**Master projects autumn 2017.**

**Sigurd Skogestad**

**Project: Process control Case study at Perstorp**

Supervisors: Krister Forsman and Sigurd Skogestad

Krister Forsman is Professor II at NTNU and has given guest lectures in the process control course about industrial control strategies. He leads the control group at Perstorp, which is a Swedish chemical company with many plants all over the world and many intersting control problems. To keep the application current and of interest to Perstorp the specific application will be decided later. The work will generally involve the following (mostly using Matlab):

1. Derive a simple process model (Simulink/Matlab)

2. Match to current operation data

3. Propose an improved control strategy. This will often involve suggestions for moving the throughput manipulator and introducing cascades or simple model-based strategies.

Typically, the project may deal with the modelling and matching with data, and the master thesis will focus on the control part.

**Project: Process control case study at Norske Skog**

Supervisor: Sigurd Skogestad

Co-supervisor at Norske Skog, Skogn: Andreas Volden

There are several possible case studies, most related to effective use of enegy. One of them is the steam system and another is the heat recovery from combustion. More details will be published on the home page of Sigurd Skogestad soon (see under project students).

The project will focus on modelling and comparing with data from the real plant and the master thesis will focus on control.

**Project: Modeling and simulation of an inclined pipe separator**

The task of the candidate will be to develop a mathematical model (dynamic / steady state) of an inclined pipe separation process with application to the oil and gas industry and potential subsea application. A pipe separator is a separation device working on the principle of separation by density differences and gravitational forces and is by principle related to gravity separators.

Specific tasks include:

• Literature review of potentially existing pipe separator models as well as inclined pipe separators with industrial applications that have already been established

• Modeling of the major dynamic / steady state principles by means of first principles / physical phenomena

• Development of a simulation model to test and verify the mathematical model in a software like Matlab/Simulink and/or Modelica

• Writing a project report about the conducted work including and describing the above-mentioned points

The project will be conducted during the fall semester 2017 at the Department of Chemical Engineering under the supervision of Prof. Sigurd Skogestad and Dr. Christoph J. Backi.

The project is part of SUBPRO (SFI Center for Subsea production and processing).

**Project: Modeling and simulation of a gravity separation device for oil and gas applications**

The task of the candidate will be to improve and further develop the mathematical model of a gravity separator introduced by C.J. Backi. A gravity separator is a device based upon the principles of separation by density differences and gravitational forces. It is widely used in the oil and gas industry and serves as a bulk separation device.

Specific tasks include:

• Literature review of existing gravity separator models and related principles (such as particle balances)

• Working and understanding the model developed by C.J. Backi and afterwards incorporating new phenomena into the model. These can include coalescence and/or breakage of droplets as well as a dense-packed layer interface.

• Extend the simulation model to test and verify the mathematical improvements in a software like Matlab/Simulink and/or Modelica

• Writing a project report about the conducted work including and describing the above-mentioned points

The project will be conducted during the fall semester 2017 at the Department of Chemical Engineering under the supervision of Prof. Sigurd Skogestad and Dr. Christoph J. Backi.

The project is part of SUBPRO (SFI Center for Subsea production and processing).

**Project: Adaptive anti-slug control**

The task of the candidate will be to improve and further develop the mathematical model of a gravity separator introduced by C.J. Backi. A gravity separator is a device based upon the principles of separation by density differences and gravitational forces. It is widely used in the oil and gas industry and serves as a bulk separation device.

Specific tasks include:

• Literature review of existing anti-slug control algorithms, including adaptive kinds

• Working and understanding the anti-slug model developed by E. Jahanshahi

• Test the developed control structures in Matlab/Simulink and afterwards in the anti-slug lab at the Department of Chemical Engineering

• Writing a project report about the conducted work including and describing the above-mentioned points

The project will be conducted during the fall semester 2017 at the Department of Chemical Engineering under the supervision of Prof. Sigurd Skogestad and Dr. Christoph J. Backi.

The project is part of SUBPRO (SFI Center for Subsea production and processing).

Project: Simple pump characteristic models based upon analytical expressions

The task of the candidate will be to investigate pump curve characteristics with respect to e.g. flow, head and rotational speed and find simple, analytical expressions for these pump curves. Further variables can include power consumption, efficiency, net positive suction head, etc.

Specific tasks include:

* • Literature review of pumps and potential existing work on simple pump characteristics modeling
* • Comparison of the simple analytical pump characteristics with existing lookup-table-based characteristics in simulation environments such as Matlab/Simulink with respect to performance. HYSYS or other environments could also be used.
* • Writing a project report about the conducted work including and describing the above-mentioned points

The project will be conducted during the fall semester 2017 at the Department of Chemical Engineering under the supervision of Prof. Sigurd Skogestad and Dr. Christoph J. Backi. The project is part of SUBPRO (SFI Center for Subsea production and processing).

**Project: Simple pump characteristic models based upon analytical expressions**

The task of the candidate will be to investigate pump curve characteristics with respect to e.g. flow, head and rotational speed and find simple, analytical expressions for these pump curves. Further variables can include power consumption, efficiency, net positive suction head, etc.

Specific tasks include:

• Literature review of pumps and potential existing work on simple pump characteristics modeling

• Comparison of the simple analytical pump characteristics with existing lookup-table-based characteristics in simulation environments such as Matlab/Simulink with respect to performance. HYSYS or other environments could also be used.

• Writing a project report about the conducted work including and describing the above-mentioned points

The project will be conducted during the fall semester 2017 at the Department of Chemical Engineering under the supervision of Prof. Sigurd Skogestad and Dr. Christoph J. Backi. The project is part of SUBPRO (SFI Center for Subsea production and processing).

**Project:** Optimization of the synthesis-gas loop as example for integrated processes.

**Supervisor:** Julian Straus and Sigurd Skogestad

Modern plants in the ammonia industry are highly integrated. This is on the one hand caused by the small equilibrium conversion in the gas phase synthesis reaction and on the other hand due to the strong competition in the market. Hence, energy recycling to utilize the heat of the reaction and compression efficiently and reactant recycling play a crucial role.

This integration leads to problems in modelling using the traditional sequential-modular approach through the huge amount of iterations needed to solve the flowsheet and the associated computational costs, especially for nested recycle loops, (recycle loop within a recycle loop). Additionally, convergence is not always achieved. Hence, conventional optimization approaches are difficult to apply. Our idea to circumvent this problem is to develop a new approach by splitting the big model into smaller sub-models and replace the sub-model itself with a simplified (surrogate) model. The surrogate models are then combined and optimization can be performed [1].

The definition of surrogate models and the sampling using the detailed model is however complicated partly due to the flowsheet topology and partly due to many connectivity variables.

The task of the project is set within the Ph.D. project of Julian Straus on optimization of integrated processes.

Depending on the process until August, several possibilities may arise about the exact nature of the project. Prospective students are encouraged to bring in own ideas. Generally, the project will involve extensive MATLAB modelling as well as MATLAB-HYSYS interaction. The student is required to have good knowledge in MATLAB.

If questions arise and/or you are interested in the project, feel free to contact me
(julian.straus@ntnu.no, or pass by in room K4-239).

[1] J.Straus, S. Skogestad, *Computer Aided Chemical Engineering* **2016**, 38, 289-294.

Project: Modelling a subsea production network

# Main Supervisor: Sigurd SkogestadCo-supervisor: Dinesh Krishnamoorthy

Subsea production systems consists of many interconnected wells and processes such as compressors and booster pumps. Models that represents the production network are crucial for Daily Production optimization. The main task of this project is to develop a subsea production network with different manifolds that are interconnected and produce to a common riser manifold equipped with a subsea boosting station.

Possible tasks of this project are:

* Use gas lifted well model as building blocks to model a large subsea production network (preferably that matches the Shell Draugen case)
* Model a subsea multiphase booster pump
* Implement simple pressure and flow controllers (regulatory control)

The project requires basic knowledge of modelling and control. Models should ideally be developed in MATLAB.

 This project is part of SUBPRO. For any questions and/or you are interested in this project, feel free to contact Sigurd Skogestad or Dinesh Krishnamoorthy (dinesh.krishnamoorthy@ntnu.no).



Project: Adaptive MPC of a subsea system

# Main Supervisor: Sigurd SkogestadCo-supervisor: Dinesh Krishnamoorthy

Subsea production systems consists of many interconnected wells and processes such as compressors and booster pumps. Models used for production optimization are subject to uncertainty due to lack of knowledge or model simplification. One way to handle unknown disturbances or structural uncertainty is to use an adaptive controller. In this project we propose to use an adaptive linear MPC to adapt the models online using measurements.

* The main aim of this project is to develop an Adaptive MPC scheme
* And test the developed controller using a gas lifted well simulator

The project requires basic knowledge of control and estimation. Models of gas lifted well network are available and the focus of the project is on developing adaptive MPC (preferably in MATLAB or SEPTIC).

 This project is part of SUBPRO. For any questions or if you are interested in this project, feel free to contact Sigurd Skogestad or Dinesh Krishnamoorthy (dinesh.krishnamoorthy@ntnu.no).

Project: Extremum seeking control of a subsea production network

# Main Supervisor: Sigurd SkogestadCo-supervisor: Dinesh Krishnamoorthy

Subsea production systems consists of many interconnected wells and processes such as compressors and booster pumps. Models used for production optimization are subject to model structural uncertainty due to lack of knowledge or model simplification. One way to handle unknown disturbances or structural uncertainty is to use a model free method. Extremum seeking control is one such model free optimization method that can be used to optimize a production network. Extremum seeking control uses the measurements to estimate the local gradient and converges to the optimum.

* The main aim of this project is to develop extremum seeking controllers to optimize production from a gas lifted well network.
* Additionally, extremum seeking control can be combined with self-optimizing control to further improve the performance.

The project requires basic knowledge of control and estimation. Models of gas lifted well network are available and the focus of the project is on extremum seeking control and self-optimizing control. The controllers can be developed in MATLAB or SEPTIC.

 This project is part of SUBPRO. For any questions or if you are interested in this project, feel free to contact Sigurd Skogestad or Dinesh Krishnamoorthy (dinesh.krishnamoorthy@ntnu.no).