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ANALYSIS OF GLOBAL WARMING MITIGATION BY WHITE REFLECTING SURFACES

Federico Rossi, University of Perugia, Department of Industrial Engineering
via G.Duranti, 67, Perugia, Perugia, 06125, Italy
T: +390755853846, F: +390755848470, frossi@unipg.it

The rapid increase in greenhouse gas (GHG) concentration over the last 50 years has produced approximately 0,64 Celsius degrees rise in global mean temperature. The most worrisome effects of global warming include severe weather and related hydro-geologic events, many of which have been already occurring. Global warming consequences are touchable also in agricultural field; species extinctions and increases in the ranges of disease vectors are actually going on. Earth's global surface temperature strongly depends on its surface radiative properties. Solar radiation absorbed by surface, together with a natural atmospheric greenhouse effect, represents the mechanism regulating Earth's temperature. Therefore, Earth's albedo modification by proper surfaces would reduce the portion of solar radiation absorbed by the Earth, and consequently decreased average global temperature. Quantification of reflecting surface effectiveness has been accomplished in this work through a mathematical relation, based on the energy balance among sky, atmosphere and earth surface. The correlation between the temperature reduction and the greenhouse gases decrease in the atmosphere has been calculated on the hypothesis that the temperature increase in the last century has been caused exclusively by the GHG concentration variation occurred in the same period. It has been estimated by the proposed model that the reflecting surface area (reflecting coefficient equal to 0.9) which is required to offset the effect, in terms of global mean temperature, of introducing in the atmosphere of 1 ton of CO2eq is equal to 8 square meters. In terms of Radiative Forcing, a drop of 0.28 W/m2 is obtained for each 106 km2 of the same kind of reflecting surfaces. Comparing earlier literature models, results that one tonne of emitted CO2 offset is obtained increasing the albedo by 25% for a surface of 23 m2 using our method, of 26 m2 in Harte's model and of 23 m2 in Berkeley study. In terms of Radiative Forcing, a drop of 0.28 W/m2 is obtained for each 106 km2 of surfaces with reflection coefficient of 0.9. Furthermore, greenhouse gas "abatement" cost through reflecting surfaces has been compared to the one obtained by the main renewable energy sources. The technologies for renewable energy sources which have been considered in this study are solar panels for the generation of thermal energy, photovoltaic panels, wind generators and hydroelectric power plants.

SUSTAINABLE AND INNOVATIVE PROCESSES FOR CARBON CAPTURE AND RECYCLING

Manuel Alvarez-Guerra, University of Cantabria
Department of Chemical Engineering and Inorganic Chemistry, ETSIIT, Avda de los Castros s/n, Santander, Cantabria, 39005, Spain
T: +34 942 200931, F: +34 942 201591, alvarezgm@unican.es
Angel Irabien, University of Cantabria

The ENVIROFRIEND-CONSOLIDER-Ingenio 2010 is a research project proposal of high level scientific activities within the framework of the CONSOLIDER-Ingenio 2010 Programme of the Spanish Ministry of Science and Innovation. The main aim of this project proposal is to make a significant progress in the knowledge and development of Sustainable and Innovative Processes for Carbon Capture and Recycling. This activity places strong emphasis upon new knowledge in cleaner combustion processes (oxycombustion, chemical looping), CO2 separation/concentration processes using membrane technologies, catalytic and electrocatalytic processes for CO2 recycling and integration and optimization of the processes based on sustainability criteria.

The most mature and applied technology for the post-combustion capture of CO2 from the flue gas and subsequent release is cycling chemical absorption/ desorption using an aqueous amine solution. However, the identification of a capture process which would fit the needs of target separation performances, together with a minimal energy penalty, is a key issue. According to this issue, innovative absorption-desorption processes based on membrane technologies intensified by ionic liquids is one of the main innovations of this project proposal.

This project will also focus on the optimization of the direct electrochemical reduction to convert the previously captured CO2 into various organic products, fuels for fuel cells or chemicals with added value for the chemical industry. In order to supply the process with such as an energy source that allows the process to perform with a positive carbon footprint, emphasis will be placed on the integration of photovoltaic solar energy with the electrochemical reduction in order to supply the required energy for the transformation.

This CONSOLIDER 2010 project proposal involves 11 research groups from Spanish Universities and CSIC Institutes: Instituto de Carboquímica ICB-CSIC, Universidad Autónoma de Madrid (UAM), Universidad Complutense de Madrid (UCM), Universidad de Alicante (UA), Universidad de Cantabria (UC), Universidad de Castilla La Mancha (UCLM), Universidad de las Palmas de Gran Canaria (ULPGC), Universidad de Santiago de Compostela (USC), Universidad de Vigo (UVigo), Universidad de Zaragoza (UNIZAR), Universidad del País Vasco (UPV/EHU), Universidad Rovira i Virgili (URV), Universitat Politècnica de Catalunya CTM-UPC.

Knowledge transfer to the Technology Platforms and Cenit projects and promotion of the international cooperation are also priorities in the Programme. In this sense, this project takes a special interest in developing demonstration projects and finding industries that could act as innovation partners for technology transfer.

AQUEOUS AMINE ABSORPTION: EXPERIMENTATION AND MODELING

Clint Aichele, ConocoPhillips
Hwys 60&123, 218 CPL, Bartlesville, OK, 74004, USA
T: 918-661-0122, F: 918-662-0025, clint.aichele@conocophillips.com
George Schuette, ConocoPhillips
Stephanie Compton, ConocoPhillips
Prakash Karpe, ConocoPhillips
Randy Heald, ConocoPhillips

Aqueous-amine absorption is currently the technology of choice for capturing carbon dioxide from industrial flue gas streams. However, the large gas volumes and low pressures associated with flue gas will result in process units much larger and more expensive than conventional acid gas treaters. Due to the significant capital and operating costs associated with treating large flue gas streams, accurate process modeling is imperative and leads to the proper sizing of these absorption systems. To more accurately account for the mass transfer in these systems, process models have shifted away from an equilibrium approach to a rate-based approach. These rate-based models depend on accurate engineering data such as the mass-transfer rate of CO_2 into the liquid amine solvent. The mass-transfer rate directly impacts equipment sizing and performance predictions, thereby affecting both capital and operating costs.

A gas-liquid contactor, such as a wetted-wall column, is a useful laboratory-scale device for measuring engineering data for CO_2 absorption by aqueous amine solvents. This presentation describes the implementation of a wetted-wall column and its application to the measurement of mass-transfer coefficients of aqueous-amine solvents for capturing CO_2 from flue-gas streams. Previous wetted-wall column studies have reported mass-transfer data for a variety of fresh amine solvents, free of any aging effects due to thermal or oxidative degradation. In real systems, aging could significantly affect the performance and lifetime of the solvents. The results reported here provide important information regarding the effects of aging on solvent performance in terms of its liquid mass-transfer coefficient. In addition, this work presents details about the computational model of the aqueous-amine absorption process. Several process simulators, including both equilibrium and rate-based approaches, were used in this work to model the aqueous-amine absorption process.

A MULTI-OBJECTIVE EVALUATION OF PC PLANTS WITH AQUEOUS AMINE CARBON CAPTURE SYSTEMS

John Eslick, National Energy Technology Laboratory
P.O. Box 880, Morgantown, WV, 26507-0880, US
T: 304-285-0237, F: 304-285-4403, john.eslick@or.netl.doe.gov
David Miller, National Energy Technology Laboratory

Previous analysis indicates that water use at conventional pulverized coal (PC) power plants is expected to nearly double if aqueous amine-based carbon capture systems are deployed at commercial scales [1]. The majority of additional freshwater consumption associated with using aqueous amines results from the cooling requirement for the stripper [1]. The purpose of this study is to more rigorously examine the interaction between water use and carbon capture.

A predictive steady-state process model of a hypothetical existing 550 MW PC power plant was developed to assess scenarios for retrofitting with carbon capture systems. The model explicitly considers the effects of steam extraction and can rigorously predict changes in freshwater use and operating cost resulting from plant modifications. Predictive steady-state models of aqueous amine-based carbon capture technologies have also been developed. The PC power plant and capture models were developed in Aspen Plus and validated against other computer models and plant operating data where available.

The PC plant and carbon capture systems were integrated through the use of an external framework that supports multi-objective optimization. This presentation discusses the tradeoffs among capital cost, operating cost and water use resulting from different potential retrofit configurations and levels of integration between the base plant and the carbon capture system. Various approaches for heat integration and alternative cooling are investigated. The results are presented as Pareto curves.

[1] U.S. Department of Energy, 'Water Requirements for Existing and Emerging Thermoelectric Plant Technologies,' Publication No. DOE/NETL-402/080108, NETL Office of Systems Analyses and Planning, (April 2009).

STUDIES ON CARBON CAPTURE AND UTILIZATION FOR ENHANCED OIL RECOVERY

Yuedong Yao, China University of Petroleum
18# Fuxue Road,Changping District, Beijing, 102249, China
T: 86-10-8974-1939, F: 86-10-8973-3157, yaoyuedong@163.com

A large number of research and application results have shown that the injection of CO2 to the reservoir can significantly improve the oil recovery. CO2 flooding can not only increase the recoverable reserves of crude oil, but also remove CO2 accumulated in the atmosphere by storing it permanently. It is one of the best ways to use and store CO2. At present, comprehensive research for CO2 enhanced oil recovery (EOR) and storage amount of injecting CO2 into reservoirs has not been reported. In this paper, all factors such as reservoirs, fluid property and production method to influence CO2 flooding and storage are studied by using reservoir numerical simulation. Based on the numerical results of reservoir parameters of the pilot area, comprehensive analysis to the factors which affecting CO2 flooding and storage coefficient is carried out, the evaluation parameters affecting CO2 storage and EOR is determined. Based on the selected factors, the function of EOR and CO2 storage with the key factors are built. Research on CO2 sequestration and flooding in typical reservoir indicates that the values calculated by prediction model fits the values obtained through numerical calculation well, which proves that the prediction model can provide criteria for attractive screening of candidate reservoir for CO2 sequestration and enhanced oil recovery.

CLEAN HYDROGEN PRODUCTION FROM SMR

Trapti Chaubey*[1], Paul Terrien[1], Solene Valentin[2], Dennis Vauk[3], Jean-Pierre Tranier[2] and Uttam Shanbhag[1]
[1]Air Liquide Delaware Research & Technology Center, Newark, DE, USA
[2]Air Liquide Claude Delorme Research Center, Jouy en Josas, France
[3]Air Liquide Oil and Gas Market, Houston, TX, USA
*T: +1-302-286-5450, F: +1-302-286-5583, E: Trapti.Chaubey@airliquide.com

Steam Methane Reformer (SMR) is commonly used to produce hydrogen, carbon monoxide and syngas from fossil fuels. The production of hydrogen is associated with carbon dioxide (CO_2) emission into the atmosphere. Hydrogen plant represents one of the largest single sources of CO_2 emissions in a typical refinery. For this reason, improving their design and operation has become critical for energy producers, even more so under a possible future CO_2 cap and trade environment. With the integration of Lurgi, Air Liquide group has acquired vital expertise in the design and engineering of syngas and hydrogen plants. Together, Air Liquide and Lurgi have developed innovative technologies to reduce CO_2 emissions and to improve the reliability, availability, efficiency and capital costs of hydrogen plants.

Carbon dioxide emission from hydrogen plants can be reduced using several different separation techniques to extract CO_2 from the flue gas, syngas or PSA off-gas. The captured CO_2 can be further compressed, transported and sequestered for under-ground storage, used for enhanced oil recovery or for industrial and consumer applications. Air Liquide is using its extensive experience in gas separation and purification processes such as cryogenic, absorption and membrane to develop low cost CO_2 capture technique. The selection of capture technology will depend on the composition of feed gas, electricity cost, steam cost and the carbon tax for the hydrogen plants.