ILLINOIS INSTITUTE OF TECHNOLOGY

IPRO 346 – Fall 2006
Design of Coal Desulfurization Processes to Improve the Environment
Project Proposal

Roster

Amy McDowell (CHE) – Team Leader

Salil Benegal (CHEM)

Tony Doellman (PHYS)

Andrew Keen (CHE)

Greg Kisiel (BME)

James Maratt (CHE)

Ranti Ogunride (CHE)

Oscar Olmos (CHE)

Myint Toe (CHEM)

Professor Mohammed Ehsani – Team Advisor

Raymond Losch – Teaching Assistant

Objective

The objective of this IPRO is to choose an appropriate method (or combination of multiple methods) for desulfurizing coal before combustion takes place in a furnace for energy production. Three methods will be researched in order to find the best way of desulfurization- physical, chemical, and biological. Whichever method(s) is found to be the most effective at removing sulfur from coal will be chosen. After this decision the group will move forward and design the process equipment; later an economic assessment will be done to cost the equipment. All of the group's goals will be completed within this semester.

Background

Coal, one of the most abundant fossil fuels on the planet, is widely known for its high output of energy, thus making it a chief proponent within the energy industry. However, as effective as its power may be, the presence of sulfur within the coal limits the industrial usage of the fuel and various environmental issues also stem from its utilization. These pollutants are generally airborne, derive from the sulfur components within the coal structure, and require extensive amount of maintenance in terms of cleaning to reduce the content within.

Because of the problems associated with the pollutants of coal, it is vital that the desulphurization of the coal member be implemented so that these harmful components do not form, providing advantages such as a higher burning efficiency when subjected to various processes such as the production of coke. A variety of methods have been developed to eliminate the sulfur components and byproducts of coal, with benefits applicable for each specific method. Generally, when coal is treated under physical removal techniques, the inorganic sulfur compounds within the coal are greatly reduced. On the other hand, microbiological techniques tend to remove the organic constituents from the mix. Select chemical methods, when used either separate or in conjunction with one another, remove both of the forms of sulfur within the coal.

Due to the select availability of the coal involved in this project, the choice of coal utilized will derive from Illinois. The two major seams located in Springfield and Herrin meet the optimal conditions of both combustion and sulfur content. These two subtypes of bituminous coal, the major coal used for coking and general power generation, are known for their low sulfur content and high energy yield per unit. It is crucial to find a process which encases the proper removal of the select sulfur compounds while still providing a flexible margin for profit for a generalized coal burning power facility. The methods that will be utilized are the ones named above for the general desulphurization of the coal member, with a specific focus on pre-combustion cleaning methods.
Overall, the desulphurization of coal is a vital process that must be implemented into the coal industry in order to reduce harmful emissions and create a higher potential for the burning of coal. Without implementing this procedure, coal may not have a distant future for the power generation industry around the world.

Methodology

The project aim is to design and evaluate a logistically and financially viable process for the removal of sulfur from coal prior to combustion.

Preliminary research by project members will cover background information on coal and its use in power generation and industry; the latter primarily will focus on conversion to coke for the purpose of steel and iron production.

Following the basic groundwork, additional research will be undertaken to study different mechanisms of coal desulfurization used both prior to and after combustion. Physical, biological and chemical methods of sulfur removal will be studied, with the group eventually concurring on a method that will be efficient from industrial, environmental and economic perspectives.

This method will then be studied in greater depth to analyze equipment and operational parameters, and the basic desulfurization process will be modeled and designed using the ASPEN simulation software to estimate large-scale efficiency and cost-effectiveness. Upon confirmation of the method being industrially viable, reports and a final presentation will be written to deliver the group’s findings and assessments for improving industrial coal desulfurization methods.

Expected Results

The major tasks that remain after this project's goals are met are the development of a simulation and a thorough economic analysis based on a semi-large scale application of our process. The simulation will be modeled using the either software package ASPEN or HYSYS. It will serve as a feasibility analysis, that is to say, whether or not it is thermodynamically possible. The economic analysis will be done preliminarily though software distributed by the Department of Energy and will be revisited by the Chemical Engineers in the group for further analysis. Cost analysis of plant construction will address the issue of whether or not is it cost effective to implement a pre-combustion desulfurization process rather than a post-combustion gas scrubber system. Deliverables will include the simulation file as well as a cost analysis for construction of a plant making use of our system.

Most of the data we acquire will be through research and not from experiments done by the group. Consequently, the results we expect are going to be along the lines of what is considered "common knowledge" by industry professionals. Specifically, we are working with the knowledge that our chosen method is less cost efficient than alternatives that are currently being implemented. Among the results we hope to acquire are accurate estimations of the expense of these alternative desulfurization methods. We also hope to isolate a few alternatives that may be economically viable or that offer an advantage that is unavailable through traditional desulfurization.

The most likely implementation of the technologies and methods we are researching will be in coal power plants. Currently, coal power plants use a calcium based post-combustion method to remove sulfur. Our proposed product would be a cost effective method to reduce sulfur (organic and pyrite) in coal prior to combustion. If cost effective, this method could significantly alter power plant design and significantly increase efficiency. However all of these potential benefits will likely require significant modification of existing coal power plant designs.

Should our solution prove economically favorable to post-combustion methods, our design may be implemented (by an outside source) to test the effectiveness of our design. In the case that both our model and tests thereof prove fortuitous, pre-combustion desulfurization may be applied to industry for the purpose of satisfying electrical demands with minimal pollution.

Project Budget

Visit to the Museum of Science and Industry

For our project we are planning a visit to the Museum of Science and Industry in Chicago, IL. This visit has the purpose of becoming familiar with existing processes of coal use for energy production. This museum has an exhibit for energy production (nuclear energy, petroleum, coal), and another exhibit for coal production.

- Admission:
  - 9 Adults: $16/each= $144
- Lunch:
  - 9 people
  - $10 per person
  - $90 total

- Total Cost
  - $234

Educational e-book

In order to work in the technical design of this IPRO we are planning to use a computer simulation tool (ASPEN), which is provided by the Chemical Engineering department. For the use of this tool we are going to need technical support. Since ASPEN classes are out of the question (price, availability, etc), a book would be very helpful.

Introduction to Chemical Engineering Computing [E-Book]
Price: $ 54.95+ Shipping+ tax @ http://www.wiley.com/WileyCDA/WileyTitle/productCd-047177667X.html

Printing and Copying

This budget is requested so that we can have the necessary means of dispersing important materials to the entire team.

- $100

Grand Total: $399

Individual Team Member Assignments

Rather than have a couple of main subgroups, IPRO 346's method for getting the entire group involved in as much of the IPRO as possible involves having many small groups with different goals to be completed throughout the semester. These groups become a main focus for a week or two, each with deadlines that must be met; after the goals of the group are accomplished, the members move on to the next step and continue building and growing towards our main goal of designing a pre-combustion desulfurization process. The description of the groups is described in the schedule.

Coal Research Group
Tony Doellman
Greg Kisiel
Myint Toe

Coke Research Group
Salil Benegal
Amy McDowell
Oscar Olmos

Desulfurization and Coal Analysis Group
Andrew Keen
James Maratt
Ranti Ogunride

Physical Methods Group
Tony Doellman
Andrew Keen
Ranti Ogunride

Chemical Methods Group
Salil Benegal
James Maratt
Amy McDowell
Oscar Olmos

Biological Methods Group
Greg Kisiel
Myint Toe

Process Design Group
All Team Members

Simulation Group
To Be Determined

Safety Group
To Be Determined

Costing and Profitability Analysis Group
To Be Determined

Designation of Roles

Assignments have also been given for some of the particulars of this IPRO:

- Project Plan – Team Leader in collaboration with members and advisor
- Research – All Team Members
- Oral Presentation – All Team Members
- Midterm Progress Report – Team Leader in collaboration with members and advisor
- Team Minutes - Ranti Ogunride
- Team Poster – To Be Determined
- Final Report/Abstract – Team Leader in collaboration with members and advisor

Schedule

-Please see attached sheets