**NTNU**
**Norges teknisk-naturvitenskapelige universitet**

**Fakultet for naturvitenskap og teknologi**
**Institutt for kjemisk prosessteknologi**

# FORDYPNINGSPROSJEKTER HØSTEN 2010
## SPECIALIZATION PROJECTS AUTUMN 2010

## TKP4550/TKP451 PROSESS-SYSTEMTEKNIKK (Process Systems Engineering)

**Coordinator: Professor Sigurd Skogestad**

**Project proposal: Sigurd Skogestad**

**1. Simulation and operation of $CO_2$ capturing process**
There are many possibilities for capturing $CO_2$ in combustion processes. We have previously considered conventional atmospheric post combustion $CO_2$ capture, but in this project other alternatives will be studied. The goal is to study the dynamics and optimal operation of the process using the ProSim (Hysys) dynamic simulator. The operational profit to be maximized is income from $CO_2$ removal minus the energy costs. It is desired to find a simple control strategy by identifying "self-optimizing" controlled variables, which when held constant indirectly maximize the profit.
**Co-supervisor: PhD student, Mehdi Panahi**

**2: Simulation, design and optimal operation of liquefaction process for natural gas**
LNG (Liquefied natural gas) is still a growing business, both in Norway and abroad. Liquified natural gas (LNG) is produced by cooling natural gas in several stages to about -162C so that it can be stored as liquid as atmospheric conditions. The volume is then reduced by a factor of about 600. The process is energy and capital intensive and many alternative designs have been proposed. The basis for the project are existing models of the process in Hysys/Unisim , MATLAB or gPROMS.

2.1: Steady-state simulation and optimization of LNG processes is difficult because of tight integration and small temperature differences between the streams.
The UniSim and gPROMS models use different solution procedures, but both programs have problems in converging. In this project the focus is on formulation robust model approaches by combining the best from the UniSim and gPROMS models.

2.2: In this project the focus will be on processes that take advantage of arctic temperature conditions.

**Co-supervisor: Magnus G. Jacobsen**
The projecta will be in cooperation with Statoil (Jostein Pettersen)

3: **Design of integrated distillation columns for separation of multicomponents mixtures**

3.1: **Integrated Process Design.** Integrated (simultaneous) design is defined as the development of a chemical process by considering both steady-state economics and dynamic controllability at all stages of flowsheet synthesis. The basic notion is that the dynamics of the process are vitally important in its ability to operate efficiently and safely and to make on-specification products with little product-quality variability.
First, the need of simultaneous consideration of design and operation and the

conflicts between steady-state economics and dynamic controllability will be studied. Afterwards, a good process design and control structure design will be done considering the steady state objectives and good controllability performance.

The model is provided is UniSim/HYSYS and the tool for manipulating the HYSYS model and doing the rest will be in MATLAB.

3.2: We have worked for many years on new integrated distillation sequenses, including Petlyuk distillation and the Kaibel column. We have build an experimental column which is operated experimentally.

More specifically, the goal of this project is to look for the optimized thermally coupled distillation sequences for multi-component separations. A rigorous model is developed in UNISIM and MATLAB or GAMS will be used for the optimization. So, the capabilities of both software systems are used at the same time. Different alternatives are simulated in UNISIM and then the best option should be selected considering the energy savings through a proper optimization of the interconnecting streams.

3.3: Comparison of two plant-wide control strategies for the case of 4-product Kaibel column. (Skogestad's method and Luyben's)

**Co-supervisor on all these projects: Maryam Ghardran and Ivar J. Halvorsen (SINTEF)**

**4: Design, simulation and Optimal operation of offshore process**
**In cooperation with Statoil Porsgrunn (Vidar Alstad)**

The details with the project will be defined by Statoil

**5: Stabilization of two-phase flow in risers from reservoirs (anti-slug control) (in cooperation with Siemens)**

These project are motivated problems with riser slugs in offshore fields in the North Sea. All projects are in cooperation with Siemens (Fredrik Dessen) and the multiphase group at the Department of Energy and Process Enginnering (Prof. Ole Jørgen Nydal).

5.1: Controllability analysis of simple nonlinear models. The objective is to perform a controllability analysis of different riser slugging models, including frequency domain analysis (disturbance sensitivity), RHP-poles and zeros, decentralized and multivariable control etc.

**Co-supervisor: Esmaeil Jahanshahi (PhD student)**

5.2: Comparison of alternative simple models.

1. Compare and analyze alternative simplified model of the process.
2. Tune the simple model based on experimental data on our mini-rig so that it represents the actual behavior
3. Discuss the possibility for avoiding the slug flow, for example, by use of active control.

**Co-supervisor: Esmaeil Jahanshahi (PhD student)**

5.3: Experimental study on small-scale rig.

We have a "mini-loop" rig which is very well suited for experimental studies, and there is also a medium scale rig in the lab of Professor Ole Jørgen Nydal. Tasks.

1. Do experiments in a small-scale rig.
2. Fit the simple models with experimental data.
3. Compare different control strategies on riser slugs.

**Co-supervisors: Weiwei Qiu (PhD student), Esmaeil Jahanshahi (PhD student)**

**6: Dynamic simulation of alternative control strategies**

**Co-supervsior: PhD student Ramprasad Yelchuru**

The objective is to simulate and compare alternative base (regulatory) control structures on some case studies using dynamic simulation (Hysys/Unisim).

Links to descriptions of the software:

http://hpsweb.honeywell.com/Cultures/en-US/Products/ControlApplications/AdvancedControlOptimization/ProfitController/default.htm
http://hpsweb.honeywell.com/Cultures/en-US/Products/ControlApplications/Simulation/default.htm

**7: Modelling and Control of District heating systems**

In Trondheim there is a district heating network for hot water based on the Tiller incineration plant for burning waste, and in Oslo there are similar plants. It is possible to save energy by improving the operation and control of such systems. This will be a continuation of previuis projects.

**Co-supervisor: PhD student Johannes Jäschke**

**8: Validation of new closed PID tuning rules**

Samsussoha and Skogestad (see home page of Skogestad) have recently (ESACAPE and Adchem conferences, 2010) proposed a new PID tuning rule based on a single setpoint step response using P-controller. The method is proposed as an improved and simplified alternative to the Ziegler-Nichols tuning. The objective of the project is to validate the tuning rules using experiments and dynamic simulation.

**Co-supervisor: Ivar J. Halvorsen (SINTEF)**

**9: Controlled variables from operation data (chemiometrics project)**

By choosing a suitable control structure for a chemical process, it is possible to increase profits while keeping environmental and safety constraints in their specified limits.
Most conventional methods for determining a good control structure depend on the availability of a good process model. However, in many practical situations good models are difficult to obtain, because of the immense efforts required to develop and test a process model which is detailed enough to describe the process adequately, while easy to solve from a numerical point of view.

A different approach is to examine data from a given process, and to analyse it in order to find a control structure which gives good performance. This project involves studying how data from a given can be used to extract good control strategies.

**Co-supervisor: PhD student Johannes Jäschke**