NTNU
Norges teknisk-naturvitenskapelige universitet

Fakultet for naturvitenskap og teknologi
Institutt for kjemisk prosessteknologi

TKP4170 PROSJEKTERING AV PROSESSANLEGG

TKP4170 Process Design, Project

Main supervisor professor Magne Hillestad

autumn 2010

1: Hydrogen production from glycerol

Hydrogen production with CO_2 management is the current national efforts for production of clean energy, which is important for Norwegian industrial. Glycerol is the by-product of biodiesel production. Recently we have developed a sorption enhanced reforming technology to achieve almost 100% yield of hydrogen. The present project will deal with process design and evaluation of sorption enhanced reforming of glycerol for hydrogen production with a yield of 99%.
Supervisor: De Chen

2: New products from sawmill waste

Pine heartwood contains significant amounts of extractives, making it very durable even without impregnation, staining or painting. Thus, lumber from pine heartwood is a valuable product, requiring no impregnation for high durability outdoors. There are several sawmills producing heartwood lumber as an environmental-friendly alternative to impregnated wood.

During the production of lumber, the sawmill also produces wood chips, sawdust and shavings as waste material. This is usually sold for bioenergy purposes, but there is no added value for wood with high contents of extractives. If the extractives can be isolated without burning the wastewood, the resulting product can be sold as an environmental-friendly impregnation compound. If a plant for the isolation of the extractives can be built, special compounds in the extractives fraction may generate even higher-valued products in the future (e.g. wood turpentine or essential oils).

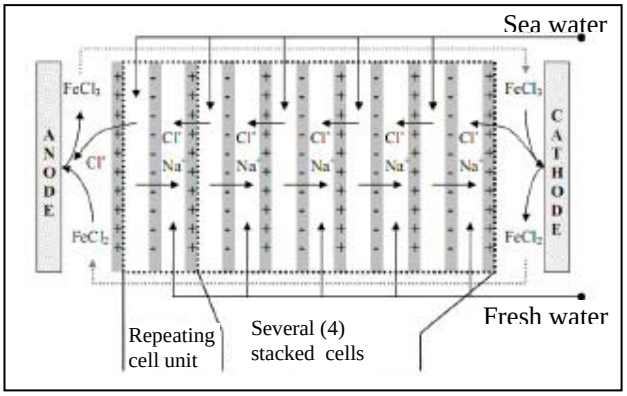
This project is related to a planned preliminary study and possible project for an existing sawmill.
Supervisor: Størker Moe

3: Method for utilizing the energy of mixing into electrical energy

One of the more pronounced problems in the world to day is the need of renewable energy. The world's energy consumption is largely relied on fossil fuels, and the usage of such fuels has been criticized for its tremendous carbon dioxide emissions. It is claimed that the increased emissions of carbon dioxide by human activities are one of the greatest contributions to global warming.

A way of producing renewable electric energy is by utilizing the energy of mixing where rivers meet the ocean. One principle used in this purpose is pressure retarded osmosis (PRO) in so called “osmotic pwer plants”. Norway is in the forefront in the research in this field.

An alternative principle is reverse electro osmosis as shown in the Figure below.



Sketch of reverse electro-dialysis (RED)

In the current project a power plant based on RED is designed and modelled, resulting in an economical assessment of the plant.
Supervisors: Magne Hillestad/Tom-Nils Nilsen

4: Process Design and economic investigation of LPG production from natural gas liquids (NGL)

Liquefied petroleum gas (also called **LPG**, **GPL**, **LP Gas**, or auto gas) is a flammable mixture of hydrocarbon gases used as a fuel in heating appliances and vehicles, and increasingly replacing chlorofluorocarbons as an aerosol propellant and a refrigerant to reduce damage to the ozone layer.

Natural gas processing plants, or fractionators, are used to purify the raw natural gas produced from underground gas fields or extracted at the surface from the fluids produced from oil wells. The separated liquids are named as NGL.

The raw NGL is sent to LPG plants to separate LPG (i-C_3 and i-C_4) from stabilized NGL (C_{6+}). Both products are very valuable and expensive in the market.

The purpose of this project is to design and simulate a LPG plant using commercial softwares.

Based on the simulated process, a feasibility study will be done at the end.
Supervisor: Prof. Sigurd Skogestad, co-supervisor: PhD student, Mehdi Panahi

5: Fischer-Tropsch from biomass

Key words: Catalysis, Fishcer-Tropsch, Bio-Diesel/renewable energy

The Ecopro plant localized in Skjørdalen in Verdal municipality is designed to treat organic waste from households, fishing- and agricultural industry, and sludge from sewage treatment plants. As of today the yearly capacity of the plant is 35 000 tons, but it is being planned to increase the capacity to 56 000 tons. The Ecopro plant is the largest of its kind in Norway. By using patented hydrolysis and fermentation technology from Cambi ASA, large amounts of biogas is produced each year. Currently the biogas is used for a yearly production of 9.4 GWh electricity.
This goal of this project is to upgrade the current plant to produce Fischer-Tropsch (FT) diesel instead of electricity. The assignment will include cleaning of the biogas and/or synthesis gas, production of synthesis gas and the Fischer-Tropsch plant itself. There is no principal difference between the plant you are going to design and a plant based on natural gas as a feedstock. The challenge is to design a smaller plant and also to handle catalyst poisons in the biogas, which most likely will require some sort of cleaning technology. If a profitable FT plant can be designed this could be a significant source of renewable energy worldwide and have a huge impact on plants similar to Ecopro around the world. The goal with the project should be to identify the realism in building small scale FT-plants and also to identify any challenges that need to be solved in order to build a profitable plant. This is a large project and the students are free to limit the scope of the work in agreement with the supervisor.
It is already suggested to utilize the biogas from Ecopro as fuel for busses in the area around Trondheim, but Cambi ASA is very interested in investigating different possibilities to utilize the biogas. Technical Director Odd Egil Solheim at Cambi ASA will be a co-supervisor for this group and will be available on phone and e-mail to answer any questions the students might have. Odd Egil Solheim has earlier experience as supervisor for students at NTNU and also studied here himself. It will be arranged a field trip in the beginning of the semester to the Ecopro plant where the students will get a guided tour. More information about Cambi ASA and the Ecopro plant can be found at www.cambi.no and at www.ecopro.no.
This project does have interest for local industry and touch upon important international topics which are highly relevant. For this reason this should be a very interesting project for any student at IKP.
Supervisor: Anders Holmen, co-supervisor PhD student Andreas H. Lillebøe

6: Post-combustion CO_2 capture by amine absorption-Optimization of stripper pressure level and integration with CO_2 compression train

The traditional process configuration for post-combustion capture using MEA as solvent system is very energy demanding and costly. Several process improvements have been proposed in the literature and one possible solution is to integrate the stripper unit with the CO_2 compression by using different pressure levels for the stripping part. It has been shown that this may reduce the energy requirement of the compression as well as the heat required in the reboiler of stripper. However, this may also add extra units and thus increase the capital expenditures. The purpose of the activity will be to find the optimal pressure levels of the stripper and how it shall be integrated with the CO_2 compression. UNISIM shall be used for determining the energy requirement.
Supervisors: Magne Hillestad and Hanne Kvamsdal SINTEF MK

7: Synthetic diesel production from Norwegian wood waste

Background

The Norwegian forests represent the largest potential for supply of raw material for production of bioenergy. The utilization of bioenergy in Norway has increased from about 10 TWh in 1985 to 16 TWh today, which corresponds to about 7% of the total inland energy consumption. A proposed target has been set to increase the use of bioenergy by 14 TWh by 2020 and to obtain 30 TWh more renewable energy and energy savings by 2020.

Gasification is a process that converts carbonaceous materials, such as coal, petroleum, biofuel, or biomass, into carbon monoxide and hydrogen by reacting the raw material at high temperatures with a controlled amount of oxygen and/or steam. The resulting gas mixture is called synthesis gas or syngas, and may be burned directly in internal combustion engines, applied for production of methanol and hydrogen, or converted into synthetic fuel via the Fischer-Tropsch process. Synthetic fuels for diesel engines and turbo engines will be one of the most important energy sources in the near future.

Task

The task is to explore the potential for profitable synthetic diesel production in Norway. The feedstock shall be Norwegian wood waste like branches and tops (GROT). In addition the synthetic diesel producer will utilize torrefaction as a pre-treatment prior to gasification.

The study will be carried out as a part of the PROFIT project at PFI. An essential topic in this project is to explore the potential for profitable synthetic diesel production by utilizing waste energy and favourable logistic costs by integrating the synthetic diesel plant with Norske Skog Follum paper mill. The work will be a continuation of a previous student projecting design work. If desirable, Xynergo will assist in the study.

Main supervisor: Magne Hillestad, Co-supervisor: Kai Toven, PFI (50958), kai.toven@pfi.no

8: Biorefineries for bioethanol production from Scandinavian softwood

Background

The Norwegian forests represent the largest potential for supply of raw material for production of bioenergy. The utilization of bioenergy in Norway has increased from about 10 TWh in 1985 to 16 TWh today, which corresponds to about 7% of the total inland energy consumption. A proposed target has been set to increase the use of bioenergy by 14 TWh by 2020 and to obtain 30 TWh more renewable energy and energy savings by 2020.

Today, bioethanol is produced commercially from starch which is a minor constituent of corn. This process is termed first generation process for ethanol production. However, extensive research is on-going to develop efficient processes for converting cellulose into ethanol, so that non-food lignocellulosic materials can be applied as feedstocks.

Profitable bio-ethanol from lignocelluloses is a challenge. Among the most essential challenges is to develop an efficient process with low operating costs (feedstock, energy, chemicals and enzymes) and value-added products from the non-fermenting compounds in the biomass. Hence, the biorefinery approach is essential for the profitability.

Task

The task is to explore the potential for profitable Norwegian bioethanol production based on two defined biorefinery concepts:

- Production of bio-ethanol from wood carbohydrates and wood pellets from wood lignin based on steam pretreatment of Norway spruce or typical Norwegian wood waste like branches and tops from softwood (GROT).
- Production of bio-ethanol from wood carbohydrates and lignosulfonates from wood lignin based on sulfite pretreatment of Norway spruce or typical Norwegian wood waste like branches and tops from softwood (GROT).

The study will be carried out as a part of the Lignoref project at PFI. If desirable, Borregaard will assist in the study.
Main supervisor: Størker Moe/Kai Toven, PFI (50958) kai.toven@pfi.no,
Co-supervisor: Magne Hillestad

9: Plug flow, mixing zones and grade changes

Problem
When making grade changes in a paper mill it is desirable that the change happen as fast as possible so that as little as possible of the production is out of specifications between the two grades. In a paper mill it is mostly plug flow in pipes and storage towers, however at the outlet of each storage tower there is a dilution and mixing zone where we do not have plug flow. This means that a quality change e.g from an unbleached to a bleached raw material will be less sharp than desirable.

The task
The design task is to use the paper mill Norske Skog Follum as a case and make a model that describe main dilution and mixing points in the process and calculate how much time these add to the grade changes in the mill and estimate the annual loss in earnings because of this. Then to make a new design where at least one of these dilution and mixing points is replaced with technology giving a larger extent of plug flow. The change shall be designed technically and an investment analysis shall be done where the pay back time of the change is calculated.
Supervisor: Øvind Gregersen

10: Parallel projects within the conversion of biomass to biofuels and other high value added chemicals are proposed.

a) economic and technical evaluation of 2.nd. gen. Biofuel from lignocellulose (biochemical conversion)
b) economic and technical evaluation of 2.nd. gen. Biodiesel from lignocellulose (thermochemical conversion)

Joint Information for both of these projects:

Research related to 2.nd. gen. Biofuels is a well-established discipline, challenge per date is profitability of the conversion of biomass to only fuel (especially when we relate this to an oil price of 70US$/barrel). The project which has been suggested will be based on engineering of a classic process for the production of biodiesel or bioethanol and carry out a technical economic evaluation of this process. Parallel to this work, alternative products need to be identified and their influence on profitability of these products needs evaluation. For example, will exploitation of lignin as byproduct of biofuel production be critical to the economy of the project; similar evaluation components are possible in thermochemical conversion.
Supervisors: Magne Hillestad, Størker Moe, Bernd Wittgens (SINTEF)