SIMS 2011

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Mälardalen University, Västerås September 29-30, 2011

2011-09-29

09:15-12:00 Mälardalen University, Room Beta

Welcome

09.15-09.25 *Rector Karin Röding*

Keynotes: *Chairman Key-note speaker: Erik Dahlquist*

09.25-10.15 Smart adaptive systems in nonlinear multivariable control and diagnostics

Prof. Esko Juuso
Oulu University, Finland

10.15- 11:05 Energy at Iceland from a modeling perspective

Mr. Jonas Ketilsson
R&D manager, Iceland energy agency, Iceland

11:05-11:10 Short break

Session ***Hydropower***
Chairman session on Hydro power: Mika Liukkonen, East Finland University

11:10- 11:35 The effect of compressibility of water and elasticity of penstock walls on the behavior of high head hydro power stations

Behzad Rahimi Sharefi, Wenjing Zhou, Bjørn Glemmestad, Bernt Lie,

Telemark University college, Porsgrunn, Norway

11:35-12:00 Modelling and control of a high head hydropower plant

Wenjing Zhou, Behzad Rahimi Sharefi, Bernt Lie, Bjørn Glemmestad
Telemark University college, Porsgrunn, Norway

12:00-13:00 LUNCH (with SIMS board meeting) Room: Kåren

13:00-18:00 Mälardalen University, Room Kappa

Session ***Water***
Chairman session on Water treatment: Esko Juuso, Oulu University, Finland

13:00-13:25 Modeling of aluminum in water treatment process

Jani Tomperi and Esko Juuso
University of Oulu Pelo Marja,Finnsugar, Finland

13:25 - 13:50 Considering culture adaptations to high ammonia concentration in ADM1

Wenche Bergland, Deshai Botheju, Carlos Dinamarca, Rune Bakke
Telemark University college, Porsgrunn, Norway

13:50-14:15 Dynamic modelling approach for detecting turbidity in drinking water

Petri Juntunen,Mikka Liukkonen, Markku Lehtola, Yrjö Hiltonen
University of Eastern Finland, Kuopio, Finland

14:15-14:40 Simulation of digestate nitrification based on cow manure

Deshaij Botheju, Yanni Qin, Knut Vasdal, Rune Bakke
Telemark University college, Porsgrunn, Norway

14:40-15:05 Trend analysis in dynamic modeling of water treatment

Esko Juuso
University of Oulu, Ilkka Laakso, StoraEnso Fine paper, Oulu, Finland

15:05-15:35 Coffee break

Session ***Energy conv***

Chairman session on Energy conversion: Rune Bakke, Telemark Univ College

15:35-16:00 Modeling and control of gas lifted oil field with five oil wells

Roshan Sharma and Bjørn Glemmestad
Telemark University College
Kjetil Fjalestad
Statoil, Porsgrunn, Norway

16:00-16:25 Stability Analysis of AGC in the Norwegian Energy System

Ingvar Andreassen and Dietmar Winkler
Telemark University College, Porsgrunn, Norway

16:25-16:50 Comparison of Control Limit Generation Approaches in Desulphurization Plant Monitoring

Riku-Pekka Nikula and Esko Juuso, University of Oulu, Anton Laari
Helsinki Energy, Porkkalankatu, Finland

16:50-17:15 Towaards multi fuel SOFC plants

Masoud Rokni, Lasse Clausen and Christian Bang-Møller,
Technical University of Denmark, Lyngby, Denmark

17:30 - 18:00 SIMS Annual general assembly

19:00 Dinner at Djäkneberget Restaurant

2011-09-30

08:30-11:55 Mälardalen University Room Milos

Keynotes: Chairman key notes: Erik Dahlquist

08:30-09:20 New trends in Automation

Mr. Erik Oja

Senior Vice President, head of Process Automation Division, ABB AB

09:20-10:10	Process industry center in linköping: Use of modeling for automation and control *Prof. Alf Isaksson* *Linköping University and ABB Corporate Research*
10:10-10:40	Coffee break
Session	***Diagnosis*** Mälardalen University Room Kappa *Chairman session on Diagnostics: Prof. Rebei bel Fdhila, ABB Corporate Research and MDU*
10:40-11:05	On-line application of diagnostics and maintenance on demand using simulation models *Elena Tomas Aparicio, Björn Widarsson, Erik Dahlquist* *Mälardalen Univ, Sweden*
11:05-11:30	Modeling Software for Advanced Industrial Diagnostics *Mika Liukkonen, Mikko Heikkinen, Yrjö Hiltunen, Teri Hiltunen, FosterWheeler, Jari Kapanen, Andritz* *Univ Eastern Finland*
11:30-11:55	Water contents of wood and peat based fuels by analysing the domain NMR data *Ekaterina Nikolskaya and Risto A. Kauppinen* *Univ of Bristol UK* *Leonid Grunin Mari* *State Technical University* *Yoshkar-Ola, Russia, Mika Liukkonen and Yrjö Hiltunen,* *Eastern Finland University, Finland*
11:55-12:55	Lunch
12:55-16:10	Mälardalen University Room Kappa
Session	***Energy systems*** *Chairman session on Energy systems: Eva Thorin, MDU*
12:55-13:20	Modeling, Simulation and Control for an Experimental Four Tanks System using ScicosLab

	Carlos Pfeiffer *Telemark University College, Porsgrunn, Norway*
13:20-13:45	Simulation of a Bubble Plume in a Water Vessel With and Without Internal Liquid Recirculation
	Rebei Bel Fdhila *Mälardalen University and ABB Corporate Research, Sweden*
13:45-14:10	Dynamic modelling of a pulp mill with a BLG plant - effects in the chemical recovery cycle
	Christian Hoffstedt and Niklas Berglin, *Innventia, Stockholm, Sweden*
14:10-14:45	Retention time and nutrient tracking inside a digester for biogas production
	Johan Lindmark and Eva Thorin, Rebei Bel Fdhila *Mälardalen University, Västerås, Sweden*
Session	***Solar and others*** *Chairman session on applications and tools: Fredrik Wallin, MDU*
14:45-15:10	Developing a computer program for the estimation of the incoming sun beam by defining a special coeficient factor for Denizli, Turkey
	G. Uckan, H. K. Ozturk, E. Cetin *Pamukkale University, Denizli, Turkey*
15:10-15:35	OMSketch — Graphical Sketching in the OpenModelica Interactive
	Mohsen Torabzadeh-Tari, Jhansi Reddy Remala, Martin Sjölund, Adrian Pop, Peter Fritzson *Linköping University, Linköping, Sweden*
15:35-16:00	Etiology of Rey generator stator core failure and study of its rehabilitation integrity
	Kourosh Mousavi Takami *Pasad Parang Co., Tehran, Iran*
16:00-16:10	Closing remarks - Esko Juuso, Erik Dahlquist

Abstract

Paper 1

Title: On-line application of diagnostics and maintenance on demand using simulation models

Erik Dahlquist, Elena Tomas Aparicio, Björn Widarsson
Mlardalens Hgskola, Sweden

Keywords: Diagnostics, modelling, simulation, boiler, CFB, decision support, BN

The need for early fault detection and effective maintenance operations in the industry makes us think about developing tools that that can handle the uncertainty of the processes and improve the maintenance scheduling. Among other decision support tools, Bayesian Networks (BN) is a method that can handle the uncertainty in industrial processes. If we add on-line physical models to this method, a significant tool for plant personal to detect and analyze possible process faults can be obtained.

The aim of this project was to develop and demonstrate an application for diagnosis and decision support that is implemented and running on-line. The application was implemented in a Circulating Fluidizing Bed (CFB) at Mälarenergi AB.

First a model in Modelica language was built and verified towards process data. The differences between measured and simulated values for different variables were given as an input into a Bayesian Network model where the probability for different faults within the process was determined.

The advantage of the application is that the combination of model based diagnostics and decision support can be used to schedule equipment and sensor maintenance. Moreover the application is used on-line which allows evaluation of the system under real circumstances.

Results from running the system shows that several different type of faults could be determined simultaneous. 16 different variables were followed and analysed in parallel.

Paper 3

Title: Modelling of Oxyfuel Combustion Processes with Aspen Plus

Arshe Said, Timo Laukkanen, Sanni Eloneva, Carl-Johan Fogelholm
Aalto University, Finland

Keywords: Oxyfuel, Process modeling, Aspen Plus

Oxy-fuel combustion is suggested as one of the most promising technologies for capturing carbon dioxide, CO2 from power plants. In the oxy-fuel combustion concept nitrogen is separated from oxygen in order to generate a nitrogen free combustion medium (95 % -wt of O2 and 5 %-wt of Ar). The flue gas produced from the combustion chamber thus consists primarily of carbon dioxide and water. Much research on the different aspects of an oxy-fuel power plant has been performed during the last decade. Focus has mainly been on retrofits of existing coal fired power plant units. The objective of this paper is to model different process

units of an oxyfuel combustion process by using Aspen Plus®. In the paper we will illustrate the effect of different process parameters and how they may contribute to overall performance of the plant.

Paper 4

Title: Retention time and nutrient tracking inside a digester for biogas production

Johan Lindmark, Rebei Bel Fdhila, Eva Thorin
Mälardalen University, Sweden

Keywords: Biogas, Mixing, Digester, CFD, Retention time, Nutrition

A large proportion of today's biogas plants are continuous stirred tank reactors (CSTR) and they are usually assumed to be perfectly mixed. Based on this assumption the retention time of the biogas plants and the organic loading rate are estimated. However, there can be large inconsistencies in the mixing parameters leading to local variations in the mixing pattern and in mixing intensity. These variations can lead to an uneven distribution of nutrients and microbiological activity inside the digester.

The digester is the heart of the biogas process where the organic material is broken down in steps to simpler compounds and finally to the energy rich gas methane. By controlling the environment for the microorganisms inside the digester the fermentation process can be improved with an increased capacity as a result. The mixing inside the digester is one of the most important measures of control available.

Several investigations have shown that the mixing inside the digester has a direct effect on the biogas yield and that the result is affected by the dry solid content of the mixture. At low dry solid content the mixing could possibly be handled by the naturally occurring mixing and only small improvements can be made by increasing the mixing.

Mixing becomes more important at higher total solid content and can affect the gas yield considerably. Previous studies, using a manure slurry with a total solid content of 10% as substrate, have shown that increased mixing can improve the gas yield by 29%, 22% and 15% compared to an unmixed digester by mixing with slurry recirculation, impeller mixing and gas injection respectively. Higher total solid contents can of course also lead to other problems in an unmixed digester like sedimentation or problems with a flouting layer.

In this study the retention time and dispersion of the feed inside the digester at the Växtkraft biogas plant in Västerås, Sweden, is studied using Computational Fluid Dynamics (CFD) to understand the effect that the mixing has on the process. This work provides the distribution of nutrition and how the nutrient disperses inside the digester. The impact of mixing is evaluated by comparing experiments and simulations of the flow and mixing intensity with simulations of the nutrient content inside the digester.

Paper 5

Title: Modeling Software for Advanced Industrial Diagnostics

Mika Liukkonen, Mikko Heikkinen, Teri Hiltunen, Jari Kapanen, Yrjö Hiltunen

University of Eastern Finland, Finland

Keywords: Software, Process, Analysis

The energy efficiency of industry is recognized nowadays as a highly important matter because of tightening environmental legislation (Directive 2009/29/EC) and increasing fuel costs. One of the key issues in this respect is to minimize the emissions released from processes. The increasing demands for process efficiency and the efforts to reduce harmful emissions have generated a number of challenges for industrial plants, and new kind of tools are needed to meet those challenges. Process data archives provide a potential source of information which can be utilized in optimization, improvement of productivity and reduction of emissions. Data-driven modeling is currently considered a useful way of diagnosing industrial processes in a diverse field.

We have presented earlier a modelling and optimization system, which can be used in monitoring and optimization of power plants and which is implemented on the Matlab-software platform (Mathworks, Natick, MA, USA). The software has been under constant development, and it currently includes new tools which are considered useful in diagnosing, not only combustion processes, but also other industrial processes. In the paper we will concentrate on those parts which are the latest advancements in the software. These include correlation analysis, calculation of process lags, variable selection and multivariate regression modelling.

The software consists of the following main parts:
• Data import: import and export data, rename and preselect variables etc.
• Data pre-processing: remove constants, filter, interpolate, create derivatives, change resolution of data etc.
• Data visualization: simple plotting, scatter plots, histograms, statistics
• Correlations and lags: calculate correlations, define changing correlations, define time lags
• Variable selection: select the most important variables using regression
• Modelling: multivariate regression, artificial neural networks

We will demonstrate the use of the software by analyzing a data set from a 63 MWth circulating fluidized bed (CFB) boiler fired by demolition wood. The data set includes 49 variables, has a resolution of 15 minutes and covers a one month’s operational period of the boiler.

In the search for solutions to current environmental problems, it is evident that industrial processes have to become more energy efficient and environmentally friendly. Energy plants, for example, will have to be able to produce their energy with less emissions of harmful gas in the future. This necessitates the development of novel systems for process diagnostics. The software presented here provides a fast way of analyzing a large amount of process data and the results show that it provides a useful modeling tool for industrial applications. The software can be utilized in advanced process diagnostics which can become a part of the service business of plant manufacturers, for example.

Paper 6

Title: WATER CONTENTS OF WOOD AND PEAT BASED FUELS BY ANALYSING TIME DOMAIN NMR DATA

Ekaterina Nikolskaya, Mika Liukkonen, Jukka-Pekka Männikkö, Risto Kauppinen, Leonid Grunin, Yrjö Hiltunen
University of Eastern Finland, Finland

Keywords: NMR, Water content, Biofuels, Wood, Peat

The water content (WC) of fuel in particular is one of the most important quality parameters for biofuels, such as wood and peat. However, a good online method to quantify the water content is currently unavailable because of complex nature of biological water. For example in wood, water can be mainly in three different forms; liquid in pores (free water), physical and chemical bonded in cell walls (bonded water) and vapour in pores. Water can also be on the surface of wood, when water content is above 60%, or in the ice form, when temperature is below 0 oC. Earlier water content measurements from biofuels using NMR have shown that it could be potentially the method-of-choice for quantifying water. Important questions to be addressed include whether NMR method are cost effective and practical in industrial settings.

A portable low-resolution nuclear magnetic resonance (NMR) analyzer has been purchased at the University of Eastern Finland for testing the NMR method for applicability for industrial measurements of water content. The permanent magnet of 0.5 T has dimension of 140x190x150 mm weighting 19 kg. Water content measurements were made over a broad range of moisture contents for several genuine fuels from an energy company. The wood and peat samples were ground into powder for NMR samples. The sample volume was approximately 1.5 cm3. NMR measurements were compared with the standard method for water content determination, in which the mass of the sample is measured before and after oven drying at reduced pressure.

Free Induction Decay (FID) signals were acquired for all samples and three values for each magnitude FID were calculated as follows: (1) the long time constant component Al of FID. (2) The short time constant component As of FID. (3) The ratio of Al / As. The As and Al values and (Al/As) ratio were calculated for all samples. The reference water content was determined as a function of the (Al/As) ratio for each sample. There was a clear 2th order relationship between these values (R2 = 0.987). Water content values of fuels using NMR data and the model were in good agreement with water content measurements with the standard test employing oven drying. The correlation coefficient between these two methods was 0.997 and the RMS error 1.14 %. The errors can be partly due to procedures used in NMR measurement and partly due to the oven drying method. The same measurements have been made for peat samples.

The current results show that one can use the same model for a variety of samples, which indicates that the NMR method can be used without additional calibration both for different kinds of samples. The calibration needs to be performed only once for given NMR probe and NMR device setup, which makes the method user-friendly and fast to implement.

The results of the study demonstrate that the NMR method is as accurate as the gold-standard test. Importantly, NMR water content measurement can be performed in 15 seconds, in contrast to the oven drying which takes up to 20 hours. Our results show that the NMR method can be successfully applied to water content measurements of wood fuels with a great potential for industrial scale application.

Paper 7

Title: Modeling and control of gas lifted oil field with five oil wells

Roshan Sharma, Kjetil Fjalestad, Bjørn Glemmestad
Telemark University College, Norway

Keywords: Gas lifted oil wells, cascade control, droop control, dynamic modeling, simulation

Distribution and control of lift gas available for a cluster of gas lifted wells in an oil field is necessary for maximizing total oil production. This paper describes a simple dynamic model of the oil field developed from mass balances at different sections of the oil wells. Dynamic behavior of the oil wells is studied by open loop simulations. For proper distribution of the available gas, the pressure of the common gas distribution manifold and the lift gas flow rates through each gas lift choke valves should be controlled when there is variation in the supply of the lift gas. Four control strategies namely cascade control, droop control, droop control with integral action and pressure control with one swing producer are presented. The total available lift gas will be completely utilized by the five oil wells without demanding any extra gas requirement.

Paper 8

Title: Simulation of a Bubble Plume in a Water Vessel With and Without Internal Liquid Recirculation

Rebei Bel Fdhila
ABB, Sweden

Keywords: computational fluid dynamics, bubbly flow, bubble plume, peudo-turbulence, liquid recirculation

Bubbly flows are encountered in a large number of industrial applications including chemical, biological, metallurgical, nuclear and environmental processes among others. Bubble plumes have important properties, as cleaners in continuous casting when they transport the undesired non metallic particles to the surface of the melt, as mixers because of their buoyancy induced recirculation in fermentors for example or as turbulence producers due to their oscillating interfaces and zigzagging and unstable motion which creates its own turbulence and agitation needed by many processes, etc.

Small bubbles of micrometric size in liquids have been thoroughly studied. Well established mathematical models for isolated bubbles or for cases where the void fraction is very small exist and are used to simulate these flows when encountered. Larger bubbles are not spherical. Depending on their size they become ellipsoidal, oblate, spherical caps ... and can even have very fast changing shapes depending on the flow where they are immersed. For these categories the mathematical models are less accurate and do not cover all flow configurations. In this study we consider bubbles in the range [1-10mm] and a maximum local gas volume fraction of 10%. Computational fluid dynamics (CFD) is used to study the effect of bubble size, gas flow rate and internal liquid recirculation induced by immersed pumps. The turbulent fluid flow and continuity equations are numerically solved using a commercial package based on finite volumes approach.

Our simulations have addressed a lab facility used in [1] where a cylindrical vessel of 1m diameter and 1.5 m height was filled with water until 0.85m height. The air injector was

moveable and positioned at the bottom and the gas flowrate was adjustable.

Some of the published cases are simulated and compared with the measured data. It was found that when the internal liquid recirculation is sufficiently intense compared to the flow induced by the bubbles the simulation results are in agreement with the measured quantities in [1]. However, for the cases where the bubbles are the governing force we show that there is no agreement between the predictions and the experimental results.
This contribution is to underline that for these flow regimes encountered in several processes, not considering properly the pseudo-turbulence (the turbulence induced by the bubbles) is a major limitation for flow predictions. A simple implementation of the basic model of this turbulence phenomena as described in [2] can improve significantly the simulated results.

1. Bel Fdhila, R., Sand, U., Rahmani, M. A., Yang, H., Eriksson, J.-E., "Model Study of Combined Gas and Electromagnetic Stirring in a Ladle Furnace", 4th International Conference on Modelling and Simulation of Metallurgical Processes in Steelmaking (STEELSIM), 27th June – 1st July 2011, Düsseldorf, Germany
2. Sato, Y., Sekoguchi, K., "Liquid Velocity Distribution In Two-Phase Bubbly Flow", Int. J. Multiphase Flow, vol.2, pp. 79-95, 1975.

Paper 9

Title: Comparison of Control Limit Generation Approaches in Desulphurization Plant Monitoring

Riku-Pekka Nikula
Fault detection, statistical process control, desulphurization plant, University of Oulu, Finland

Keywords: process monitoring

Early detection of faults and changes in the operation of an industrial plant brings financial benefits, improves safety and facilitates the observance of environmental regulations. In this study, statistical approaches to generation of control limits for process measurements are considered. Exceedings of the limits are monitored to detect an abnormal state in the process. Methods which are capable of updating the limits in real time according to the current operating mode give a practical solution to continuous monitoring. In a case study, statistical methods are used in desulphurization plant monitoring. Two reactors of the plant are monitored using control limits generated by different methods. The results show that a fault connected to operation of the other reactor can be detected by combining the control limit exceedings of the measurements in both reactors. Graphical presentation of the combined control limit exceedings offers promising assistance for operator’s decision making.

Paper 10

Title: THE EFFECT OF COMPRESSIBILITY OF WATER AND ELASTICITY OF PENSTOCK WALLS ON THE BEHAVIOR OF A HIGH HEAD HYDROPOWER STATION

Behzad Rahimi Sharefi, Wenjing Zhou, Bjørn Glemmestad, Bernt Lie
Telemark University College, Norway

Keywords: Hydropower, Modeling and Simulation, Finite Volume Method

A high head hydropower generation unit typically consists of reservoir, waterway (head-race tunnel, surge shaft, penstock, turbine case and draft tube, and tale-race), turbine, and generator. The overall system is highly non-linear and its controller is usually designed for stability and best performance at the best-efficiency operating point using a linearized model. For having a stable operation and acceptable performance at the other operating points it may be necessary to change the controller parameters when the operating point of the system changes.

It is important to be able to model and simulate the system as accurately as possible. With an accurate model, a designed controller can be tested more reliably for stability and performance in different operating points. Different models with different degrees of complexity have been published [1]. The simple models consider rigid penstock walls with incompressible water column in the penstock. A more accurate model can be obtained if a penstock with elastic walls and compressible water column in the penstock is considered. Such a penstock can be modeled by two nonlinear partial differential equations. These equations can be linearized and solved by the Method of Characteristics (MOC) [2]. Numerical methods can also be used for solving these equations. Some software solutions such as WHAMO [3] and Hydro-Plant Library [4] are available for numerical simulations.

In this paper, first various parts of a typical high head hydropower generation unit and their functionality will be described briefly. Then modeling and numerical methods available for simulation of such system will be described in some detail. Specifications of the system under study will be as follows:

- elastic walls and compressible water column in the penstock
- rigid (inelastic) walls and incompressible water in other parts of the waterway (due to less pressure variations or short distances)
- the standard IEEE1992 model for turbines [5]
- synchronous generator connected to an infinite bus
- conventional PID controller with speed droop characteristics

In simulation of the penstock with elastic walls and compressible water column, the emphasis will be on the Finite Volume Method of Computational Fluid Dynamics [6]. The overall system will be simulated and the effect of compressible water in the penstock and with elastic penstock walls will be studied.

References:
[1]. Nand Kishor et al. “A Review on Hydropower Plant Models and Control.” Renewable and Sustainable Energy Reviews 11 (2007) 776–796.
[2]. Balino, J.L. et al. “The Differential Perturbative Method Applied to the Sensitivity Analysis for Water Hammer Problems in Hydraulic Networks.” Applied Mathematical Modeling 25 (2001) 1117-1138.
[3]. US Army Corps of Engineers. “Water Hammer and Mass Oscillation (WHAMO) 3.0 User's Manual.” US Army Corps of Engineers: Construction Engineering Research Laboratories. September 1998.
[4]. Modelon AB. “Hydro Plant Library Version 2.0 User’s Guide.” Modelon AB. 2010.
[5]. IEEE working group on prime mover and energy supply models for system dynamic performance studies “Hydraulic Turbine and Turbine Control Models for System Dynamic Studies” IEEE transactions on power systems, Vol. 7, No. 1, February 1992.

[6]. Versteeg H.K. & Malalasekera W. “An Introduction to Computational Fluid Dynamics: The Finite Volume Method” Longman, 1995.

Paper 11

Title: Modeling, Simulation and Control for an Experimental Four Tanks System using ScicosLab

Carlos Pfeiffer
Telemark University College, Norway

Keywords: Model Predictive Control, Four Tanks System, Kalman Filter, ScicosLab

During the last years, an interconnected four tanks system originally developed at Lund University has become popular for research and testing of advanced control schemes in universities across the world. In this system, water is pumped through two independent variable speed pumps, and flows are split using two three-way valves to feed the tanks. Different experimental flow configurations can be achieved by modifying the positioners of the valves. The system is very challenging, since it is nonlinear, it is multivariable with strong variables interactions, and it may present non-minimum phase characteristics for some configurations. Most published papers utilize a fourth order state space model to approximate the system. However, for laboratory scale systems the dynamics of the pumps may be important, and they should be considered.
In this work a six state variables nonlinear state space model is presented, considering the tanks and the pumps dynamics. The parameters of the model were fit using experimental data, and the resulting model was linearized and used to test a Model Predictive Controller on the experimental system. Since only the levels of two of the tanks were measured, a Kalman filter was used to estimate the state variables. All the simulations and the implementation of the control algorithms were performed using the free open-source software package ScicosLab.

Paper 12

Title: Modelling and control of a high head hydropower plant

Wenjing Zhou, Behzad Rahimi Sharefi, Bernt Lie, Bjørn Glemmestad
Telemark University College, Norway

Keywords: Modeling, simulation, control, hydropower

This paper describes an effective mathematical model of a hydropower plant and how a decentralized control strategy for frequency and terminal voltage can be simulated. Several dynamic equations are presented for each hydraulic element of a typical high head hydropower with ODEs (ordinary differential equations), as well as a fourth order model of synchronous generator with exciter is proposed for the modelling of generated electrical power and terminal voltage. This paper merged these two models and eventually results in a MIMO system. The frequency and terminal voltage were chosen as the control objectives according to the quality of power. For the control strategy, a PI controller coupled with droop characteristics was implemented for the frequency, and a decentralized controller with stabilizer was applied to terminal voltage control. The interactions of these two controllers are simulated and analyzed. The simulation results are presented and discussed.

Paper 13

Title: Modeling of aluminum in water treatment process

Jani Tomperi
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Keywords: Aluminum, Water Treatment, Modeling, Variable Selection, MLR, PLS

Surface and groundwater by itself contains fairly little amount of aluminum, excluding some exceptions. However, aluminum sulfate is used as a flocculating agent in water treatment process to coagulate impurities of the water. Flocculated impurities can be removed for instance by filtering or skimming. The quality of water treatment process can be valued by measuring residual value of aluminum.

High quantity of aluminum in drinking water causes the pipeline corrosion and has negative influences to health. E.g. nerve damages, allergies and Alzheimer disease are connected to high intake of aluminum from food and drinking water. Aluminum may even be mutagenic and carcinogenic. Taking account of all these disadvantages it is essential to use proper dosage of aluminum sulfate in water treatment process to reach an optimal purification level of water and avoid high residual quantity in drinking water. In this paper residual value of aluminum in water treatment process is studied and modeled. The goals of the study are to find the most significant variables affecting to quantity of residual aluminum and create a prediction model to predict the residual aluminum in a water treatment process. The case process is a chemical water treatment plant in southern Finland. Plant uses mainly the surface water from the lake nearby.

On-line process data and laboratory measurement data is used in data analysis and modeling. Data covers the whole year 2010. Laboratory measurements are done at least once every working day. On-line process data is first hour averaged and combined with laboratory measurements data. Outliers and clearly incorrect values are manually filtered and interpolation is used to fill the missing data values. Every measuring variable in combined dataset is scaled between [-2, 2] using a nonlinear scaling method. Forward variable selection method is used to select the significant variables. Dataset includes over 60 variables so variable selection is an important part of data analysis.

Prediction models are created using Multiple Linear Regression (MLR), Partial Least Squares (PLS) and neural network. Data processing and modeling are done with Matlab (Mathworks, Inc., Natick, MA).

Paper 15

Title: Stability Analysis of AGC in the Norwegian Energy System

Ingvar Andreassen, Dietmar Winkler
Telemark University College, Norway

Keywords: energy generation, hydro power production, Modelica, Automatic Generation Control

The power system frequency in the Norwegian energy system should not deviate outside of 49.9 and 50.1 Hz. However, since 1995 a rising tendency has been seen in a frequency deviation outside this limit in the Norwegian energy system. A model of an energy system containing several hydropower plants, a power grid and an AGC (Automatic Generation Control) system was made. This model is based on the Modelica language and the hydro-power plant library HydroPlant from Modelon AB.

An AGC system is used to control the power production in an area, according to the production plan and the frequency response of the system due to actual frequency deviation. A stability analysis was performed on the model to investigate the influence of AGC to the power system model. This showed the conditions for which the AGC controller caused more instability to the system frequency.

Paper 16

Title: Ammonium limiting anaerobic digestion of ethanol containing waste

Wenche Bergland, Rune Bakke
Telemark University College, Norway

Keywords: Anaerobic digestion, ammonium limitation, ADM1, apple waste, ethanol, biogas

The Anaerobic digestion model No. 1 (ADM1) contains anaerobic digestion reactions which occur in a biogas reactor fed municipal wastewater sludge. The ADM1 is especially adjusted to this waste but can also be used for other wastes, with or without adaptations. ADM1 is here tested for possible use on a type of waste that demands model modifications. A new two stage process design for low cost biogas production of waste containing a high solid content is developed, and waste from apple juice production is tested in this process. The two stages are termed: 1. Storage, in which the wet organic solid waste is stored and where the waste undergoes various degradation processes. 2. A hybrid biogas reactor (HBR), in which dissolved degradation products from storage are converted to mainly methane containing biogas. The apple waste is quickly fermented to alcohol and organic acids in the waste storage, from which a liquid substrate is extracted and fed the HBR. Alcohol degradation, which is not included in the original ADM1, is therefore included here, by adding two new state variables; ethanol and an extra bacteria culture for ethanol degradation. Reaction stoichiometry is determined from basic biochemical reaction theory while kinetics applied is based on published experimental work.

It is determined that the microbial activity is limited by lack of nitrogen, which is a necessary constituent of microbial growth. This is due to the low protein content in the waste. This limits both the uptake of substrate and the growth of the various biomass cultures in ADM1. An alternative model of how this nitrogen limitation influence the process is tested: Assuming it only causes growth suppression, while the biomass keeps consuming the substrates. This is based on published observations of microbial behavior.

Simulations show that the observed substrate consumption is well predicted by the modified ADM1. Changes in biogas production due to feed load changes are also reasonably well predicted. The observed nitrogen limitations cause process instabilities that can lead to acid accumulation and detrimental pH drops. Such a failure is also predicted by the model, but the time of its occurrence is very sensitive to initial conditions that are not well identified.

Paper 17

Title: Considering culture adaptations to high ammonia concentration in ADM1

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Keywords: anaerobic digestion, ADM1, ammonia, Syntrophic acetate oxidation, biogas

The Anaerobic digestion model No. 1 (ADM1) contains terms to calculate to what extent high ammonia content will inhibit anaerobic digestion (AD). It has, however, been observed that AD can adapt to much higher ammonia levels than predicted by ADM1. Schnürer et al. (1994; 1999) found that this adaptation is a result of the addition of an alternative pathway of acetate degradation by syntrophic acetate oxidizing organisms. This adaptation has great practical implications since many energy rich wastes available for biogas production have high protein content that will cause inhibiting ammonia levels during degradation. The aim of this study is to include high ammonia adaptation in ADM1 to make it applicable as a tool for design of AD of high ammonia and/or protein wastes.

Syntrophic acetate oxidation, which is not included in the original ADM1, is included here, by adding syntrophic acetate oxidizing organisms as a new state variable. Reaction stoichiometry is determined from basic biochemical reaction theory while information regarding reaction kinetics is not available. It is, however, known that this alternative pathway only occurs in processes with long sludge retention times (>20 d) and that it evolves slowly (over months). This indicates that these organisms have lower growth rates that the other organisms accounted for in ADM1.

Simulations show that the observed adaptations to high ammonia can be modeled by the simple modification of ADM1 proposed here. The predicted speed of adaptation is sensitive to both biomass yield parameter and the maximum specific growth rate. Changes in biogas production due to feed load changes are also reasonably well predicted. There is not yet enough experimental data available to estimate these parameters well. The model will be used to design experiments for improved parameter estimation.

Paper 18

Title: Dynamic modelling of a pulp mill with a BLG plant - effects in the chemical recovery cycle

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Keywords: Gasification, pulp mill, dynamic, WinGEMS, black liquor

A modern chemical pulp mill has a considerable surplus of energy. The black liquor, containing dissolved lignin, extractives and residual cooking chemicals, is sent to the recovery line and later combusted in the rather inefficient recovery boiler, producing steam and electricity. A more thermal-efficient way of utilizing the energy in the black liquor is by gasification, producing a syngas that may be used for biofuel production. The next step for this technology is the construction of a demonstration plant in parallel with a recovery boiler. When the gasifier is of demonstration size, it will affect other parts of the pulp mill. This is

important to know about when, for example, designing equipment. Data from the Chemrec pilot plant in Piteå, Sweden has been used in the model. The model mill is a BAT-mill (best available technique) with a black liquor gasification plant running in parallel with the recovery boiler. The simulations were carried out in WinGEMS. Realistic start-up and shut down procedures have been applied. The focus of the work was to study the dynamic effects in the recovery line and the lime kiln load as well as the build up time of salts in the mill liquors when operating a recovery boiler and a gasifier in parallel. The work was carried out within the BLGII (Black Liquor Gasification)-program.

Paper 19

Title: DYNAMIC MODELLING APPROACH FOR DETECTING TURBIDITY IN DRINKING WATER

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Keywords: Dynamic modelling, Water treatment, Water quality

The modelling of water treatment processes is of particular importance since water of low quality causes health-related and economic problems which have a considerable impact on people's daily lives. This not only increases the need for monitoring the process but also complicates the development of new methods for process diagnosis and monitoring. Nonetheless, the process is also considered challenging because of its com-plexity, dynamics and numerous contributory variables. It is essential to take process dynamics into account when data-driven applications are being developed, because successful modelling often requires an ability to adapt to changing conditions.

In water treatment there are observable cycles present which cause the process to be-have dynamically. The variation in water consumption is one of these, causing changes not only within a day but also within a week and even within a year. Year cycles can be distinguished even more clearly if surface water is treated, because the water tempera-ture is observed to have some effects on the process. In addition to cyclic behaviour, other factors such as the addition of lime may cause sudden changes in turbidity.

Soft sensors which utilize process history can be used in replacing difficult and expen-sive measurements or in predicting the behaviour of a process in the future. They have proved to be efficient in process monitoring and control and therefore provide a poten-tial means of estimating turbidity in drinking water, for example. In the paper, we will present a dynamic soft sensor based on multivariate regression for predicting turbidity of treated water. Because process data typically consist of a large number of variables, a group of them is selected adaptively before a dynamic predictive model is created, which is then used in estimating the degree of turbidity in the future.

Because of the dynamic character of the water treatment process, static process models may become inapplicable, which we will demonstrate using a case process. Our results show that the static model is not able to follow the changes in turbidity ($r = 0.4$), whereas the adaptive one can produce a reasonable estimate for it ($r = 0.75$). This dy-namic behaviour is probably due to the cyclic behaviour of the process, which can also be seen in several process variables. In conclusion, dynamic models seem to provide a fruitful way of modelling the process.

Paper 22

Title: DEVELOPİNG A COMPUTER PROGRAM FOR THE ESTİMATİON OF THE INCOMMİNG SUN BEAM BY DEFINING A SPECİAL COEFİCİENT FACTOR FOR DENİZLİ/TURKEY

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Keywords: Pyronometer, Visual C#.Net, Solar Radiation, Solar Estimation Methods

Hottel has presented in 1976 a method for estimating the solar beam radiation transmitted through clear atmospheres which takes into account zenith angle and altitude for a standard atmosphere with respect to four climate types. In this work a computer program is developed in Visual C#.Net using Hottle's estimation method. The developed computer program will estimate the incoming instantaneous solar beam radiation with respect to a given time period, incline, longitude and climate type of the region. On the other side, a pyronometer has been replaced to the Clean Energy Research Center at the Pamukkale University to measure the incoming sun beam for Denizli/Turkey. These measurements have been stored every hour into a database. Afterwards, using the developed estimation program the incoming solar beam to Denizli is calculated for defined time periods and stored to another database. Afterwards a special coefficient factor is calculated only for Denizli for a better estimation of the incoming sun beam. This is done by taking the correlation and mean value of both stored results for the same given time interval. The calculated coefficient factor can be used in the developed estimation program by multiplying the end results. This will give a more realistic solution of the estimated incoming sun beam for Denizli.

Paper 24

Title: OMSketch — Graphical Sketching in the OpenModelica Interactive Book, OMNotebook

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Keywords: OMSketch, DrControl, DrModelica, modeling, simulation, OMNotebook, teaching, interactive

In this paper we present a new functionality for graphical sketching in the OpenModelica interactive book, OMNotebook, which is part of the OpenModelica environment and used mainly for teaching. The new functionality is called OMSketch and allows the user to edit and draw shapes and figures within the electronic book. This allows teachers to prepare more pedagogic course material and stu-dents to make graphical notes in addition to the current textual ones.

The active electronic notebook, OMNotebook, is already used as basis for two course materials, DrModelica and DrControl for teaching the Modelica languages and control theory respectively. Electronic notebooks can be an alternative or complement compared to the traditional teaching me-thod with lecturing and reading textbooks. Experience shows that using such an electronic book will lead to more engagement from the students. OMNotebook can contain interactive technical computations and text, as well as graphics. Hence it is a

suitable tool for teaching, experimentation, simu-lation, scripting, model documentation, storage, etc.

Paper 25

Title: Modeling digestate nitrification

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Keywords: ASM 3, cow manure, digestate, nitrification, simulation

A simplified adaptation of Activated Sludge Model no. 3 (ASM 3) is used to simulate a biological nitrification process carried out in a laboratory scale 10 L volume bio-reactor fed anaerobically digested cow manure effluents. Nitrification is applied to enhance the fertilizer quality of such digestates by converting unstable ammonical N into nitrates. This study aims at using the nitrified digestate as an organic fertilizer in greenhouses for ecological food production.

The behavior of the laboratory bio-reactor was closely resembled by the simulations carried out using the ASM 3 adaptation. Despite the fact that ASM 3 model was originally developed for domestic waste water treatment processes, it can successfully be adopted for simulating the digestate nitrification, without modifying the values of kinetic and stoichiometric constants. Process simulations carried out using this model facilitate to assess and optimize different process variables such as feed rate, hydraulic retention time, extent of aeration, alkalinity content, etc. Modeling and simulations in this regard can significantly boost the knowledge gain of the study while restricting the costly experimental efforts to the most relevant scenarios. Simulations are also helpful to operate the process at minimum energy consumption and hence at the maximum profitability.

Paper 27

Title: Trend analysis in dynamic modeling of water treatment

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Keywords: Trend analysis, dynamic models, nonlinear systems, water treatment, linguistic equations, statistical analysis

Temporal reasoning is a very valuable tool to diagnose and control slow processes. Identified trends are also used in data compression and fault diagnosis. Although humans are very good at visually detecting such patterns, for control system software it is a difficult problem including trend extraction and similarity analysis. In this paper, an intelligent trend index is developed from scaled measurements. The scaling is based on monotonously increasing, nonlinear functions, which are generated with generalised norms and moments. The monotonous increase is ensured with constraint handling. Triangular episodes are classified with the trend index and the derivative of it. Severity of the situations is evaluated by a deviation index which takes into account the scaled values of the measurements. Case studies are from water treatment. Modelling and simulation of biological wastewater treatment in pulp and paper industry requires hybrid models since the operating conditions can fluctuate

drastically. A compact dynamic simulation is realized with linguistic equation (LE) models. The models consist of two parts: interactions are handled with linear equations, and nonlinearities are taken into account by membership definitions. The same scaling approach is used in trend analysis and modeling. The resulting model has a cascade structure with specialized LE models. The trend analysis is used model selection and model adaptation to activate recursive modeling.

Paper 29

Title: Etiology of Rey generator stator core failure and study of its rehabilitation integrity

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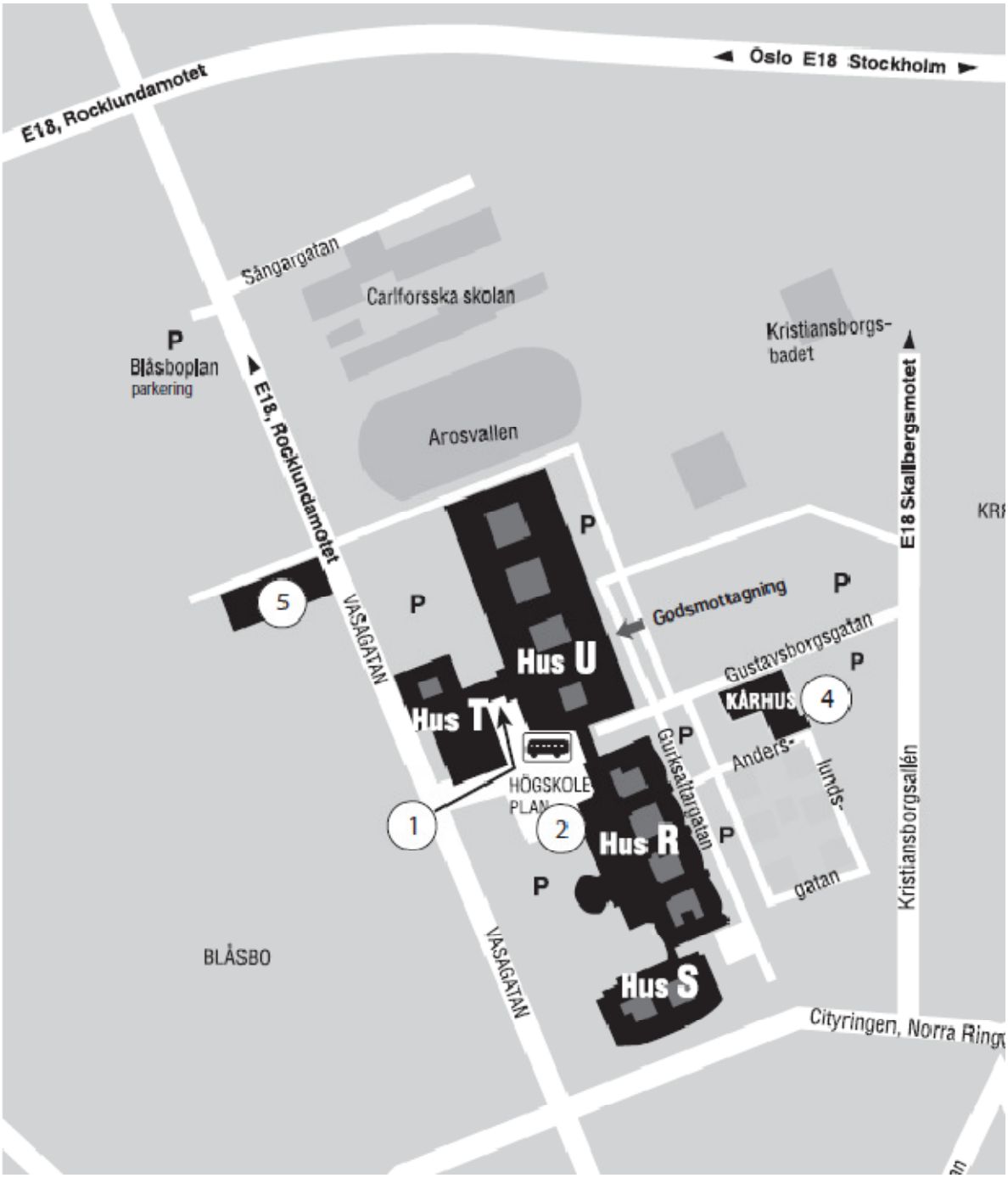
Keywords: generator, core sheet, breakage top teeth, stator

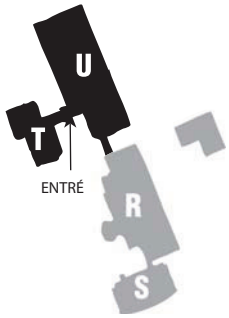
Rey stator core failure reported in Nov. 2010 and generator CB was manually opened. Mitsubishi 1 is a 102 MVA air cooled GE design, operating at 11 kV and is run by gas turbine. The operator observed high temperature in stator and decreased load to reduce it. Temperature stabilized when load reduced to 20% of nominal value. A group of broken core sheets between conductor and air gap was found after precise inspections and removing the rotor. The damage was worst at the armature end (drive end) but extended to the entire length of the core and caused sheets deformed. The area involved was between the tooth tips and two sides of the slot. Core teeth vibration, increasing of negative phase current due to single phase earth fault or breaker failure, unbalanced load, over or under excitation, loosing of core due to tooth vibrations, coating destruction, rod-finger and wedge loosing and etc. can cause core failure in the generator. Vibration of teeth tips is the main supposition of their physical breakage. For evaluation of stator rehabilitation integrity, several parameters such as core arrangement method, strip quality, sheet thickness, coating material and integrity, coil forming method, end core arrangement, pressures on the stator core etc. are studied in theory and by Finite Element Method (FEM).FEM results showed that using of new type sheets with nonhomogenous strips with higher loss in machine stator, created higher back of core, axial and unbalanced fluxes. Axial flux increased end core temperature and caused a limitation on loading. Furthermore, use of different strip with nonhomogonous thickness, permeability and coating at each segment caused unbalanced flux, increased eddy currents, axial flux, end core temperature,bearings vibration etc and is led to reduction generator life.



”**Hus U**” (The U-building) contains lecture rooms **Alfa and Kappa** (1st floor). Main entrance is at 1.

“Hus R” (The R-building) contains lecture rooms **Milos** (2nd floor). Main entrance is at 2.

There is a bridge connecting the U-buildings 2nd floor to the 3rd floor of the R-building.



Hus T och Hus U

plan 1
First floor

Hus U

U1-072

IDT
Expedition
U1-097

U3

Gamma

Kappa

U1-124

Beta

Lambda

Hus T

Central studievägledning

Kopieringsrum
studenter

U1-186

STC

Alfa

T1, U1

Entré

Infocenter

Godsmottagning

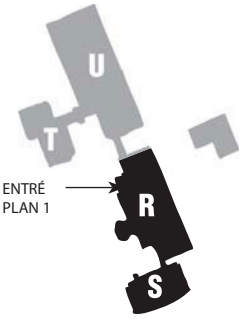
U1, T1

Entré

Interntryckeriet

Högskolebibliotek

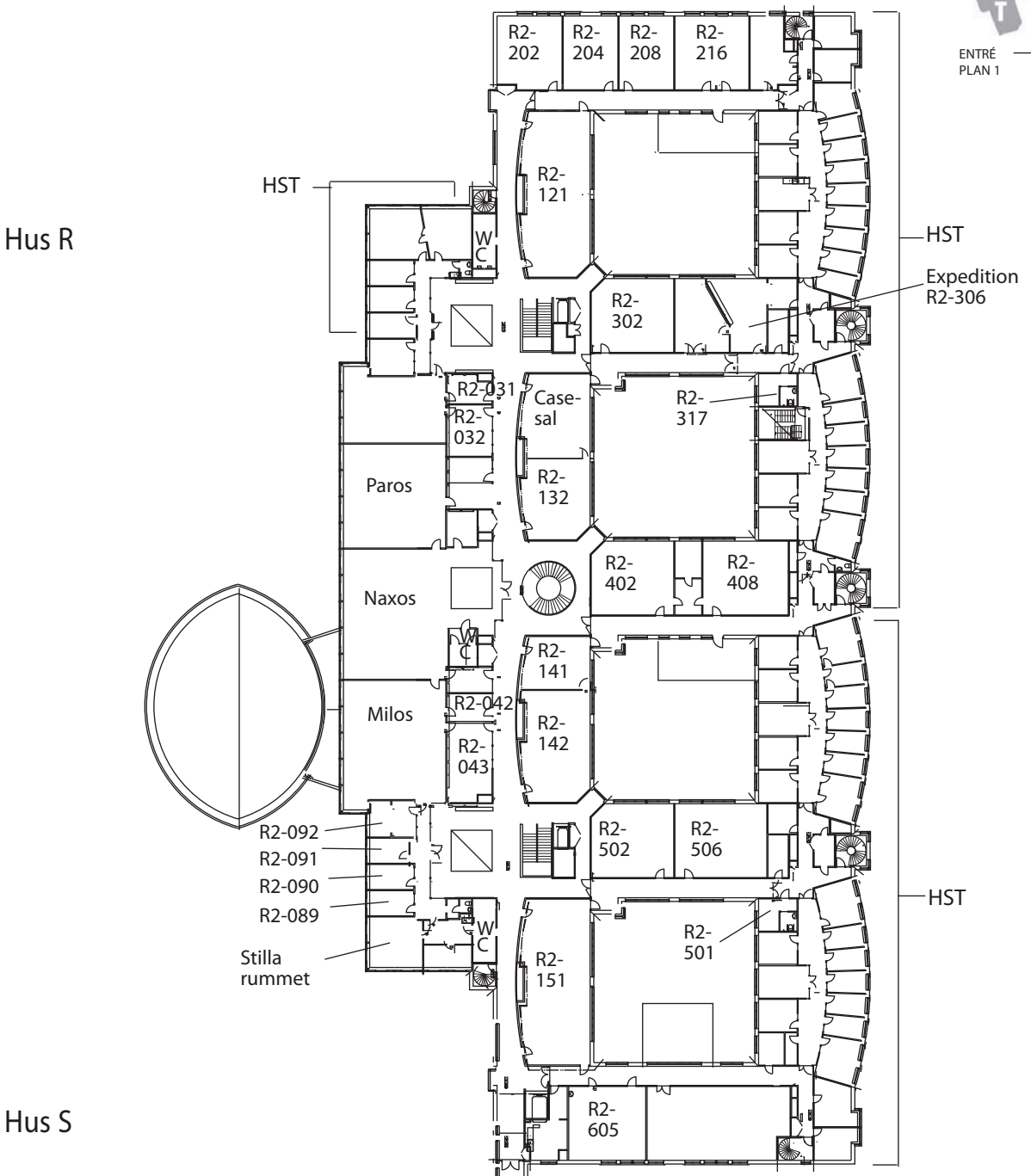
Restaurang
Rosenhill



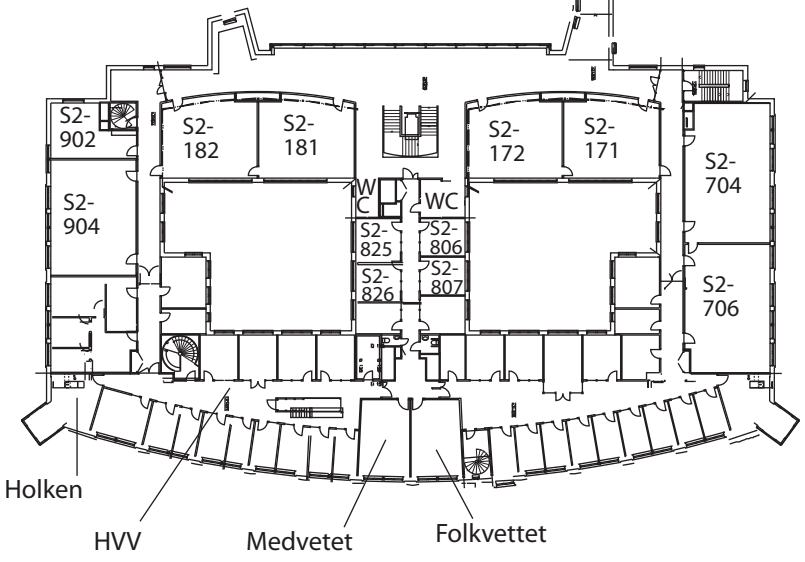
Hus R och Hus S

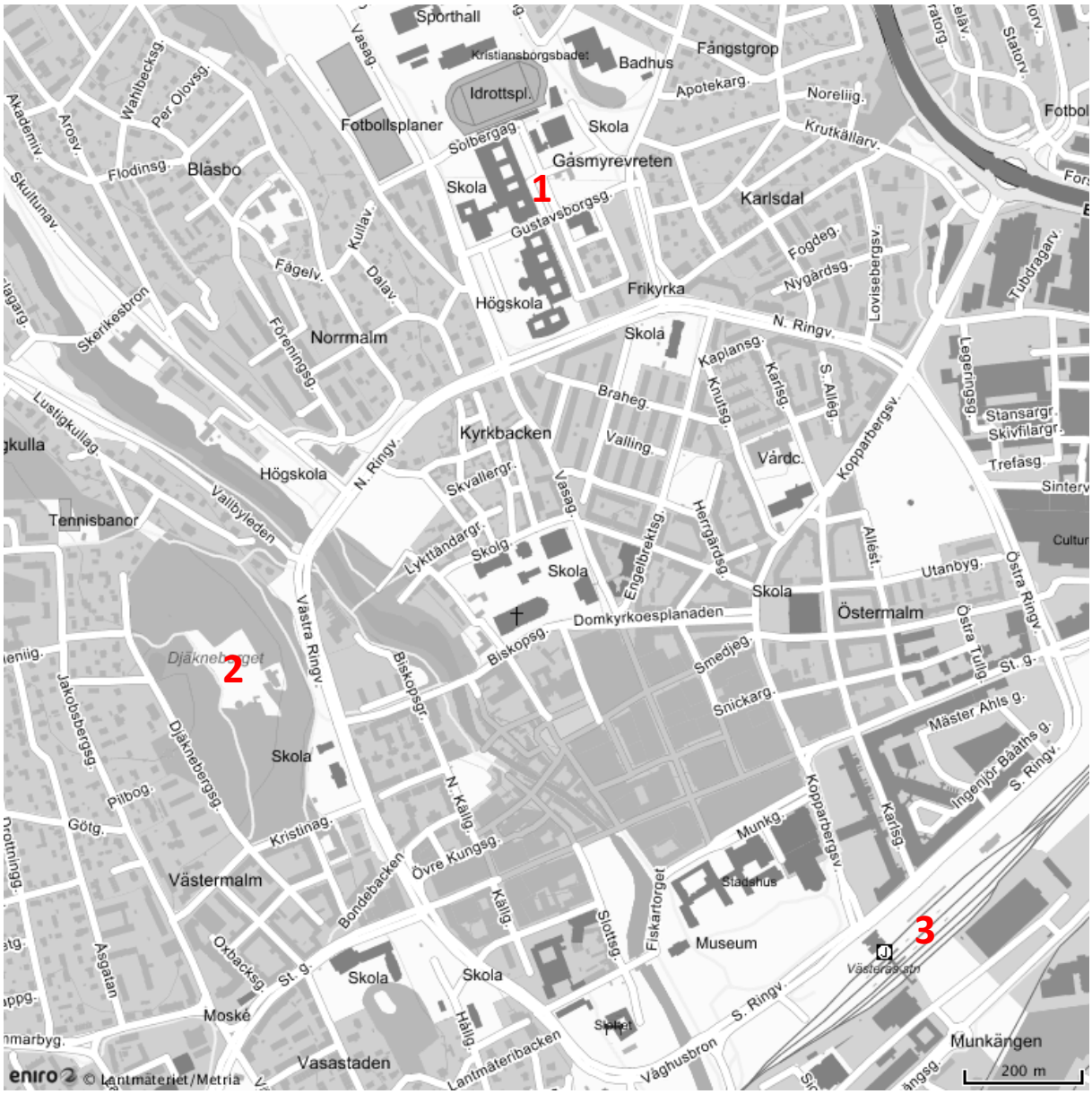
plan 2
Second floor

Hus R



Hus S





Important conference locations:

1. Mälardalen University
2. Djäkneberget park (the dinner will be held at Djäkneberget Restaurant located in the partk)
3. The train station