced process control and make connections between academy and industry. The program starts with a two-day Tutorial on 20-21 August, 2013: Algorithms with focus on PFC (Predictive Functional Control) by former NPC award winner Dr. Jacques Richalet. The scientific contributions of the 18th NPC Workshop will be presented on 22-23 August, 2013. The main focus of the scientific meeting is on process modelling, simulation, optimization and control. The University of Oulu will host the Workshop.

It is our pleasure to welcome you to the 18th Nordic Process Control Workshop!

Jenő Kovács

Laura Niva

Matias Hultgren

Enso Ikonen

<http://www.oulu.fi/npcw2013/>



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Suomen Automaatioseura
Finnish Society of Automation



ABOUT THE ORGANIZER

The University

The University of Oulu (Oulun yliopisto in Finnish) was founded in 1958. It has six faculties with a total of approximately 17,000 students and 3,000 staff, making it the second largest university in Finland. The University of Oulu is an international research and innovation university engaged in multidisciplinary basic research and academic education. The fields of Information Technology; Biosciences and Health; Cultural Identity and Interaction; and Environment, Natural Resources and Materials have been defined as special research focus areas. The University of Oulu cooperates closely with industry and commerce and has connections with hundreds of international research and educational institutions. The NPCW will be held in the Saalasti Hall (Saalastinsali, HR 145), which is located in the main building of the University of Oulu Linnanmaa Campus and marked in red on the university [map](#). The tutorial days take place in classroom TF 103 (red). More information for visitors is available [here](#).

The City

The city of Oulu is located by the Gulf of Bothnia at the mouth of the Oulu River, which is an ancient trading site. The city was founded in 1605 by King Carl IX of Sweden and has been a provincial capital since 1776. The name “Oulu” comes from a word in the Sami language meaning floodwater. Up to the end of the 19th century, Oulu was a significant centre for the wood tar trade. Tar was exported throughout Europe, where it was used mainly for waterproofing wooden ships. In the 1860s Oulu had the largest fleet of merchant ships of any Finnish city. Today, Oulu has evolved into a city with a population of approximately 190,000, making it the fifth largest city in Finland. What sets Oulu apart from other Finnish cities is its youthful age structure: there is a constant influx of students and job applicants, and nativity has always been high in the region. Oulu is internationally known as a city of technology and it has become one of the most important centres of competence in Northern Europe, as a notable amount of high technology know-how has concentrated in the area. Cooperation between enterprises, research, education and public organizations has produced significant results. Indeed, the city combines Northern hospitality, nature, a lively cultural climate and modern technology.



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ABOUT THE NPCW

General Info

The Nordic Working Group on Process Control (NPC Working Group) was founded on October 24, 1994. The Group initiates activities in order to strengthen the ties between the Nordic process control communities. One activity of the Working Group is to propose the location, date and organizers of an annual or semi-annual "Nordic Process Control Workshop", which brings together leading academics, researchers and industrialists mainly from the Nordic countries.

[More information](#) on the Nordic Working Group on Process Control.

The IPC members

Bjarne Foss (Norway)

Kurt-Erik Häggblom (Finland)

Tore Hägglund (Sweden)

John Bagterp Jørgensen (Denmark)

Bernt Lie (Norway)

Enso Ikonen (Finland)

Jenö Kovács (Finland)

Sirkka-Liisa Jämsä-Jounela (Finland)

Sigurd Skogestad (Norway)



NPC AWARD

The NPC Working Group awards the "Nordic Process Control Award" to persons who have made a lasting and significant contribution to the field of process control.

Nordic process control award recipients

1. [Howard H. Rosenbrock](#) (Aaland, Finland, Aug. 1995)
2. [Karl Johan Åström](#) (Wadahl, Norway, Jan. 1997)
3. [F. Greg Shinskey](#) (Skeviks Gård, Stockholm, 24 Aug. 1998)
4. [Jens G. Balchen](#) (Lyngby, Denmark, 14 Jan. 2000)
5. [Charles R. Cutler](#) (Åbo, Finland, 23 Aug. 2001)
6. [Roger W. Sargent](#) (Trondheim, Norway, 09 Jan. 2003)
7. [Ernst Dieter Gilles](#) (Gothenburg, Sweden, 19 Aug. 2004)
8. [Manfred Morari](#) (Lyngby, Denmark, 26 Jan. 2006)
9. [Jacques Richalet](#) (Espoo, Finland, 23. Aug. 2007)
10. [John MacGregor](#) (Porsgrunn, Norway, 29 Jan. 2009)
11. [Graham Goodwin](#) (Lund, Sweden, 26 Aug. 2010)
12. [Lawrence](#) ("Larry") T. [Biegler](#) (Lyngby, Denmark, 26 Jan. 2012)

The NPC award winner in 2013 is

James B. Rawlings, from the University of Wisconsin-Madison



CONFERENCE PROGRAM

Tuesday, 20 August, 2013

09:00-17:00

17:00-18:00

Wednesday, 21 August, 2013

09:00-17:00

18:30-

Thursday, 22 August, 2013

09:00-09:15

09:15-09:30

09:30-10:15

10:15-17:00

17:00-18:00

19:30-24:00

Friday, 23 August, 2013

09:00-16:00

16:00-17:00

Tutorial Day 1

Dr. Jacques Richalet: Algorithms with focus on PFC (Predictive Functional Control), Part 1

Technical visit possibility 1

Tutorial Day 2

Dr. Jacques Richalet: Algorithms with focus on PFC (Predictive Functional Control), Part 2

Get Together Reception

18th Nordic Process Control Workshop

Welcome to 18th NPCW

NPC Award Ceremony for J.B. Rawlings

Keynote lecture by J.B. Rawlings

18th NPCW contributions

NPC Working Group meeting

Technical visit possibility 2

NPC Dinner

18th Nordic Process Control Workshop

18th NPCW contributions

Closing ceremony and invitation to 19th NPCW



PARTICIPANTS

1	Aaltonen	Harri		Finland	33	Lindholm	Anna		Sweden
2	Airikka	Pasi		Finland	34	Mauricio-Iglesias	Miguel		Denmark
3	Backi	Christoph	J.	Norway	35	Mayer	Martin		Austria
4	Boriouchkine	Alexandre		Finland	36	Minasidis	Vladimirov		Norway
5	Böling	Jari		Finland	37	Mocha	Karl		Germany
6	Carstensen	Anna-Maria		Sweden	38	Mousavi	Hossein		Sweden
7	Frison	Gianluca		Denmark	39	Nielsen	Morten	S.	Denmark
8	Garpinger	Olof		Sweden	40	Oliveira	Vinicius	de	Norway
9	Ghosh	Ramkrishna		Finland	41	Petersen	Lars	N.	Denmark
10	Grimholt	Chriss		Norway	42	Pozo Garcia	Octavio		Finland
11	Halvgaard	Rasmus		Denmark	43	Price	Jason		Denmark
12	Hast	Martin		Sweden	44	Rawlings	James		USA
13	Hultgren	Matias		Finland	45	Richalet	Jacques		France
14	Huusom	Jakob		Denmark	46	Ruuska	Jari		Finland
15	Hägglund	Tore		Sweden	47	Segovia	Vanessa	Romero	Sweden
16	Ikonen	Enso		Finland	48	Selek	István		Finland
17	Jacobsen	Elling		Sweden	49	Shirdel	Ämirhossein		Finland
18	Jegoroff	Mikko		Finland	50	Skogestad	Sigurd		Norway
19	Johansen	Daniel	Witt	Denmark	51	Škrjanc	I.		Slovenia
20	Johnsson	Ola		Sweden	52	Sokoler	Leo	Emil	Denmark
21	Juslin	Kaj		Finland	53	Sorsa	Aki		Finland
22	Jämsä-Jounela	Sirkka-Liisa		Finland	54	Standardi	Laura		Denmark
23	Jørgensen	John	B.	Denmark	55	Szabó	Zádor		Hungary
24	Karlström	Anders		Sweden	56	Szentannai	Pal		Hungary
25	Kause	Risto		Finland	57	Trollberg	Olle		Sweden
26	Knudsen	Jørgen	K.H.	Denmark	58	Tushar	Jain		Finland
27	Kortela	Jukka		Finland	59	Vatanski	Nikolai		Finland
28	Kortesuoma	Riitta-Liisa		Finland	60	Wik	Torsten		Sweden
29	Kovács	Jenö		Finland	61	Yli-Korpela	Antti		Finland
30	Kufoalor	Kwame	Minde	Norway	62	Yu	Miao		Finland
31	Landman	Rinat		Finland	63	Zakharov	Alexey		Finland
32	Lie	Bernt		Norway					



TUTORIAL DAYS

Algorithms with focus on PFC (Predictive Functional Control)

Tutorial before the Nordic Process Control (NPC) Workshop in Oulu, Finland

August 20/21, 2013

Dr. Jacques Richalet
Consultant
3 allée des Nourets
78430 Louveciennes - France
jacques.richalet@wanadoo.fr

Day 1

9:00 Introduction of the participants
9:15 PFC (Predictive Functional Control): origin, principle, basic algorithm
10:45 *Break*
11:00 Practical Matlab implementation: 70 Matlab files
12:30 *Lunch*
13:30 Practical extensions of PFC: dead zone control, constraints etc.
15:00 *Break*
15:15 Feed-forward control with measured and estimated disturbance
16:30 Discussion: How to proceed in practice?
17:00 *End*

Day 2

9:00 Modelling: Practical test signal procedure. Iso-distance in the state space
10:45 *Break*
11:00 Different industrial applications, discussion
12:30 *Lunch*
13:30 Predictive multivariable control (Presented by the Group of Prof. I. Škrjanc, Laboratory of Modelling, Simulation and Control, Univ. of Ljubljana, Slovenia)
15:00 *Break*
15:15 Case studies and industrial realization of PFC (Presented by M. Mayer, Evon Automation GmbH, 8200 Gleisdorf, Austria)
16:30 Consultation
17:00 *End*

References:

1. Richalet, J., O'Donovan D. (2009). Elementary predictive functional control, Springer, Berlin, 222 p.
2. Haber, R., Bars R., Schmitz U. (2011). Predictive Control in Process Engineering. From the Basics to the Applications. Wiley-VCH, Weinheim, Germany, 629 p.

The basics of the algorithms are explained in the two books cited. During the [lectures](#), the participants get some additional written documents (in paper form) and some published papers. In most subjects programming and simulation exercises will be offered using Matlab ([files](#)). Tutorial [references](#).

SCIENTIFIC PROGRAM

18th NPCW, 22-23 August, 2013		University of Oulu, Oulu, Finland	
Thursday 22 August 2013			
8:00	9:00	Registration	
9:00	9:15	Welcome to 18th NPCW	
9:15	9:30	NPC Award Ceremony for J.B. Rawlings	
9:30-10:15 Keynote lecture by Professor J.B. Rawlings. Chair: Sigurd Skogestad			
10:15	10:30	Coffee break	
10:30-12:10 Session 1: Control Theory. Chair: Tore Hägglund			
10:30	10:50	The importance of the modeling method in optimal PID tuning	Garpinger O., Hägglund T., Åström K. J. PDF
10:50	11:10	Systematic controlled variable selection for a reactor-separator-recycle process	Minasidis V., Jäschke J., Skogestad S. PDF
11:10	11:30	Adaptive Iterative Learning Control for Discrete-Time Nonlinear Systems without Knowing the Control Gain Signs	Yu M., Jämsä-Jounela S.-L. PDF
11:30	11:50	Multiple Stationary Solutions to the Extremum Seeking Control Problem	Trollberg O., Jacobsen E. W. PDF
11:50	12:10	Evaluation of Input Designs for MIMO System Identification Using Subspace Identification	Ghosh R., Böling J. M., Häggblom K. E. PDF
12:15	13:00	Lunch offered by Metso Corporation	
13:00-14:40 Session 2: Process Control 1. Chair: Jenő Kovács			
13:00	13:20	New Method for Controlling Combustion in a Grate Boiler	Jegoroff M., Leino T., Heiskanen V.-P. PDF
13:20	13:40	Input and State Estimation Tool for Dynamic CFB Models	Hultgren M., Kovács J., Ikonen E. PDF
13:40	14:00	Cost Function Formulation and Realization Methods for Optimum Control of Fluidized Bed Combustors	Szentannai P. PDF
14:00	14:20	PID and Predictive PID Control Design for Crushing And Screening	Airikka P. PDF
14:20	14:40	Practical Implementation of Advanced Process Control for Linear Processes	Knudsen J. K. H., Huusom J. K., Jørgensen J. B. PDF
14:40	15:00	Coffee break	
15:00-16:40 Session 3: Scheduling, Optimisation, Monitoring. Chair: Enso Ikonen			
15:00	15:20	An autonomous valve stiction detection system based on data characterization	Zakharov A., Zattoni E., Xie L., Pozo Garcia O., Jämsä-Jounela S.-L. PDF
15:20	15:40	Optimal control of mass/energy distribution networks under uncertainties	Selek I., Bene J. G. PDF
15:40	16:00	Hierarchical production scheduling in the process industry	Lindholm A., Nytzén N.-P. PDF
16:00	16:20	A strategy for controlling production-scale industrial fermentations	Johnsson O., Andersson J., Lidén G., Johnsson C., Hägglund T. PDF
16:20	16:40	Long term follow up of control performance in TMP processes	Karlström A., Eriksson K. PDF
17:00	18:00	NPC Group meeting / Technical visit to the OMS mini-pilot beneficiation process	
19:30-24:00 Conference Dinner			

Friday 23 August 2013

8:00 9:00 Registration

9:00-9:45 Keynote lecture by Professor J. Richalet. Chair: John Bagterp Jørgensen

9:45 10:00 Coffee break

10:00-11:00 Session 4: Predictive Control. Chair: Sirkka-Liisa Jämsä-Jounela

10:00 10:20 Predictive Functional Control (PFC) of a Heating Ventilation Air Conditioning (HVAC) Process

Kreutz M., Richalet J., Mocha K., Haber R.

[PDF](#)

10:20 10:40 Embedded Model Predictive Control: Moving an Industrial PC-based MPC to an Embedded Platform

Kufoalor D. K., Aaker V., Johansen T. A., Imsland L., Eikrem G. O.

[PDF](#)

10:40 11:00 Model predictive control utilizing fuel bed height model and moisture soft-sensor for the BioPower plant

Kortela J., Jämsä-Jounela S.-L.

[PDF](#)**11:00-12:15 Poster Session (see program)**

12:15 13:00 Lunch offered by Foster Wheeler Energia Oy

13:00-14:40 Session 5: Process Control 2. Chair: Bernt Lie

13:00 13:20 Optimization of substrate feeding for enzymatic biodiesel production

Price J., Huusom J. K., Nordblad M., Woodley J. M.

[PDF](#)

13:20 13:40 Analysis of splashing in Basic Oxygen Furnace through systematic modelling

Ruuska J., Sorsa A., Ollila S., Leiviskä K.

[PDF](#)

13:40 14:00 A case study of using radial basis function neural networks for predicting material properties from Barkhausen noise signal

Sorsa A., Santa-Aho S., Vippola M., Lepistö T., Leiviskä K.

[PDF](#)

14:00 14:20 Control of a Biological Nitrogen Removal Process in an Intensified Single Reactor Configuration

Vangsgaard A. K., Mauricio-Iglesias M., Gernaey K. V., Sin G.

[PDF](#)

14:20 14:40 Street heating: modeling for control

Lie B.

14:40 15:00 Coffee break

15:00-16:00 Session 6: eMPC. Chair: Jakob Kjøbsted Huusom

15:00 15:20 Introduction to economic MPC

Jørgensen J. B.

15:20 15:40 A Dantzig-Wolfe Decomposition Algorithm for Economic MPC of Distributed Energy Systems

Sokoler L. E., Standardi L., Edlund K., Jørgensen J. B.

[PDF](#)

15:40 16:00 Early Termination of Dantzig-Wolfe Algorithm for Economic MPC

Standardi L., Sokoler L. E., Poulsen N. K., Jørgensen J. B.

[PDF](#)**16:00-17:00 Closing Ceremony**

Poster session**23 August 2013, 11:00-12:15**

1	Implementation of gain scheduling controller(s) for a water level and temperature control	Aaltonen H.	PDF
2	Continuous-time Parameter Identification Using PI Controllers	Airikka P.	PDF
3	Optimal Neumann boundary control for a freezing process with phase change	Backi C. J., Gravdahl J. T.	PDF
4	A Modelling Framework for Conventional and Heat Integrated Distillation Columns	Bisgaard T., Huusom J. K., Abildskov J.	PDF
5	Biomass combustion for power generation: Dynamic modeling and full-scale industrial experiments	Boriouchkine A., Zakharov A., Huotari J., Jämsä-Jounela S.-L.	PDF
6	Excess light detection for greenhouse illumination control	Carstensen A.-M., Wik T., Pocock T.	PDF
7	Online optimization of the energy consumption in buildings	de Oliveira V., Jäschke J., Skogestad S.	PDF
8	Parallel Implementation of Riccati Recursion for Solving Linear-Quadratic Control Problems	Frison G., Jørgensen J. B.	PDF
9	Optimal PID-Control for First Order Plus Time Delay Systems & Verification of the SIMC Rules	Grimholt C., Skogestad S.	PDF
10	Dual Decomposition for Large-Scale Power Balancing	Halvgaard R., Jørgensen J. B., Vandenberghe L.	PDF
11	Convex-Concave Procedure for Design of PID Controllers	Hast M., Åström K.-J., Bernhardsson B., Boyd S.	PDF
12	A note on frequency spectrum analysis and finite-time stability of the time trajectory-based active fault-tolerant control	Jain T., Yamé J. J.	PDF
13	Model-based Adaptation of Nonlinear Control by using Intelligent Indices in Detecting Operating Conditions	Juuso E. K.	PDF
14	Data-Driven Causal Analysis and its application on a Large-scale Board Machine	Landman R., Jämsä-Jounela S.-L.	PDF
15	The Potential of Economic Model Predictive Control for Spray Drying Plants	Petersen L. N., Poulsen N. K., Niemann H. H., Utzen C., Jørgensen J. B.	PDF
16	The systematic experimental design scheme for mini-pilot beneficiation plant	Ruuska J., Hynynen I., Kuopanportti H., Leiviskä K.	PDF
17	Design of Measurement Noise Filters for PID Control	Segovia V. R., Häggglund T., Åström K. J.	PDF
18	System Identification in the Presence of Trends and Outliers	Shirdel A., Böling J. M., Toivonen H. T.	PDF
19	Runability Failure Analysis of a Continuous Digester	Yli-Korpela A., Ikonen E.	PDF
20	Integrated valve stiction detection system	Pozo Garcia O., Tikkala V.-M., Zakharov A., Jämsä-Jounela S.-L.	PDF
21	Stabilizing gain design for PFC with estimated disturbance feed-forward	Zabet K., Haber R., Mocha K.	PDF

TECHNICAL VISIT

During the NPCW tutorial and workshop days there will be two opportunities for NPCW participants to visit the recently constructed mini-pilot beneficiation plant of the Oulu Mining School (OMS):

Tutorial days: **Tuesday 20th August, 17.00-18.00**

NPCW days: **Thursday 22nd August, 17.00-18.00**



The continuous mini-pilot beneficiation plant of the OMS is a unique, university-based research platform for sustainable mining and mineral engineering. The 14 metre-long process line covers the whole beneficiation chain typical in most Finnish mines. The mini-pilot plant both optimizes the use of resources, and minimizes production costs as well as overall impacts on the environment. The beneficiation plant may be used for sulphide ore studies and education. However, the plant has great potential for a variety of different applications.

The mini-pilot innovation environment is used for education and research functions of the University of Oulu. Mining companies are a key target audience for the plant. The mini-pilot investment was funded by the University of Oulu and the Council of Oulu Region (from the European Regional Development Fund). Outotec Oyj together with Geological Survey of Finland has been the main planner and equipment supplier. Schneider Electric has delivered and supported electrification and automation.

For more information on OMS and the mini-pilot please write to: hannu.kuopanportti@oulu.fi