SIMS 2005 Papers

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1 A mathematical model of multicomponent mass transfer in electro-dialysis

Loubna Firdaous

A mathematical model has been developed which describes the mass transfer across monovalent-ion-permselective membranes as used in an electro-dialysis cell. The mass transfer model is based on the Maxwell-Stefan transport equations. The latter are derived in the membrane phase with two unstirred layers on each side. Donnan equilibrium is used to describe the concentration and the potential discontinuity on the membrane-solution interface by means of sorption measurements. The combination of the mass transfer model and the equilibrium model enables the prediction of concentration and potential profiles across the electro-dialysis stack once the model parameters are available which are obtained from literature, separate experiments or existing correlations.

2 A model of relative position and attitude in a leader-follower spacecraft formation

Raymond Kristiansen, Esten Ingar Grøtli, Per Johan Nicklasson, Tommy Gravdahl

Flying spacecraft in formations is revolutionizing our way of performing space-based operations, and this new paradigm brings on several advantages in space mission accomplishment and extends the possible application area for such systems. Spacecraft formation flying is a technology that includes two or more spacecraft in a tightly controlled spatial configuration, whose operations are closely synchronized. Earth and deep space surveillance with radio interferometry and Synthetic Aperture Radar SAR technology is one area where spacecraft formations can be useful. These systems involve data collection and processing over an aperture where the resolution of the observation is inversely proportional to the baseline lengths. Further exploration of neighboring galaxies in space can only be achieved by indirect observation of astronomical objects, and space based interferometers with baselines of up to ten kilometers have been proposed. However, to successfully utilize spacecraft formations for this purpose, accurate synchronization of both position and attitude of the cooperating spacecraft is vital,which again depends on accurate system models of the formation including external elements that might perturb the flight. This paper presents a detailed nonlinear mathematical model in six degrees of freedom of relative translation and rotation of two spacecraft in a leader-follower formation. The model of relative position is based on the two-body equations derived from Newtons inverse square law of force, and the position and velocity vectors of the follower spacecraft are represented in a reference frame located in the center of mass of the leader spacecraft, known as the Hill frame. In addition, rotation matrices between the Hill frame and an earth centered inertial reference frame are given. The relative attitude model is based on Euler's momentum equations, and the attitude is represented by unit quaternions and angular velocities. The model also includes the mathematical expressions for external disturbances originating from gravitational variations, atmospheric drag, solar radiation, and perturbations due to other celestial bodies, known as third body effects. Results from simulations in Matlab are presented to visualize the properties of the model and to show the impact of the different disturbances on the flight path.

3 A Novel Modeling Method of Surface Roughness in a Microfluidic Channel

Jarkko Mäkiranta, Pasi Kallio, Jukka Lekkala

A novel modeling method of a surface roughness is presented. A straight channel having a random, normally distributed roughness is studied by measuring the change of a hydraulic resistance. The modeling is made more realistic by focusing attention to the roughness definition. Navier-Stokes equations are solved numerically with a finite element method FEM. Both two and three dimensional cases with roughness varying 1 30 are studied. The results and developed modeling method create base for further experimental research on the effect of surface roughness on micro-channel flows.

4 A reduced basis element method for the steady Stokes problem: Application to hierarchical flow systems

Alf Emil Løvgren, Yvon Maday, Einar M. Rønquist

The reduced basis element method is a new approach for approximating the solution of problems described by partial differential equations. The method takes its roots in domain decomposition methods and reduced basis discretizations, and its applications extend to, for example, control and optimization problems. The basic idea is to first decompose the computational domain into a series of sub-domains that are similar to a few reference domains or generic computational parts. Associated with each reference domain are precomputed solutions corresponding to the same governing partial differential equation,but solved for different choices of some underlying parameter. In this work, the parameters are representing the geometric shape associated with a computational part. The approximation corresponding to a new shape is then taken to be a linear combination of the precomputed solutions, mapped from the reference domain for the part to the actual domain.We extend earlier work in this direction to solve incompressible fluid flow problems governed by the steady Stokes equations. Particular focus is given to the mapping of the velocity fields, to satisfying the inf-sup condition, and to gluing the local solutions together in the multi domain case.We also demonstrate an algorithm for choosing the most efficient precomputed solutions. Two-dimensional examples are presented for pipes, bifurcations, and couplings of pipes and bifurcations in order to simulate hierarchical flow systems.

5 A symmetric splitting method for rigid body dynamics

Elena Celledoni, Niklas Sæfstrøm

It has been known since the time of Jacobi that the solution of the free rigid body FRB equations of motion is given in terms of a certain type of elliptic functions. Using the Arithmetic-Geometric mean algorithm these functions can be calculated efficiently and accurately. The overall approach yield a faster and more accurate numerical solution to the FRB equations compared to standard numerical integrators and symplectic solvers. In this paper we investigate the possibility of extending this approach to the case of rigid bodies subject to external forces. By using a splitting strategy, we decompose the vector field of our problem in a FRB problem and another completely integrable vector field. We apply the new method to the simulation of the heavy top.

6 An Overview of Marine Systems Simulator (MSS): A Simulink Toolbox for Marine Control Systems

Tristan Perez, Øyvind N. Smogeli, Thor I. Fossen, Asgeir J. Sørensen

The Marine Systems Simulator MSS is an environment which provides the necessary resources for a rapid implementation of mathematical models of marine systems with focus on control system design. The simulator targets models and provides examples ready to simulate of different floating structures performing various operations. The platform adopted for the development of MSS is Matlab Simulink. This allows a modular simulator structure, and the possibility of distributed development. Openness and modularity of software components have been the prioritized design principles for systematic reuse of knowledge,resulting in improved and more efficient tools for research and education. This paper provides an overview of the structure of the MSS, its features, current accessibility, and plans for future development.

7 Applicability of OPC to real-time data collection: simulation study

Ari Koponen, Manu Huttunen, Riku Pöllänen, Olli Pyrhönen

The OPC OLE for Process Control provides an easy way to connect simulation systems to control systems, but there has been little research on the reliability and timing accuracy of OPC servers.

Actual sampling time of data can be determined using a fast counter as a variable. Variations in the sampling time can be examined using consecutive sampled values of the timer to construct jitter values. Difference in sampling time between variables can be observed by reading the same counter value from different server channels.

In this study timing accuracy of one OPC server was considered and reliability of variable values assessed. Accuracy of the time stamp provided by the OPC server was evaluated and network and CPU load monitored. Tests were conducted using different settings at both server and client side.

According to the results the timing accuracy and variable reliability varies depending on the server and client settings. By using correct settings the timing accuracy of the server is good and it provides correct values. Settings also affect the accuracy of the time stamp as well as the CPU and network load.

8 Application of the ENBIPRO Software Code for the Simulation of a Novel IGCC Plant with CO2 Capture

Emmanouil Kakaras, Reinhard Leithner, Antonios Koumanakos, Nikolaos Aronis, Aggelos Doukelis

The purpose of this work is to present a thermodynamic cycle calculation software and its potential in the simulation of novel electricity generation cycles integrating CO2 sequestration. The software codeENBIPRO ENergie-BIllanz-PROgram is a powerful tool for heat and mass balance solving of complex thermodynamic circuits, calculation of efficiency, exergetic and exergo economic analysis of power plants. The software code models all pieces of equipment that usually appear in power plant installations and can accurately calculate all thermodynamic properties temperature, pressure, enthalpy at each node of the thermodynamic circuit, power consumption of each component, flue gas composition etc. The code has proven its validity by accurately simulating a large number of power plants and through comparison of the results with other commercial software.

9 Comparison of Kalman Filter Estimation Approaches for State Space Models with Nonlinear Measurements

Fredrik Orderud

The Extended Kalman Filter EKF has long been the de-facto standard for nonlinear state space estimation, primarily due to its simplicity, robustness and suitability for real-time implementations. However, an alternative approach has emerged over the last few years, namely the unscented Kalman filter UKF. This filter claims both higher accuracy and robustness for nonlinear models. Several papers have investigated the accuracy of UKF for nonlinear process models, but none has addresses the accuracy for nonlinear measurement models in particular. This paper claims to bridge this gap by comparing the performance of EKF to UKF for two tracking models having nonlinear measurements.

10 Control-relevant modeling and simulation of a SOFC-GT hybrid system

Rambabu Kandepu, Lars Imsland, Christoph Stiller, Bjarne Anton Foss, Vinay Kariwala

In this paper, control-relevant models of the most important components in a SOFC-GT hybrid system are described. Dynamic simulations are performed on the overall hybrid system. The model is used to develop a simple control structure, but the simulations show that more elaborate control is needed.

11 Design and application of a motion platform in three degrees of freedom.

Webjørn Rekdalsbakken

Aalesund University College is building the first full-size high-speed craft simulator in Norway. In preparation of the construction of the simulator there has been built a small-scale motion simulator to test the possibilities to imitate the movements of the ship. The model is based on a Stewart platform in three degrees of freedom roll, pitch and heave. The platform deck is moved by three DC-servomotors through three legs situated at the corners of an equal sided triangle with its center aligned with the mass center of the deck. The movements of the ship are generated in a ship simulator on a PC, and the primary signals are transformed to equivalent manipulating signals to the three servo drives. These signals are converted to analog voltages which are applied as the reference signals to a Pulse Width Modulation card controlling each motor. There has been done comprehensive testing of the motion simulator, and it seems like the platform will imitate the movements of a ship in a satisfactory way. As part of the testing there has also

been developed a control loop for manipulating the path of a moving object, e. g. a ball or a wheel, on the platform. For this purpose a camera is used to measure the position and velocity of the object in the x- and y-directions and the results used to make the object follow a given reference path. Different regulator strategies have been tried, like pole placement, optimum control, fuzzy logic and neural networks. The results have been satisfactory and the object is controlled to move in a circle or 8-curve or from point to point as decided.

12 DNA – A General Energy System Simulation Tool

Brian Elmegaard, Niels Houbak

The paper reviews the development of the energy system simulation tool DNA Dynamic Network Analysis. DNA has been developed since 1989 to be able to handle models of any kind of energy system based on the control volume approach, usually systems of lumped parameter components. DNA has proven to be a useful tool in the analysis and optimization of several types of thermal systems Steam turbines, gas turbines, fuels cells, gasification, refrigeration and heat pumps for both conventional fossil fuels and different types of biomass. DNA is applicable for models of both steady state and dynamic operation. The program decides at runtime to apply the DAE solver if the system contains differential equations. This makes it easy to extend an existing steady state model to simulate dynamic operation of the plant. The use of the program is illustrated by examples of gas turbine models. The paper also gives an overview of the recent implementation of DNA as a Matlab extension Mex.

13 Dynamic Modeling and Sound (Noise) Diagnostics of Robot Gearboxes for Fault Assessment

Erik Olsson, Rostyslav Stolyarchuk

Some gear faults in industrial robots can during operation be recognized as abnormal noise peaks coming from the gearbox. A library of such recordings has been assembled in order to automate fault diagnosis of the robots. A computer records sound from the gearbox and compare the new recordings with recordings stored in the library. The result of the comparison is a diagnosis of the condition of the robot. This paper proposes an extension of the sound library by incorporating model based reasoning. A dynamic model of the gearbox in the drive system has been constructed and gear vibrations on the force level are extracted from the model. These vibrations are projected onto the sound recordings with a statistical vibration diagnostic parameter known as the Crest Factor CF.

14 Dynamic simulation of a fed-batch enzyme fermentation process

Esko Juuso

Batch bio-processes are difficult to model due to strong nonlinearity, dynamic behaviour, lack of complete understanding and unpredictable disturbances from their external environment. The data sets obtained from process are in practice distinct sets obtained through different process performances because usually one or more substantial physical parameters, such as dissolved oxygen, temperature or pH are maintained on distinct level. The optimal values of parameters, such as pH, temperature and DO might not be the same for the growth phase and metabolite production phase in secondary metabolite production. Large differences exist between different fermentation runs because the variations in the feeding strategy, metabolic state of the cells and the amount of oxygen available. Even if the process conditions were kept same in each fermentation, the microorganisms would behave differently every time.

The dynamic modelling was based on the process data obtained from an industrial fed-batch fermenter. The models were tested using a number of different testing data, which were not included in the training data set. When necessary, the noise in the data was filtered by taking moving averages of the measured values. The variables for each model were chosen mainly based on correlation analysis. Variables that could be used for control were preferred when choosing the input variables of the model. These variables include mixing rate, aeration, substrate feed rate etc.

The models have a NARX Nonlinear Auto-Regressive with eXogenous input structure. A multi-model approach was applied as different growth phases need different models. As the prediction of the future values required three

interacting models, which each produce prediction of a different variable, the overall system consists of nine models. Various modelling methodologies have been compared. The compact implementation of the linguistic equation models made such a complex structure possible to use. Smooth transitions between the phase models are based on fuzzy logic.

The controllable variables were preferred as inputs and these include mixing, aeration, feed rate, pressure, temperature and cooling power. The variables used in the models include the concentration of carbon dioxide in the exhaust gas, mixing power, feed rate, oxygen transfer rate, dissolved oxygen concentration, volumetric oxygen transfer coefficient, position of the pressure valve and VVM. The choice of the variables was quite similar to the choice of the modelling variables in the literature.

The dynamic simulator operates accurately throughout the fermentation even for more than 40 hours. The simulator can be used as a online forecasting tool in connection to the real process. The simulator is started on chosen time intervals the previous online measurements on a chosen horizon are used for constructing a starting point and the simulator predicts the operation on a chosen prediction horizon by using the planned control actions.

The simulator is aimed primarily on detection of fluctuations of the process control. However, model-based predictive control can be considered as a new option since the simulator is very compact.

15 Dynamic study of a subsea processing system

Heidi Sivertsen, John-Morten Godhavn, Audun Faanes, Sigurd Skogestad

This paper describes the simulation setup applied in an introductory study in connection with implementation of subsea processing equipment at a field at the Norwegian Continental Shelf. The primary aim of the subsea processing equipment is to increase the oil recovery, but is it also considered as an important technological step forward. A subsea separation and boosting station is planned installed.

Several challenges need to be addressed before the implementation process, and simulations have therefore been performed to see how different types of control strategies can be introduced to overcome these challenges. The simulation model includes all the pipes and equipment from the wells to the topside first stage separators. The flow in the pipelines is modeled with the dynamic multiphase flow simulator OLGA 2000, whereas most of the processing equipment is modeled in Matlab. The focus of the paper is different ways of combining these simulation tools.

16 Evaluation and Comparison of Models and Modeling Tools Simulating Nitrogen Processes in Wetlands

Stina Edelfeldt, Peter Fritzson

The global problem of eutrophication, the enrichment of water bodies by nutrients, has in recent years resulted in an increased interest in non-conventional ways to reduce the amount of nutrients discharged into the environment. One of the more commonly proposed and also used solutions is to append artificial or constructed wetlands as a final step in the treatment of wastewater. However, both the construction of the wetlands and the maintenance thereof are time and resource consuming, hence a high production and maintenance cost. Due to these high costs, tools for modeling and simulation have turned out to be valuable asset in the development of constructed wetlands.In this paper, two ecological models of nitrogen processes in treatment wetlands have been evaluated and compared. These models were implemented, simulated, and visualized in the Modelica language 6. The differences and similarities between the Modelica modeling environment used in this thesis and other environments or tools for ecological modeling have also been evaluated.

17 Event Handling in the OpenModelica Compiler and Run-time System

Håkan Lundvall, Peter Fritzson

The paper gives an introduction to the problem simulating hybrid DAEs with event-handling using the Modelica language. An implementation in the OpenModelica compiler is presented, and some preliminary results are reported.

18 Forward propagation of acoustic pressure pulses in 3D soft biological tissue

Trond Varslot, Svein-Erik Måsøy

A simulation method for forward propagation of acoustic pressure pulses in a medium with spatially variable acoustic properties is presented. The intended application is to study aspects of ultrasound imaging of soft biological tissue.Ideally the ultrasonic pulse would pass undistorted from the transducer array, through the body, until it reaches the organ to be imaged. The pulse should be reflected by this organ, and then pass undistorted back through the body to the transducer array. Most ultrasound imaging techniques are based on this assumption. However, in many situations this is not the case, leading to degraded image quality. The aim for the method presented here is to perform simulations of the forward wave propagation. To this end a one-way wave equation is used. The equation describes tissue exhibiting nonlinear elasticity and arbitrary frequency-dependent attenuation, and is a good approximation of the full wave equation when all acoustically-important quantities are sufficiently smooth.A numerical solution to this equation is found by means of first-order accurate operator splitting and propagation along the spatial depth coordinate. Thus diffraction, nonlinearity and attenuation are solved independently at each propagation step, making their relative importance easy to monitor. The method is seen to yield an accurate simulation of the wave propagation when compared to numerical solutions of the full wave equation and experiments in a water tank.By this approach it is possible to simulate wave propagation over relatively large distances – typically 300 wavelengths – at a modest computational complexity compared to solution of the full wave equation. It furthermore facilitates a high degree of parallelism, thus enabling efficient distribution of the required computations over multiple processors. The method is implemented using MPI under Matlab.

19 Hardware-in-the-loop testing of marine control systems

Roger Skjetne, Olav Egeland

Hardware-in-the-Loop HIL testing is proposed as a new methodology for verification and certification of marine control systems. Formalizing such testing necessitates the development of a vocabulary and set of definitions. This paper treats these issues by constructing a framework suitable for industrial HIL test applications and certification of marine systems.

20 Mathematical Modeling of Molten Slag Granulation Using a Spinning Disk Atomizer

Purwanto Hadi, Tomohiro Akiyama

To optimize granulation process, a mathematical model of a spinning disk atomizer was developed to produce particle from high-temperature molten slag. The model comprises three parts 1 fluid flow model of molten slag on the spinning disk, 2 physical model of ligament formation of slag, and 3 heat transfer model of slag drops dispersed from the ligament. First, a 2-D fluid flow model was developed to evaluate the film thickness of slag layer and was calculated using the scalar equation method. The number and diameter of the ligaments formed were evaluated using the physical model. Finally, the heat transfer model was employed to evaluate the quenching rate and temperature distribution within the drop. The developed model was verified by comparing the calculated result with the experimental data of drop diameter, both of which were found to be in reasonable good agreement. The advantage of this model is that it can also be used to predict the cooling rate and temperature distribution within the particle, which controls the slag properties.

21 Modelling and control of growing slugs in horizontal multiphase pipe flows

Steinar Elgsæter

In this paper, a method to detect slugs with typical sparse and local measurements in eld lines is developed.It is also shown how active control can be used to restrict slug growth. Simulations in OLGA2000show that a feedback controller can use measurements or estimates of slug length to control the growth of aslug in a horizontal pipeline by partially closing inlet or outlet chokes. A control-volume approach is used to develop a low-order model of inlet

choke-slug growth dynamics based on mass- and impulse balances. The resulting model is a system of nonlinear differential algebraic equations, which is suitable for estimator design. The tuned model is found to be in good agreement with experiments and OLGA2000-simulations. Linearizations of the model are found to be observable around realistic trajectories when rates and pressures at the inlet and outlet are measured. An extended Luenberger-observer is shown to give good estimates of slug length and -position in simulations.

22 Modelling of Pd-membranes deformation during hydrogen separation

Artem Pilipenko

Abstract Pd-membranes used for hydrogen separation work at elevated temperatures under pressure causing plastic deformation of the membranes. To complicate the problem these membranes are very thin. Thickness varies between 1 and 5m. Different modelling approaches can be used for modelling of this complex situation. Variety of 2D and 3D ABAQUS modes are tested for this purpose. To simulate interface between the membrane and substrate, some models include contact analysis. Results from different models are compared.

23 Modelling of steam turbines for mixed integer nonlinear programming (MINLP) in design and off-design conditions of CHP plants

Tor-Martin Tveit, Tuula Savola, Carl-Johan Fogelholm

In this paper mathematical models of steam turbines used in mixed integer nonlinear programming (MINLP) are improved to enable more realistic results from the optimisation and more robust and reliable optimisation models.

24 New computational technologies for reliable computer simulation: ideas and implementation

Sergey Korotov, Antti Hannukainen

The present work is devoted to one of the most challenging problems in mathematical modelling and numerical analysis, which also has great importance for many practical applications in industry it reliable verification of the accuracy of approximate solutions obtained via computer simulations. This task is deeply related to the so-called it a posteriori error estimates, giving computable bounds of modelling errors of various types and detecting zones, where such errors are excessively high and some mesh-refinement algorithm should be used.On the base of a model boundary value problem of elliptic type we present new effective ideas and discuss relevant implementation issues on how to obtain two-sided a posteriori error estimates for verifying the overall accuracy of computed solutions in the it global energy norm,item to derive two-sided a posteriori error estimates for the control of local errors in terms of various it quantities of interest,item to develop parallel numerical procedures for computing the above types of a posteriori estimates. Two numerical tests performed with a help of the PDE Toolbox of Matlab and demonstrating the high effectivity of the technologies are presented.

25 On Model Portability

Heinz Preisig, Tore Haug-Warberg

With the software of various commercial providers becoming mature, portability of models and associated data comes higher and higher on the agenda. CAPE-Open has accomplished a compromise getting various players on the market to communicate and agree on generating and accepting wrappers for their process models and also thermo data, both key issues in the chemical engineerings software world. Improving a step beyond wrappers requires a more basic approach, which allows to take advantage of the model structure. The design method and the used representation of the Modeller project have already proven a great degree of portability as models can be mapped into all major solver environments including Matlab, gProms, and other DAE solvers. We attempt to line out the motivation, the present and the future of this approach.

26 Preconditioning of fully implicit Runge-Kutta schemes for parabolic PDEs

Gunnar Andreas Staff, Kent Andre Mardal, Trygve K. Nilssen

Recently, the authors introduced a preconditioner for the linear systems that arise from fully implicit Runge-Kutta time stepping schemes applied to parabolic PDEs. The preconditioner was a block Jacobi preconditioner, where each of the blocks were based on standard preconditioners for low-order time discretizations like implicit Euler or Crank-Nicholson. It was proven that the preconditioner is optimal with respect to the timestep and the discretization parameter in space.In this paper we will improve the convergence by considering other preconditioners like the upper and the lower block Gauss-Seidel preconditioners, both in a left and right preconditioning setting. Finally, we improve the condition number by using a generalized Gauss-Seidel preconditioner.

27 Process optimization utilizing an external simulation model

Andreas Kvarnström, Erik Dahlquist

Optimization of industrial processes is traditionally performed using personal knowledge and experience. Thanks to the recent years rapid computer development, optimization of industrial processes using computers and mathematical optimization algorithms have become possible and an excellent tool in the aspiration of more efficient processes. When performing computer-based optimization of processes it is often required to build a model of the process in the environment of the optimization software. Many companies have already made large investments in powerful simulation software for their specific processes and to rebuild the model in the optimization software environment adds more costs and may result in a less accurate simulation of the process. For that reason, it would be preferable to be able to use the already existing and better tuned simulator model of the specific process in the optimization. This paper describes a method of performing computer-based optimization of industrial processes using external simulation models. This approach is accomplished by establishing communication and interoperability between the optimization software and the simulation software using component-based software technology as Microsofts COM technology. In addition to the obvious benefit of not having to rebuild an already powerful and well tuned simulator model, is the easier maintenance and ability to change the process model using the graphical user interface often included in the simulation software. When using an external and a more process-specific simulation model there is also the advantage of having more functionality and process dynamics incorporated into the optimization, such as the mass and energy balances of the process and the quality characteristics of the product produced in the process. Using a more accurate process model also gives the possibility to check the feasibility of the optimization results where a larger scope of the process is simulated than is directly included into the objective function and constraints of the optimization.

28 Real time hardware-in-loop simulation of ESMO satellite attitude control system

Rune Finnset, Sudhakara K. Rao, Jøran Antonsen

This paper studies attitude control of the ESMO satellite, using six reaction thrusters. Bang-bang control with dead-zone and Pulse-Width Modulation PWM for the modulation of the on-time of the thrusters are treated. Closed loop hardware-in-loop simulations, using the micro controller unit MCU Microchip PIC18F452 for implementation of attitude control and MatLab in a standard PC for simulating satellite dynamics, are carried out. Results for real time simulation are compared with autonomous simulations. The controller gives a satisfactory performance in the real time environment.

29 Real-time simulation environment for control loop performance monitoring using Matlab

Riku Pöllänen, Ari Koponen, Manu Huttunen, Olli Pyrhönen

Abstract Evaluating control loop performance has attracted considerable interest in recent years. Different kinds of performance indices have been developed and tested with simulation models and offline process data before

implementing them in real automation system or performance monitoring tool. For developing and simulation stages of process control and control performance monitoring, Matlab is often regarded as an efficient tool among both academic researchers and industry. As a major drawback, however, there have been only reduced possibilities to connect it directly to the distributed control system DCS and programmable logic controllers PLCs of the plant for testing the designed algorithms with the real application. An easy way to establish a link between DCS or PLC and plant or process simulator running in an ordinary PC hardware is provided by OPC OLE for Process Control data access specification. Now, the same data exchange principle is emerging to be applied also with Matlab-based control engineering tools. In this paper, a simulation environment consisted of Matlab-based process simulation, control and monitoring tools and connected to the commercial PC automation system by the aid of OPC is demonstrated. A summary of typical performance indices and case studies of real-time control performance assessment are given.

30 Simplified observer design and simulation for leak detection in fluid pipelines

Jørgen Salvesen

A pipeline simulator and a procedure for leak detection and isolation are presented. The leak detection system uses a linearized system description in the design of observers. The design is based on extracting observable subsystems from the pipeline description which is done through the use of a numerical algorithm. The observer design is improved by finding the structure of the subsystems, providing an easier way to update the operating point and friction parameters of the system. Leak detection and isolation is tested against the pipeline simulator and the need for a correct operating point in the observers is confirmed.

31 Simulating rolling and colliding balls on free-form surfaces

Arne Lakså, Børre Bang

We introduce an interactive REAL-TIME simulation of rolling balls on free-form parametric surfaces. The simulation includes solid and hollow balls with different size, moment of inertia, slip and rolling friction and collision detection and handling. We consider examples with several hundred balls of different types rolling and colliding on a free-form surface limited by a closed set of walls. We introduce a time discretization method which is a combination of a global nonuniform computation time depending time stepping, and a local nonuniform time discretization based on time sorted event handling. Finally we discuss some computational aspects. The examples are done on a standard workstation. We useC, OpenGL and GM_lib, an in-house geometric and graphic modeling library developed at Narvik University College.

32 Simulation of a Steel Factory's Closed Gas Circulation

Timo Mäki, Jari Ruuska

This paper presents the simulation possibilities of a steel factory's closed gas circulation the project name is ReGenGas. A real composition of a steel factory gases is used. The main aim in this project is to decrease carbon dioxide emission into the air and/or to re-use it to produce more hot metal or some chemicals. Actual processes will be compared to the developed system in this project. Trial runs in laboratory scale help to establish a use of non-ideal gases and potentiality to recirculation these gases.

The simulation tool will be done with Matlabs Simulink and will be based on the data collected from the test campaigns. The real measurements of the experimental data and the simulated results will be compared. Simulation will consist of models for the mixing of pure gases and for the mixed real process gases like coke oven and blast furnace gases. In laboratory trials the variables are for example the composition of the gas, the operating temperature, recirculation rate, catalysts dimensions and composition and the characters of the iron charge.

The test equipment and trials are based on the calculated results of Outokumpu Technology's HSC-software done in the same research groups earlier CO2H2-project. In this project the lab scale test runs are made to certify earlier calculations. Expert knowledge and an experimental design matrix will be utilized.

The goal of simulation and dynamic modeling is the preliminary information of a re-using of gases in a steel factory and designing of trials. As a result of this research it is possible to decrease a steel factory's carbon dioxide

emissions and at the same time the production of hot metal increases. The feed gases in test runs will be H2, N2, CO, CO2, H2O, CH4 and O2.

This ReGenGas -project is financed by the National Technology Agency of Finland TEKES, Outokumpu Technology Oy, Neste Oil Oyj and Ehovoc Oy. Research partners in this consortium are University of Oulu 3 laboratories and bo Akademi Turku, Finland.

33 Simulation of an innovative stand-alone solar desalination system with an organic Rankine cycle

Andreas Schuster, Sotirios Karellas, Juergen Karl

The rising of the world population leads automatically to the rising of water demand. As a consequence the lack of drinking water increases.Since a large part of the world population is concentrated in coastal areas, the desalination of seawater seems to be a promising solution.An innovative stand-alone solar desalination system could be used to produce drinking water from seawater. The great advantage of such a system is that it combines an efficient desalination technology reverse osmosis with a renewable energy source solar radiation. Thermal energy produced by the solar array evaporates a working fluid, which is used in an organic Rankine cycle that drives the pumps needed for the reverse osmosis process.Due to the fluctuation of solar irradiation the dynamic simulation of such a system is necessary in order to assure the sufficient supply of water throughout a year. The simulation provides important information for optimum system sizing and design. The aim of this work is to present a modelling of the solar desalination system and to investigate the impact of different working fluids, thermodynamic parameters and cycle variations on the efficiency and water production of such a system.

34 Case-study: Simulator-based control system tuning and testing using an estimated process model

Finn Haugen

A mathematical model of a process to be controlled can be used for off-line tuning and testing of control systems for the process. The tuning and testing can be performed using analytical methods or using simulations. The benefit of simulations in this respect is that it is straight-forward to include non-linearities in the model. This presentation demonstrates the application of commercially available functions for system identification and simulation, and control design. Focus is on functions available in National Instrument's LabVIEW, but similar functions are available in other tools, as MATLAB. The presentation shows a practical application, namely a speed servo for a DC motor.

35 Solving the nonlinear Schrödinger equation using exponential integrators

Håvard Berland, Bård Skaflestad

Using the notion of integrating factors, Lawson developed a class of numerical methods for solving stiff systems of ordinary differential equations. However, the performance of these Generalized Runge-Kutta processes was shown to be inferior when compared to the ETD schemes of Certaine and Nørsett, recently rediscovered by Cox and Matthews. The deficit is particularly pronounced when the schemes are applied to parabolic problems and is due to larger error constants. In this paper we compare a fourth order Lawson scheme and a fourth order ETD scheme due to Cox and Matthews, using the nonlinear Schrödinger equation as the test problem. The primary testing parameters are degree of regularity of the potential function and the initial condition, and numerical performance is heavily dependent upon these values. The Lawson and ETD schemes exhibit significant performance differences in our tests, and we present some analysis on this.

36 Stabilizing a CFD model of an unstable system through model reduction

Svein Hovland, Tommy Gravdahl

In this paper we consider stabilization of a computational fluid dynamics CFD model of an unstable system. As a case study, cooling of a two-dimensional plate with an inner heat source with positive feedback from the

temperature is considered. The plate temperature is originally described by a partial differential equation PDE. In order to simulate and design a controller for the system, the PDE is discretized using computational fluid dynamics.

The open-loop CFD model has unstable eigenvalues, and it is demonstrated that without control, the plate temperature is increasing above desired limits due to the inner heat source. By introducing feedback control through cooling on the boundaries of the plate, we wish to control the plate temperature to reach a desired uniform distribution.

Although acceptable for simulation purposes, the CFD model is of such high order that it is infeasible to use it in control design. This is often the case in computational fluid dynamics, necessitating model order reduction tools.

Based on simulation data and the CFD model equations, the order of the model is reduced by proper orthogonal decomposition POD. POD, also known as the Karhunen-Lograveve Expansion, is a method for reducing the complexity of a model while keeping the essential dynamics of the original model, in order to perform the control design. The resulting reduced order model is unstable, but it has a state space structure, which is convenient for controller synthesis.

A stabilizing controller based on pole placement is designed for the reduced order model. To account for stationary errors and the deviation between the full CFD model and the reduced order model, integral action is included to enhance performance. The controller is then extended to the full CFD model, where it is shown through simulations to stabilize the system around the desired temperature distribution.

The demonstrated procedure makes it possible to analyze stability properties of a class of systems that would otherwise be very computationally demanding.

37 Systematic Analysis of Parameter Identifiability for Improved Fitting of a Biological Wastewater Model to Experimental Data

Cristina Sarmiento Ferrero, Qian Chai, Marta Dueñas Díez, Sverre H. Amrani, Bernt Lie

In this paper, we describe a Biological Wastewater Plant situated at Duvbacken in Gävle, Sweden. A dynamic model based on the ASM2d description is developed, and is implemented in Matlab. The model is qualitatively verified based on the nominal parameter values available for ASM2d Henze et al., 1999.

It is of interest to adjust the parameters in the model such that the developed model fits better to experimental data from the Gävle plant. One problem with the ASM2d model is that of parameter identifiability the model holds a large number of parameters, and few measurements are available. This leads to problems related to both output insensitivity to parameters, and correlation between parameters some parameters may be unidentifiable. Three strategies for avoiding this problem are i to find the theoretically identifiable parameters, and only include these in the parameter updating algorithm, ii to remove numerically insensitive and correlated parameters from the parameter list, and only update the remaining parameters, and iii to project the parameters into the numerically identifiable subspace, where the parameter updating takes place. Strategy ii and iii use the available experimental data in a numerical analysis, while strategy i makes the unrealistic assumption that the system is persistently excited.

In this paper, we use a method proposed by Brun et al. 2002 which is based on strategy ii, see also Duenñas Díez et al. 2005 for an application. When a low number of identifiable parameters have been found, a standard least squares technique is used to calculate the improved parameter estimates. The adjusted model is validated against experimental data, and the consequence of many parameters combined with few measurements is highlighted.

Finally, possible uses of the dynamic model are discussed briefly.

38 The OpenModelica Modeling, Simulation and Development Environment

Peter Fritzson

Modelica is a modern, strongly typed, declarative, and object-oriented language for modeling and simulation of complex systems. This paper gives a quick overview of some aspects of the OpenModelica environment an open-source environment for modeling, simulation, and development of Modelica applications. The OpenModelica environment is the only Modelica environment so far with good support for debugging Modelica algorithmic code as well as support for meta-programming integrated in the language.

39 Transient hydraulics simulations using component sub-vis in LabVIEW

Bjørnar Svingen

Transient simulations of hydraulic piping systems consists of simultaneous solution of the 1D wave equations that relates flow to pressure in a pipe, and solutions of all other non-pipe components constituting the total system. The method of characteristics MOC is the most widely used method due to its analytic accuracy and speed. This paper present an implementation of MOC as a so-called toolkit or library in LabVIEW. Each type of physical component pipe, valve etc is programmed as a component sub-vi component sub virtual instrument. A component sub-vi can best be described as a lightweight variation of an object in an object oriented programming language, because data and procedures are encapsulated within each component. Hydraulic systems, with virtually limitless complexity, are then constructed intuitively using point and click methods in the standard LabVIEW interface, and later run, without needing any prior knowledge of LabVIEW. The modularity means that new components and upgraded components are easy to incorporate, while the LabVIEW interface provides all interactive graphical representation, both in batch mode and in real-time simulations. This toolkit is implemented in a package called LVTrans LabVIEW Transient Simulations. This package is actively used and under continuous development at SINTEF Energy Research, and is also licensed to Statkraft ASA.

40 Study the Behavior of a Pump-less Absorption System Using Bubble Pump

M. Naghash Zadegan, Y. Rezvanifar and K. Javaherdeh

Referring to the global warming issue, conventional air conditioning machines contribute both to the release of CFC refrigerants and the emission of carbon dioxide for their energy requirements, to the destruction of the ozone layer. The objective of current study was to simulate LiBr-water pump-less vapor absorption system, using bubble pump to circulate the solution thermally and to eliminate the shaft power. Doing this the heat addition to the fluid at the base of a vertical tube creates vapor, thereby increasing the buoyancy of the fluid causing it to rise through the vertical tube under two-phase flow conditions. In this way, where the power is expensive or unavailable, or where there is waste, gas, geothermal or solar heat available, pump-less absorption machines could provide reliable and quiet cooling. Two-phase flow models will be used to analyze the bubble pump. The relationship between the submergence ratio and the velocities has been obtained. The drift flux model has been used to find the gas void fraction. The results show that a 25 mm bubble pump tube diameter is suitable for residential size absorption chiller. A computer program has been written based on the bubble pump analysis. Heat and mass transfer and the appropriate equations describing the properties of working fluids have been used to analyze the absorption behavior. The results shows, with a single lift tube, it is possible to reach a COP of 0.48.