GERG RESEARCH ACADEMIC NETWORK

ABSTRACTS OF THE POSTERS
SHORT RESUME OF SPEAKERS

EGATEC 2013 is a joint effort of:

MARCOGAZ (www.marcogaz.org) is the representative body of the European Natural Gas Industry on all technical issues. MARCOGAZ aims to monitor and take influence when needed on European technical regulation, standardization and certification with respect to integrity and safety of pipeline systems, equipment, and the rational use of energy. MARCOGAZ has 28 member organizations from 22 European countries.

GERG (www.gerg.eu), the European Gas Research Group, is the joint R&D organization for the European gas industry. GERG initiates research and technological innovation in all aspects of the gas chain; from production and processing, through transmission, storage and distribution, to utilization of natural gas. GERG has 34 members from 14 European countries.

Association Française du Gaz (www.afgaz.fr) , the French Gas Association is the union of the whole gas industry. All business activities of the gas chain are represented: infrastructure operators, equipment and appliance manufacturers, installers, gas supply companies, etc. Its role is to promote the use of gas and the development of the gas industry in France, to contribute at international level, to represent its members towards the French public authorities, to add value to legislations, regulations and standards by taking active part in drafting rules. It has also an operational role in trainings and certification, as well in France as on international level. AFG has 7 standing members, 20 associated members and about 1000 individual members.

GDF SUEZ (www.gdfsuez.com) develops its businesses (electricity, natural gas, services) around a model based on responsible growth to take up today's major energy and environmental challenges: meeting energy needs, ensuring the security of supply, fighting against climate change and maximizing the use of resources. The Group provides highly efficient and innovative solutions to individuals, cities and businesses by relying on diversified gas-supply sources, flexible and low-emission power generation as well as unique expertise in four key sectors: liquefied natural gas, energy efficiency services, independent power production and environmental services. GDF SUEZ employs 219,300 people worldwide and achieved revenues of €97 billion in 2012. The Group is listed on the Paris, Brussels and Luxembourg stock exchanges and is represented in the main international indices: CAC 40, BEL 20, DJ Euro Stoxx 50, Euronext 100, FTSE Eurotop 100, MSCI Europe, ASPI Eurozone, Vigeo World 120, Vigeo Europe 120 and Vigeo France 20.

CONTENT

POSTER 1

Title

Gas quality tracking in gas grids including gas from renewable sources

Authors

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About the main author: Christian Fiebig received his M.Sc. degree in energy and process engineering from the Ruhr-University of Bochum in august 2012. Currently he is there a Ph.D. student and a research assistant at the chair of thermodynamics. He joined the SmartSim project, a development of E.ON to simulate local natural gas distribution grids with the main application in invoicing. His focus is on finding new methods to validate the simulation results.

Abstract

National gas markets growing together to form a European gas market and rising imports of liquefied natural gas (LNG) transported to Europe by tanker have led to stronger variations in gas quality over the past few years. The trend has been reinforced by increasing production of biomethane to be injected into regional and local distribution grids. In future hydrogen, produced by electrolysis from surplus wind/solar electricity may also be integrated in natural gas grids. The diversification trend is welcome as it enhances supply security. On the other hand greater changes in gas quality lead to an increased demand for an accurate and cost efficient determination of calorific values (CVs) admissible in end user billing.

Gas quality tracking systems have been used in transportation networks in Germany for some years now and are state-of-the-art technology. With such a system, the CV of a gas can be calculated for any point in the network at any time. Recently a method for tracking gas quality has also been developed for distribution grids1. The so called SmartSim tool has been tested successfully in an E.ON local distribution grid including a biomethane injection.

By now the method is approved for use in legal metrology. In the work presented here the method is applied to gas grids with potential hydrogen injection. Based on the simulation results, it is possible to predict the total capacity of hydrogen to be injected into the grid in accordance with the maximum H2-concentration specified by technical rules. This information can be used to choose a suitable location for the hydrogen injection during the planning phase of a “power to gas” plant and helps to optimize grid control. In case of a multi point injection including natural gases with and without hydrogen admixtures, gas quality tracking can be applied to determine CVs at all exit points of the grid to ensure correct end user billing. The application and its benefits are demonstrated for a local distribution grid of E.ON.

1*Schenk, J.; Schley, P.; Hielscher, A.:* A new method for gas quality tracking in distribution grids. gas for energy, 3/2012

POSTER 2

Title

Technologies for biogas to biomethane transformation

Authors

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About the main author: Chemical Engineer from the Faculty of Technical Engineering of Bilbao (UPV/EHU) and currently Organizational Engineering student. She has been working in wastewater treatment area for Degremont Bilbao (Suez Environment Group) from 2009 to 2010. In 2012 she joined the Chemical and Environmental Engineering Department of the University of the Basque Country (UPV/EHU) and started working in collaboration with Naturgas Energía Organization (gdp Group) in the field of gas, focused on the research of technologies for biogas to biomethane transformation.

Abstract

Biogas consists primarily of a mixture of methane and carbon dioxide. Traces of other different components that can be often present in biogas are steam, hydrogen sulphide, siloxanes, hydrocarbons, ammonia, oxygen, carbon monoxide and nitrogen.

The distribution of this trace compounds depends on the biogas source. In order to transform biogas into bio-methane, it is necessary to remove these trace components and most of the carbon dioxide. In the case of the traces removal, the main process is hydrogen sulphide removal.

A number of techniques have been developed to remove this compound from biogas. To reach high methane concentrations (97 % of methane to be considered as bio-methane) it is necessary to eliminate traces and CO2. This work is focus on the CO2 elimination by non-conventional techniques. Nowadays, the carbon dioxide capture problem has not yet been fully solved. That is why new techniques are being developed.
Among these techniques the use of cryogenic distillation and the reduction of CO2 via photosynthesis with microalgae are the most attractive ones. In this context, this work discusses the use of cryogenic distillation and the reduction of CO2 via photosynthesis for the transformation of biogas into bio-methane. In this study three different configurations were analyzed. The first two ones were the cryogenic distillation and the use of micro-algae in a bioreactor, and the third one was the combination of these two technologies: first part of the CO2 was eliminated by micro-algae. After this, the next step is cryogenic distillation to reach methane concentrations high enough to generate bio-methane as the final product. The present study demonstrates that microalgae photobioreactor systems are a future promising alternative for biogas upgrading eliminating CO2 and increasing biogas CH4 concentration.

The advantages of this technology can be discussed as due to environmental and economic aspects. Nevertheless, the use of cryogenic distillation seems to be at present the best economic alternative. The possibility of using a single equipment to directly transform biogas to biomethane is its main advantage. In addition liquid CO2 production avoids its emission to the atmosphere and it could be easily transported to be used in different applications.

POSTER 3

Title

Integration of bio-methane in the natural gas grid: thermodynamic characterization of non-conventional energy gases

Authors

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About the author: Roberto Hernández-Gómez received his BS in Chemical Engineering (2008) and Master in Fluid Thermodynamics Engineering (2010) from the University of Valladolid (Spain). He works at the Knowledge Transfer Office of the University of Valladolid on the management and promotion of research projects, administration of the technology portfolio and consultancy on intellectual property. He is member of the research group TERMOCAL (Thermodynamic and Calibration) and started his PhD in October 2012 on the study of the thermodynamic behavior of gas mixtures for the introduction of non-conventional gas fuels and the improvement of capture and storage of greenhouse gases processes.

Abstract

The European Union has set as priorities for 2020 a 20% contribution from renewable resources to the total energy consumed and a 20% reduction of greenhouse gases emissions. The use of alternative energy gases as bio-methane and their blends with natural gas will allow a meaningful introduction of renewable and non-conventional fuels into the existing energy infrastructure and the reduction of carbon dioxide emissions. Due to the diversity of sources of non-conventional energy gases, their composition may vary significantly, making it essential to have a detailed knowledge of their thermophysical properties, which are determined through equations of state, in order to solve technical and design problems during the transport and exploitation stages. The development of thermal equations of state for these new mixtures needs from a large number of very high accuracy experimental data of density and speed of sound over wide temperature and pressure ranges.

This PhD project is studying the thermodynamic behavior of multicomponent (methane, carbon dioxide, nitrogen and other gases) mixtures through accurate (p,ρ,T) experimental data obtained by using a single sinker densimeter with magnetic suspension coupling. The measurement principle of this densimeter is based on the Archimedes' principle and consists in measuring the buoyancy force that experiments a sinker immersed in a fluid, which is proportional to the density of the fluid and the volume of the sinker. The uncertainty in density has been estimated to be between 0.02% and 0.34% for the working temperature range from (250 to 400) K and pressures up to 20 MPa. The gas mixtures will be prepared by the gravimetric methodology with the collaboration of the Spanish National Metrology Institute (CEM) and the Bundesanstalt für Materialforschung und -prüfung (BAM), to achieve the highest accuracy in composition.

A synthetic mixture of 10 components (Coal Mine Methane type) and another multicomponent mixture simulating the composition of a standard biogas are currently being measured. These measurements are part of the European research project 'Characterization of Energy Gases' (European Union ENG01 JRP-Contract number, Decision No. 912/2009/EC) in which our research group participates. It is also planned to study other energy gases mixtures, such as bio-methane and mixtures relates to carbon capture and sequestration processes.

POSTER 4

Title

Power for Gas (P4G) – Power Storage and Demand Side Management Service Opportunities for Electric Compressor Drive Operators

Authors

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Abstract

By repowering gas turbine and gas motor driven natural gas compressors with electric drives, the natural gas infrastructure becomes a highly efficient power storage and power system flexibility service provider:

Electric motors are able to use the surplus of intermittent renewable power generation with the same effect of the "power to gas" (P2G) concept as 1 MWh of renewable power used by electric drives may result in more than 4.5 MWh of unused fuel gas remaining in the gas system.
Transferring the former fuel gas to combined cycle power plants also reduces overall CO_2 emissions. Secondly, the linepack flexibility of pipelines may also be used for Demand Side Management by shifting the compressors' hours of operation, lowering the energy cost by increasing compression at times with low electricity prices. For determining amount, availability, and limits of this savings potential, research includes transient gas pipeline simulation.

Both natural gas and power infrastructures are being modeled for a dynamic co-simulation that allows for assessing the business opportunities for electrically driven gas compressor operators, taking into account the current tax and regulatory framework.

POSTER 5

Title

Maximising green energy in the smart grid: the interaction of different technologies

Authors

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Jeroen Vandewalle is a PhD student at the division of Applied Mechanics and Energy Conversion of the Energy Institute of the KU Leuven. His work is focusing on the potential role of the natural gas distribution network and gas supplies in the framework of smart grids for urban areas. This includes analysis of the impact of small-scale cogeneration and CNG vehicles on the distribution network, possible strategies for demand-side management and the interaction of different smart grid technologies.

Abstract

The aim of this work is to investigate how different *green* technologies (e.g. small-scale cogeneration, heat pumps and photovoltaics) interact with each other and how the total amount of green technologies can be maximised in a certain neighbourhood.

The main method consists of technically simulating a residential neighbourhood. We assess the impact on the electric and the gas networks of different amounts of heat pumps and cogeneration units. The most important boundary conditions are that (1) the electric network should not be loaded more than in the reference case (2) nor should there be back flow in the transformer, and (3) the peak gas flow should not exceed the one in the reference case. High shares of heat pumps lead to high electrical network loading while high shares of cogeneration units may lead to inverted flow in the transformer, while increasing the gas demand.

From the analysis, we find that combining cogeneration and heat pumps leads to higher possible amounts of these technologies in the network. The most restricting element is the electrical network while the gas network does not pose a restriction on the maximum penetration levels of green technologies. The gas network can rather be seen as the enabler of more green technology, as it allows cogeneration, which subsequently allows more heat pumps in the smart grid.

POSTER 6

Title

Ensuring Operational Safety of the Natural Gas Grid by Removal of Oxygen from Biogas via Catalytic Oxidation of Methane

Authors

Felix Ortloff – Winner of GERG Research Academic Network

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Felix Ortloff received his degree as a chemical engineer (Dipl.-Ing.) from the Karlsruhe Institute of Technology (KIT) in 2010. In the same year he started his PhD studies at the DVGW research center, which is also located in Karlsruhe. His work is focusing on the further development of gas purification processes, mainly related to biogas and its injection into the natural gas grid.

Abstract

The production and injection of biogas into the natural gas grid is politically promoted in Germany. The Gas Grid Access Regulation Act (GasNZV) sets up ambitious goals by defining the annual amount of injected biogas to be 6 % of the total natural gas consumption by the year 2020 (in 2030: 10 %). If these goals are achieved, an increasing amount of biogas has to be recompressed from the local gas distribution grids into the national gas transportation network due to capacity reasons. In recent DVGW biogas monitoring programs oxygen contents ranging from lower than 0.1 vol.-% up to 1 vol.-% have been reported. Thus, a higher concentration of oxygen, stemming from the recompressed biogas, has to be expected in the transportation network in future, where the total amount is limited to 10 ppm-v by federal law, following EASEE-gas recommendations. By exceeding this threshold, corrosion in gas installations may occur. Even worse, storage infrastructure (particularly pore storages) may be damaged by deposition of oxidized minerals as well as elemental sulfur, caused by the oxidation of hydrogen sulfide.

Therefore, critical points of oxygen intake during the biogas production and purification process were identified within a DVGW research project. Recommendations on the optimization of the biogas upgrading chain against the background of preventing oxygen intake were given. Since a small remaining amount is inevitable, options for the removal of the oxygen from biogas were presented. Up to now, traces of oxygen are usually removed by adsorption based processes (e. g. on Cu, Cr) or by oxidation of hydrogen. The amount of oxygen in biogas typically exceeds the threshold value for economical application of adsorption based processes. One promising alternative is the catalytic oxidation of methane. The most important advantage of the utilization of methane instead of hydrogen as a fuel for the oxidation reaction is that methane is available in situ, whereas hydrogen has to be supplied, stored and added separately. Besides, the utilization of methane appears to be the more sustainable as well as the economically and technically preferred option.

Hence, experimental investigations on the removal of oxygen are currently being performed in lab scale. The examinations focus on the selection of suitable and economically feasible catalyst materials and required reaction conditions for compliance with the limiting value of 10 ppm-v oxygen in (S)NG. In the paper presented the necessity of oxygen removal for the gas grid as well as the latest results of the catalytic oxidation of methane will be discussed.

POSTER 7

Title

Analysis of Main components of Biomethane Using MicroGas Chromatography

Authors

Eva Perez Tamayo

She studied in Zaragoza and completed a degree of chemical Science. In 2011, she made a Master of Sustainability Chemistry in the University of Zaragoza. She worked at the Institute of Chemical Synthesis and Homogeneous Catalysis (ISQCH) doing a project of “Homogeneous catalyst design for H/D exchange process”. Now, she is working at the Univesity of Zaragoza in Laser laboratory & Environment group (Department of Analytical Chemistry) collaborating with the company Enagas SA.

Abstract

In Spain the injection of biomethane in natural gas pipelines is just starting and a new regulation has been developed with additional quality parameters that must be controlled. Hence, collaboration between Enagas and the Analytical Chemistry Department of the University of Zaragoza has been set up in order to work up those analytical techniques required to check the new quality aspects reflected in this regulation.

The first result of this collaboration has been the development of a method to analyze simultaneously those components typically present in natural gas (helium, nitrogen,, carbon dioxide, hydrocarbons from methane to hexanes) with those that can be present in biomethane and affect the final calorific value of energy gas or could be critical for the integrity of installations (such as oxygen, hydrogen or carbon monoxide).

The selected analytical technique has been *-gas Chromatography with thermal conductivity Detector, employing two different carrier gases: argon and helium and three capillary columns. The whole analysis takes less than five minutes time and it works with a multi-level calibration made with seven different gas reference mixtures certified in accordance with ISO 0725 standard.

For this method, peaks resolution, repeatability, reproducibility, detection limits, linearity and uncertainty have been measured or established for all the range of concentration allowed for energy gases in Spain.

POSTER 8

Title

Zirconium electrolyte optimization of a thin film electrochemical sensor for the measurement of biogas and natural gas quality

Authors

Lander Rojo – 2nd place of GERG Research Academic Network

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Abstract

Introduction

The control of the quality of biogas and natural gas (NG) has become an essential task for the gas industry, whether they are used in homes, in cogeneration plants or for emissions control. The concentration of carbon dioxide (CO_2) in these two gases is a key factor to know the quality of both gases. The concentrations are between 25-55 % and between 0-8 % (despite existing a 2.5 % limit established by law for the processed NG) for the biogas and raw natural gas respectively. A cost-effective sensor for measuring the concentration of CO_2 in biogas and natural gas is required, therefore a thin film solid state electrochemical sensor has been chosen for measuring the CO_2 concentration in biogas and natural gas. Nevertheless, this work focuses on the optimization of the zirconium electrolyte of the electrochemical sensor that has been performed by electrochemical impedance spectroscopy (EIS). This technique, very used in many fields such as corrosion or fuel cells, allows studying separately the contribution of the different process involved (conduction through grain core, grain boundary or electrode reactions) in the conduction through the material under study in order to analyze it and finally optimize its functioning operation. Hence, a comparison between two electrolyte thicknesses and two electrode geometry has been carried out at different test temperatures.

Experimental

The fabrication process of the entire CO_2 sensor begins with the deposition of a zirconium electrolyte by PVD techniques onto an alumina substrate. A Pt heater is deposited by sputtering on the bottom part of the substrate in order to provide the required temperature to the sensor. Then, an auxiliary phase electrode is deposited by sputtering. Finally, Au and Pt electrodes are deposited by RF and DC magnetron sputtering respectively. The Au|auxiliary phase electrode has the function of sensing electrode and the Pt electrode acts as reference. However, the EIS analysis of the electrolyte has been performed with a simpler device composed of a 200 nm and 500 nm zirconium electrolyte onto an alumina substrate, a Pt heater and two identical Pt electrodes (square or interdigitated geometry) on the zirconium electrolyte. All the thin films have been fabricated with the same techniques as mentioned above. The electrochemical impedance spectroscopy analysis has been performed with a Solartron 1260 FRA in the frequency range of 0.1 Hz – 1 MHz with signal amplitude of 100 mV at test temperature between 315 ºC and 465 ºC.

Results and conclusions

The following table shows the most favorable cases obtained from the fitting of the EIS equivalent circuits. From the results may be concluded that, the best performance of the electrolyte has been achieved with a 500 nm electrolyte attached to interdigitated electrodes measured at the higher possible temperature (in this case 415 ºC). Moreover, from the evolution of the R_p a with the temperature 0.9 eV activation energy has been obtained. This energy value is similar to the values of other electrolytes fabricated with other techniques that suppose to have lower activation energy than the thin film electrolyte.

POSTER 9

Title

In situ quantification of gas components in biomass gasification

Authors

Helge Grosch

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Abstract

For many applications in the gas industry, measurements for the identification and quantification of major and minor (or trace) gas components are of high interest to control the gas quality. In processes like biomass gasification, anaerobic digestion or fermentation trace gases such as sulfur-containing gases (e.g. H_2S, SO_2) and aromatic hydrocarbons (e.g. benzene and phenol) have a great impact on the quality of produced gas in respect to it further utilization (e.g. directly in gas engines/power plants, methanol/hydrogen production or, after upgrade, in the existing gas grids). Here, especially *in situ* measurements are of importance, since they enable the quantification of the components during the process. While there are already commercial techniques available for the major gas components, trace gases are still subject of research and sensor developments. Optically-based techniques as e.g. infrared (IR) and ultraviolet (UV) absorption spectroscopy are possible solutions for the *in situ* gas monitoring because of their non intrusive nature on the gas without the need of extraction. Since many gas components can be found in syngas and biogas, IR/UV absorption spectra are very complex and therefore, further research and developments on this topic still needs to be done.

The goal of the PhD work is to develop and establish an *in situ* measurement technique for the quantification of trace gas components in the producer gas of a biomass gasifier by means of UV and IR absorption spectroscopy. Measurements on 100 kW^{th} low temperature circulating fluidized bed (LT-CFB) gasifier are presented. Besides the quantification of one of the key trace gases of this process, the aromatic hydrocarbon phenol, also the major gas compounds as e.g. CO, CO_2, C_xH_y and H_2O are measured and compared with already established non *in situ* techniques. Advantages of *in situ* technique compare to non *in situ* one (gas extraction) are discussed.

POSTER 10

Title

Improving biogas reforming for hydrogen production

Authors

Laura Barrio

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V.L. Barrio studied industrial engineer and doctorate at the University of the Basque Country, where she received her PhD. She was a Postdoctoral researcher in the Engler-Bunte-Institut at the Karlsruhe Institute of Technology (2003-2004). She is Assistance Professor in the Bilbao Faculty of Engineering since 2006 and Vice Dean for Relations with Companies sin 2012. Her current research fields are catalytic processes focused on different areas related to energy technologies, fuel upgrading and catalytic processes and specially in renewable methane (PtG). Barrio is co-author of more than 40 articles and 2 patents on these subjects.

Abstract

In this work biogas valorisation – a renewable resource – for synthesis gas and hydrogen generation through dry reforming or tri-reforming (TR) is studied. It is time for hydrogen as an energy vector and this opportunity should be seized by doing improvements and innovations in the existing technologies and processes as well as for developing new ones. This renewable hydrogen can also be used for the Power to Gas technology. For this purpose, nickel monometallic and rhodium-nickel bimetallic based catalysts were prepared, characterized and tested in dry reforming (DR), steam reforming (SR), oxidative reforming (OR) and tri-reforming processes for hydrogen generation. As catalyst support, three different Zeolites L were synthesized to be used. For all the experiments, a synthetic biogas which consisted of 60% CH_4 and 40% CO_2 (vol.) was fed to a fixed bed reactor system at 1073 K and atmospheric pressure. The different activity results obtained can be correlated to the physicochemical characterization results of the Zeolites L and catalysts using SEM, ICP-AES, H_2 chemisorption, N_2 physisorption, TPR and XRD techniques.

To sum up, for the TR experiments high conversions were reached for the cylindrical bimetallic Rh-Ni catalyst (30-60 nm), being the most active and promising one as a possible source of hydrogen for the methanation process in the power to gas technology.

POSTER 11

Title

Modelling and monitoring of natural gas networks

Authors

Tania Rodriguez

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Abstract

This project results of the collaboration between Intergeo Tecnología and the System Engineering and Automatic Control Department of the University of Valladolid. It is focused on the development of a monitoring and simulation tool of ENAGAS's gas natural network. These tools are designed to increase the quality of the management and operation of the gas network through the improvement of information about the process that can be obtained through the use of simulation techniques and monitoring and estimation methods and algorithms. Additionally, they can be used in a decision support system to recommend operators about optimal decisions to transport gas, using optimization methods.

A library of dynamic components has been developed in the simulation environment EcosimPro®, which incorporates an object-oriented simulation language. This library contains rigorous models based on balance equations for mass, energy and momentum and additional equations for describing the dynamic of real gases. The models represent typical elements, such as pipes, compressors, valves, regulation, measurement stations, etc.

Gas pipelines and compressor stations are the main elements described in this library. The behavior of natural gas inside a pipeline depends on both the time and the position of the gas in the pipe (longitudinal coordinate). This leads to a distributed model formed by a set of partial differential equations (PDEs).

The use of distributed models makes impossible to use conventional integrators for integrating the model. That is why in this model the numerical method of finite differences is used to approximate the partial differential equations with respect to the longitudinal coordinate to ordinary differential equations (ODEs). Compressor stations are formed by centrifugal compressors that have been modeled in order to get the required pressure ratio (discharge pressure control) and avoid the unstable operation that can be caused if at any given speed suction flow rate decreases, then the pressure developed by the compressor also tends to decrease, and may reach a point at which this pressure is lower than the suction pressure resulting in a momentary change in the direction of the flow (anti-surge control).

Use of the models:

- From these libraries a version for production is generated in a multiprocessor environment to reduce the execution time of the simulations of large- scale gas networks.
- Integrate simulations in different multiprocessors in order to incorporate the results in a SCADA for observing data's model, manipulating variables and predicting what are going to happen in a certain future time.
- Study of the proper parameterization of such models in order to adjust them to the real operating conditions of the network.
- Study of monitoring techniques relying on models developed, including data reconciliation (based on dynamic and stationary models) and reorganization and optimization of the distribution.

POSTER 12

Title

Spherical resonator speed of sound measurement of new low carbon synthetic gas mixtures

Authors

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Fernando J. Pérez Sanz studied chemical engineering in the University of Valladolid in Valladolid, Spain. He stayed one year as research assistant in the University of Arizona in USA in 2008-9. After finishing a research master in engineering thermodynamics of fluids in September of 2011, he started a PhD degree in thermodynamics in the energy engineering department of the University of Valladolid. He made a pre-doctoral stay in the national institute of metrological research (Instituto Nazionale di Ricerca Metrologica-INRiM) in Torino, Italy from September 2012 to December 2012. He is currently involved in 3 European projects: Determination of the Boltzmann constant for the redefinition of the Kelvin, Implementation of the new Kelvin, and Characterization of new gases; also in 2 national projects both about Thermodynamical properties of biogases. He has presented some results of the studies carried out in several congresses, like the Consultative Committee of Thermometry TG-SI meeting in 2013, the Eighteenth Symposium on Thermophysical Properties, Consultative Committee of Thermometry (implementation of the new Kelvin kick off meeting) in 2012,3rd and 4th International Seminar on Engineering Thermodynamics of Fluids…

Abstract

New gases produced in bioprocess (bio-methane and green gas) are more often used as energy source. In order to get high efficiency when biogases are involved in energy process, it is important to know their equation of state and the heat capacity, in order to assure the gas quality. The accurate knowledge of both allows the calculation of the other thermodynamic properties and it is important in the production, processing, storage and transport of the biogases.

The speeds of sound were measured using a spherical resonator which can be use on a wide temperature range (-150 °C to 250 °C) and pressures up to 20 MPa.

The speed of sound is a thermodynamic property from which it is possible to develop an equation of state. The speed of sound u in a real gas is given as a function of the density ρ:

$$u^2 = \left(\frac{\partial p}{\partial \rho}\right)_S = A_0(1 + \beta_a \rho + \gamma_a \rho^2 + \cdots$$

where the coefficients β_a, γ_a are the acoustic virial coefficients and A_0 is the value of the speed of sound when the density is zero and it is given by the equation(1)

$$A_0 = \gamma^{pg} RT/M$$

It is easily solve for γ^{pg} (the ratio of the isobaric and isochoric heat capacities for a perfect gas) and, according to Mayer´s relation ($C_p - C_v = R$) both, pressure and volume constant heat capacities, can be calculated(2).

The precise measurements of the speed of sound have contributed to the establishment of new and more-reliable equations of state from which a wide range of thermodynamic properties may be computed as GERG-2008 (3).

In this work, speed of sound measurements of two different gas mixtures, with the composition of 10% CO+90% N_2 one and 5% CO+95% N_2 other. Those measurements will be also presented as a contribution to the research project EMRP ENG01 of the European Metrology Research Program, in the field of characterization of energy gases. The final objective of the project is a complete thermodynamic characterization of non-conventional energy gases which will enable the “inter-changeability” of energy gases so that gaseous fuels from non-conventional sources can access conventional natural gas grids.

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POSTER 13

Title

GINA : Gas infrastructure and Network Analytics

Authors

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Steven Hotopp studied industrial engineering (Management Science & Engineering) at Clausthal University of Technology and received his diploma in 2010. After finishing his studies he became a research associate of Professor Müller-Kirchenbauer and PhD student at the department of gas supply. His current research project and PhD thesis is developing a framework for complex gas infrastructure with focus on data management.

Abstract

Climate change, renewable energy, decarbonization, energy efficiency and energy intensity are challenges affecting all parts of the supply infrastructure: production, transport, storage and consumption.

European energy policy brought major changes to the energy industry by the 3rd package which provides for liberalization, intensive sector regulation and new market structures. Heading towards a sustainable future with energy transition in a liberalized environment involves a new age of complexity in energy supply.

We are developing GINA as field of research to be able to handle these complex conditions for the gas supply industry and other stakeholders. GINA is an analytical framework for gas transport modeling and simulation for scientific engineering research purposes. Given a set of boundary conditions about the existing infrastructure, predicted energy production and demand, it is able to quantify the effects and influences of a change in energy supply, e.g. power-to-gas.

POSTER 14

Title

New criteria of the flow profiles evaluation in the gas metering installations

Authors

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Graduate of Warsaw University of Technology, Faculty of Mechatronics. Currently a postgraduate student at the AGH University of Science and Technology and the Ph.D. student at the Faculty of Mechatronics. Dissertation thesis involve identifying disturbances which may occur in the calibration facility for instruments measuring the volumetric flow rate or mass flow rate.

Abstract

The aim of the study was to find criteria for the evaluation of the calculated flow profiles in gas metering installations and experimental data. New criteria developed by the author enable the quantitative comparison of measurement results (experiments) with computational results (simulations). These new criteria proved to be very useful during the validation of CFD calculations.

The shape of flow profiles has significant influence on measurement accuracy of volumetric flow rate. Designing the gas metering installation we try to obtain flow profiles similar to fully developed ones.The shape of flow profiles depends on geometrical shape of installation, external conditions and types of devices used in particular installation.

The study was focused on finding such geometrical shape of gas metering installations that causes least distorted flow profile in a metering run.

To identify the level of the flow profiles deformation and to optimize the construction of the gas metering installation (e.g.high pressure calibration facility), computational fluid dynamics methods (CFD) were used. Unfortunately CFD methods are still not perfect and usually need experimental validation. Results of the numerical simulations made during the constructions optimization were experimentally verified in the laboratory.

During the experimental validation of CFD results, difficulties were encountered because of the lack of the quantitative criteria for assessing the consistency between experiments and numerical simulations.
Author has modified existing criteria. The new criteria better describe the flow profiles deformation and enable quantitative assessment of the type of the boundary conditions and the turbulence models which fit best to the typical gas metering installations.

Results of this study were used to design the first Polish high pressure calibration facility for gas meters used for billing purposes in natural gas transmission and distribution systems.

POSTER 15

Title

Calculating Dew Points for Natural Gas containing Water and/or selected Production Chemicals: Comparison of the CPA and GERG-water models

Authors

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Abstract

The water found in natural gas (NG) is seen as an impurity by operators, since its management presents several challenges and costs. From a flow assurance point of view, gas hydrate formation is undoubtedly the major risk of plugging the gas system. However also ice formation and water condensation are common problems observed in NG production systems and can cause serious problems such as corrosion and low heat transfer. Accurate predictions of the gas phase water content in equilibrium with such heavy phases (liquid, hydrate and ice) could be of great help when trying to control the amount and composition of the aqueous phases found in the pipelines system and comply with strict dew point specifications.

The purpose of this project is to evaluate and compare the performance of the CPA (Cubic-Plus-Association) equation of state (EoS) [1] and GERG-water calculation method (an ISO-standard model specifically designed to correlate water content and dew points of natural gas [2]) regarding the calculation of dew points of natural gas systems containing water and traces of selected production chemicals. The models have been validated against extensive experimental data, both water content and phase equilibrium data, and the solid model parameters were (re)estimated where necessary. For water content / dew point calculations without chemicals, the model results were compared against results obtained using the GERG-water calculation method. In case of chemicals, the GERG-water method cannot be applied, as it was designed to be applied to specific natural gas components and water.

Several modeling challenges have been encountered, such as the modeling of multicomponent multiphase mixtures (f.ex. VLLE or VLH calculations), inconsistent water content data found in the literature (f.ex. for the very important type III CO2-H2O binary system), experimental data where the heavy phase was not know in advance, natural gas sub-systems where hydrate structural transitions are being observed, solvation phenomena in mixtures with high CO2 content, lack of experimental data when it comes to sulfur compounds found in NG, such as H2S and gas odorants, the sensitivity of water content/dew point calculations to the use of T-dependent vs. T-independent binary interaction parameters depending on the chemicals present (f.ex. glycols vs. alcohols), the ability of the model to capture the hydrate dissociation conditions at very high inhibitor concentration, which is used nowadays as exploration and production activities move into colder and deeper regions, and so on.

Our calculations revealed that CPA coupled with the van der Waals-Platteeuw (vdW-P) theory for hydrates [3], even when used in a purely predictive way (i.e. all binary interaction parameters are set equal to 0) it provides qualitatively correct results and can be used for calculating the thermodynamically stable phase (liquid, ice or hydrate), which is often not known in advance, with or without chemicals over extended temperature and pressure conditions and different NG compositions. However, there is still a lot to be done, in terms of experimental data consistency tests, water analysis accuracy and model development.

The project is being supported by GERG, the European Gas Research Group (www.gerg.eu), to which grateful acknowledgements are being expressed.

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POSTER 16

Title

Natural gas entry-exit operation model – application to the Iberian Market

Authors

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Abstract

The Third European Package for Electricity and Gas Markets has boosted the development of a single gas market within the EU. Most countries have transposed the Directive 2009/73/EC. The immediate consequence has been the implementation of entry-exit systems, which ignore the path followed by gas from a supply point to a consumption point. Gas networks are indeed embedded in the so-called balancing zones, which have several entry and exit points. Inflows from LNG terminals, imports by cross-border pipelines, and withdrawals from storages are entry points; while consumptions, injections to storages, and exports through cross-border pipelines are exit points. Connections to neighboring balancing zones are also entry-exit points. Companies usually must observe a daily balance among entries, exits and inventory variations in gas facilities and balancing zones. Some countries have established virtual hubs, in which gas can be traded to achieve a daily balance. Virtual hubs are indeed spot markets. Neighboring countries can use these virtual hubs for coupling their markets and foster competition, which may result in an improvement on the security of supply and sustainability as well. Competition, security of supply and sustainability are indeed the EC objectives.

On the other hand, gas supplies have traditionally relied on long-term contracts. Gas facilities utilization also requires signing capacity contracts in advance. In contrast, companies operate on a daily basis to provide gas. Consequently, companies should be ready to manage their long-term supply contracts, compose a capacity contract portfolio and operate in the system. We present a model that is able to cope with the above mentioned objectives: management of supply contracts and operating and contracting in an entry-exit gas system. The model represents the gas system components: LNG terminals, storages, cross-border pipelines, and balancing zones. The market structure (number of companies, market share, and demand segmentation) and LNG vessel arrivals are also included. We introduce the model and simulate the regional initiative to constitute the Iberian Natural Gas Market between Spain and Portugal.

POSTER 17

Title

New methods and development in biogas analysis

Authors

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Abstract

The development of renewable energy is a major topic all over the world, in response to various environmental, geopolitical and economic issues. Biomass gasification is a promising way to make renewable energy. Particularly, the 2G biomethane pathway produces syngas that may be converted into a green substitute to natural gas.

Some developments need to be achieved before reaching industrial scale. Present all along the biomass gasification process, gas sampling and analysis constitue key steps in order to control and adjust the different process parameters and reach finally the biomethane specifications.
Different strategies have to be used to measure tars and sulphur compounds. On-line measurement using e.g. micro-chromatography or optical spectroscopy is one solution. However, off-line methodology is needed when on-line measurement is not possible or when on-line quantification limits are too high. A pre-concentration step (Tar Protocol or solid phase adsorption) is necessary before quantifying the sample by gas or liquid chromatography.

Thus, the Gas Quality Section of CRIGEN - GDF SUEZ, in collaboration with the CEA – LITEN, has investigated many technologies of tars and sulphurs on-line measurements as well as different protocols of gas sampling with different compounds concentration, sample conditioning and off-line analysis in order to provide the most performant methodology to characterize syngas.

POSTER 18

Title

2nd generation Biomethane synthesis by catalytic methanation, kinetic and catalyst deactivation study

Authors

Nouria Fatah – 3rd tie of GERG Research Academic Network

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Abstract

The development of renewable energy is a major topic all over the world, in response to various environmental (reducing greenhouse gases emissions), geopolitical (reducing dependency on fossil fuels) and economic (developing new activities) issues.

Biomass gasification is a promising way to make renewable energy. It produces a syngas which can be turned into different kinds of energy: CHP (Combined Heat Power), second generation bio-fuel or combined second generation biomethane fuel (or BioSNG: a green Substitute Natural Gas) and heat [1][2]. Combined 2G Biomethane/heat is environment-friendly (high energetic and chemical yields, local heat valorisation, reasonable biomass supply volume and radius) and is complementary to the other renewable energies [3].

The 2G biomethane is produced from biomass trough thermochemical processes: gasification, gas cleaning, gas conditioning, methanation and subsequent gas upgrading. In the methanation process, the nickel-catalyzed CO methanation ($CO + 3H_2 <=> CH_4 + H_2O$, R1) is a key reaction, accompanied by side reactions like water gas shift ($CO + H_2O <=> CO_2 + H2$, R2) and Boudouard reaction ($2CO <=> C + CO_2$, R3). The aim of UCCS was to study the methanation reaction from a kinetic point of view over a wide range of operational conditions (pressure, temperature, input gas composition). The objective of this work is to validate and improve a kinetic model which could be used in the methanation process under various realistic operating conditions.

Previously, we have studied CO methanation and water gas shift reaction in a Micro-Berty reactor (Autoclave Engineers) [4, 5]. This type of reactor presents the advantages for the kinetic investigation of a catalytic reaction, such as limiting of the gradient of concentration and temperature, minimizing the risk of temperature runaway. However, it was observed that the reactions were limited by the strong external mass transfer at high temperatures. Therefore, the kinetic model was only validated for temperature below 250°C. In the present work, the kinetics of methanation reaction and the catalyst deactivation were first reviewed, followed by the introduction of experimental details (reactor and procedures). A micro-fixed bed reactor was used to investigate the methanation reaction over nickel catalysts in order to produce biomethane with very high chemical specificity. The effect of different parameters (pressure, temperature, input gas composition) was studied. The physical and chemical characterizations of the catalyst with instrumental methods were carried out so as to understand more in detail the deactivation of the catalysts. The kinetic parameters of the catalytic methanation reaction and the deactivation by coking were finally determined.

This work is a part of the GAYA demonstration project which aim to develop a new efficient and renewable production pathway of 2nd generation biomethane.

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POSTER 19

Title

Measuring stress state of gas pipelines

Author

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S. Eldevik is Senior Engineer at DNV. He has a Master of Science degree in Physics from the Norwegian University of Science and Technology (NTNU). Since 2005 he has been working with pipeline integrity at DNV (Det Norske Veritas), mainly focusing on reliability analysis and pipeline integrity management. He started his PhD studies in 2010 studying the capability of the DNV developed Acoustic Resonance Technology (ART) to estimate the stress state of pipelines. He expects to submit his thesis in the fall of 2013.

Abstract

Pipeline wall thickness can be measured using resonant ultrasonic signals. The resonant frequencies are linked to the wall thickness via the speed of sound. Equivalently, the speed of sound can be estimated when the wall thickness is known.

Classic elastic models predict a constant sound speed, unaffected by the current stress state of a material body. However, the acoustoelastic effect includes higher order elastic moduli, and indicates that the sound speed changes with the current stress state of the body. Experiments on steel plates subjected to uniaxial stress have confirmed this effect. This presents a potential method to estimate pipeline wall stress by measuring changes in the speed of sound with ultrasonic signals.

Because of the axial nature of pipelines, the best way of probing its interiors with acoustic is by letting acoustic waves propagate normal to the pipe wall. It is thus important that an acoustic measuring system is able to measure the tangential stress state based on acoustic waves propagating with normal incidence.

This work has investigated the capability of the Acoustic Resonance Technology (developed by Det Norske Veritas for thickness measurements) to measure the acoustoelastic effect in a steel sample subjected to a uniaxial tension. The sound velocity changes have been calculated in both the elastic and plastic deformation range, and a fundamental difference in the changes of compressional and shear wave velocities has been observed.

For the elastic regime the results show a linear dependency with the applied stress/strain for both compression and shear waves, but with different slopes and opposite sign. When the sample is plastically deformed this dependency no longer follow the same linear behavior, but the original dependency is recovered once the tension is unloaded.

The experiments show consistent results. However, a high accuracy in the measurements is needed to be able to utilize the sound speed to estimate a pipeline's stress state.

POSTER 20

Title

The second life for gas: Optimizing decentralized load balancing through the use of locally available gas resources.

Authors

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Currently, F. Pierie is a PhD researcher at the Hanze University of Groningen. He is specialized in energy flow analysis and environmental impact analysis through the use of Life Cycle Assessment. He graduated from the Hanze University of Applied Science with a B Eng. and holds a MSc. in Energy and Environmental Sciences from the University of Groningen.

Abstract

High penetration of wind and solar PV energy production, both centrally and de-centrally, can possibly destabilize the electricity grid. One possible method of assisting the electricity grid in achieving and maintaining balance is by pre-balancing local decentralized energy grids.

Adopting flexible gas based decentralized energy production can help integrate intermittent renewable electricity production, short lived by-products (e.g. heat) and at the same time minimize transport of energy carriers and fuel sources. Hence, decentralized energy grids can possibly improve the overall efficiency and sustainability of the energy distribution system. However, there are a lot of potentially variables which effect a successful integration of renewable intermittent production and load balancing within decentralized energy systems.

The flexibility of gas in general opens up multiple fuel sources e.g., natural gas, biogas, syngas etc. and multiple possibilities of energy transformation pathways e.g. combined heat and power, fuel cells, high efficiency boilers etc.

Overall, there is need for decentralized load balancing. The system achieving this should be optimized on sustainability, efficiency, stability and economics. From the aforementioned, one can conclude that there is a need for an optimization tool.

The Flexigas project is working towards economic and *sustainable* integration of (bio)gas into future decentralized energy systems. One of the main goals is to design a modeling tool called the (Dynamic) BioGas Simulator. The theoretical background (methodology) of the simulator is based on the industrial metabolism concept and life cycle analysis. The method allows for the integration of local dynamic factors, multiple fuel sources and transformation pathways. The resulting BioGas simulator will be capable of integrating fuel availability, energy demand, flexible energy production and energy production by intermittent renewable sources, such that conclusions can be drawn on the sustainability, efficiency, flexibility and economy of load balancing within local decentralized smart energy grids.

Together with future research the tool can help determine, first, if decentralized load balancing is a suitable solution for renewable integration, second, how much gas is required to achieve the previous and finally, how the flexibility of gas can be used most effectively in specific decentralized energy systems. Ultimately, the model can indicate the big need for decentralized load balancing, which can usher in a second life for gas and the gas network.

POSTER 21

Title

Improved Flow Modeling in Offshore Natural Gas Pipelines: Effect of unsteady heat transfer model

Authors

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Abstract

Gassco is a state owned Norwegian company responsible for the operation of 7800 km offshore natural gas pipelines lying in the North Sea. Natural gas from the Norwegian continental shelf is transported to continental Europe and the UK through these large diameter high pressure pipelines.

Measurements of the state of the gas such as pressure, temperature, mass flow and composition are done only at the inlet and outlet. Between these two points one has to rely on computer models to predict the state of the gas. These models are used to design, monitor and operate the pipeline, predict the pipeline hydraulic capacity and as leak detection systems.

This project is focused on improving existing flow models for transportation of natural gas through long distance transport pipelines, especially during transient conditions. In this work we demonstrate by example how the modeled temperature can be improved by using an unsteady heat transfer model to simulate the heat exchange between the gas and the environment compared to a steady heat transfer model which has been used previously. The main difference between these two approaches is that the unsteady heat transfer model takes into account heat accumulation in the ground surrounding the pipeline.

POSTER 22

Title

Temperature measurements in oxy-fuel non-premixed combustion using laser-induced fluorescence

Authors

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Abstract

In most combustion processes air is used as the oxidizer. Oxygen-enhanced combustion may be used in high temperature thermal or thermochemical processes, novel power plant concepts or in gasification processes. It provides significantly higher flame temperatures and benefits like increased thermal efficiency, increased processing rates and reduced flue gas volumes. The flame temperature is a major physical factor in combustion processes and a key parameter for kinetics, emissions or soot formation, as well as for the furnace or combustion chamber design, so that the knowledge of the local temperature in flames is essential.

Intrusive measurement techniques destroy the flame front by locally quenching the reaction zone and are also hardly applicable at very high temperatures; hence, detailed temperature measurements require the utilization of non-intrusive techniques. Among different techniques, laser-induced fluorescence (LIF) is a versatile tool for especially detecting intermediate species like OH, C_2HO, CH or NO. By analyzing the fluorescence spectra and the signals, LIF gives also the possibility to determine the temperature. The two-line approach was applied first by Cattolica in [1], where the temperature depends on the fluorescence ratio of two different excited lines. The sensitivity of line pair ratio depends on the ground-state energy difference and on the ground-state population of a selected species [2].

With enhanced oxygen content, the flame temperature increases from approximately 2200K (air combustion) to 3000K (pure oxygen combustion). Common spectral approaches, which are available in the literature [3-5] were adapted for conventional air combustion, hence, they are not suitable in high temperature regimes.

The scope of this work was the development of an approach for two-line temperature LIF based on the hydroxyl radical (OH) in high temperature environment. In order to provide a sufficient signal-to-noise ratio, overlapped lines have been used. A detailed analysis of different rotational lines and the spectra has been performed. The parameter of the laser line width was experimentally determined for calculating the ratio of the overlapping line pairs.

The calibration of the system and the reliability in high temperature regime of the selected spectral line pairs were investigated in co-flowing non-premixed methane flames. The flame temperature was controlled by (a) changing the oxygen content on the oxidizer side and (b) diluting methane with carbon dioxide on the fuel side in order to investigate a temperature range of 2000K to 3000K. Subsequently the temperature field of an inverse non-premixed CH_4/CO_2-O_2 flame was mapped.

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