Centre for Energy, Fluid Science Division
Gas & LNG Processing, Flow Assurance,
Magnetic Resonance Engineering, Carbon Capture and Sequestration
W/Prof. Eric May, W/Prof. Michael Johns, Dr Brendan Graham

Final Year Research Projects for the School of Mechanical & Chemical Engineering
Semester 2, 2013

The Fluid Science Division of the Centre for Energy will offer up to 15 new places across 6 projects in the second semester 2013 to undergraduate and postgraduate students. Students should follow the process for applying for these projects established by the School of Mechanical & Chemical Engineering

FSD-1: Advanced property prediction for natural gas processing & LNG production.

Supervisors: W/Prof. Eric May, Dr Brendan Graham

Positions available: up to 2.

Unplanned shutdowns of LNG plants caused by hydrocarbon solids blocking cryogenic heat exchangers are a major, ongoing problem for the industry. Current methods of avoiding them are costly and energy intensive. In addition, LNG production systems are over-engineered because the predictions of process simulators are unreliable. Furthermore, the natural gas industry needs new thermophysical property data at high-pressures and low temperatures to develop more efficient processes capable of handling more problematic gas reserves. These projects aim to develop new predictive models to avoid shutdowns and improve plant efficiency, and/or improve the reliability of process simulator predictions by anchoring their underlying thermodynamic models to data characteristic of realistic LNG fluids and conditions. Students working on these projects will help develop or improve models that predict crucial properties such as vapour-liquid and solid-liquid equilibrium, density, heat capacity, viscosity, surface tension or thermal conductivity for binary and multi-component hydrocarbon mixtures. This will be done by combining state-of-the-art measurements of these properties with new property package models in process or multi-phase flow simulation software.

FSD-2: Advanced separations for natural gas processing, LNG production and CO₂ capture.

Supervisors: Dr Brendan Graham, W/Prof Eric May

Positions available: up to 3.

Carbon dioxide capture, whether from natural gas streams or from flue gases, is an important and increasing area of research with significant implications for our economy and environment. N₂ capture from natural gas is increasingly important in the development of LNG projects where this component is energetically parasitic. These projects will look at the use of novel materials for improved capture efficiency that are either solid adsorbents, including carbons, zeolites and calixarenes, or liquid solvents, such as transition metal complexes. Students working on these projects will help develop and characterise the separation performance of new materials synthesized in our laboratory over a wide range of temperature, pressure and mixture compositions, and/or use the results of such experiments to develop numerical models of advanced industrial separation processes.
FSD-3 – Flow assurance and natural gas hydrates.
Supervisors: W/Prof. Eric May, W/Prof Mike Johns
Places available: up to 3.

Natural gas hydrates are ice-like solids that form and can often suddenly stop the flow during oil and gas production. The cost of their prevention during design and production is high and the removal of hydrate plugs is expensive and dangerous. Today hydrates are still a major flow assurance concern especially as production moves to deeper water, and many of Australia’s major new gas field developments are considering innovative approaches to this long-standing problem. However, naturally-occurring gas hydrates also represent a tremendous energy reserve and offer significant potential for CO₂ sequestration. In early 2013, first production was reported from a naturally occurring hydrate reserve located offshore the coast of Japan. These projects aim to provide the knowledge needed for a risk-based approach to hydrate management by establishing quantitative model to assess plugging potential, optimize inhibitor doses, and develop methods to detect hydrate formation and location using novel technologies. The outcomes will help reduce chemical use by the industry, provide better methods to locate plugs and provide safer methods for their remediation, ultimately allowing for the reliable and economic development of marginal oil and gas fields. Students working on these projects will measure and/or model hydrate formation, agglomeration and dissociation processes.

FSD-4 – Novel breaking of water-in-crude oil emulsions
Supervisors: W/Prof. Mike Johns, Dr Brendan Graham
Positions available: up to 3.

Unwanted Emulsions of (crude) oil and water are frequently encountered during oil production across the world including in Western Australia (which is now Australia’s main liquid fuel provider). Such emulsions add significantly to operating (e.g. pumping) and capital (e.g. processing vessel size) costs, accentuate corrosion and generally adversely affect product quality. Essential to process routes/treatments to break such emulsions (i.e. separate the water and oil phases) are the use of cheap, robust methods and real-time measurement of the emulsion droplet size distribution. In this context, projects are available that focus on Optimising our unique Nuclear Magnetic Resonance (NMR) instrumentation for on-line emulsion droplet sizing; Modelling and experimental observation of oil-water gravity separation units with the inclusion of a water recycle for emulsion inversion (crude oil-in-water emulsions are much easier to break than water-in-crude oil emulsions); efficient extraction of naturally occurring resins from crude oil that have been proven to significantly reduce emulsion strength, use of CO₂ for emulsion droplet disruption and encouraged coalescence and technical reviews of emerging emulsion breaking technologies.

FSD-5: Remote Water Analysis in (i) Fe Ore Deposits and (ii) Desalination Membranes
Supervisors: W/Prof. Mike Johns, Dr Brendan Graham
Positions available: up to 2.

The moisture content of iron ore deposits is a critical parameter for their subsequent extraction and processing. There is extensive industrial interest in the mining industry in the use of Nuclear Magnetic Resonance (NMR) logging tools for the in situ determination of this moisture content in exploration wells (of which in excess of 40,000 are drilled in Western Australia annually) before mining has commenced. Alternative logging techniques have proven to be inadequate for this purpose. However significant laboratory based measurements are required to properly interpret this NMR logging data – this essential calibration is currently being performed at UWA and the project would assist with development and implementation of these measurements. The approach adopted is equally applicable to glauconite-containing greensands as are frequently encountered during gas and oil NMR logging in Western Australia. (ii) Desalination of seawater to provide potable water is a rapidly expanding activity in Western Australia (providing 50% of your potable water) and across the world. Increasingly this is done using reverse osmosis membranes in the form of spiral-wound modules (ROMs). These are however susceptible to biofouling by a range of organisms which can cause serious performance degradation and complete failure of the ROMs within one year. We have developed cheap, mobile Nuclear Magnetic Resonance (NMR) instruments employing the Earth’s magnetic field to provide an early warning (i.e. more sensitive than trans-
membrane pressure drop) of such biofouling development in ROMS, such that corrective actions can be initiated. We are currently expanding the capability of this instrument such that faster velocities can be realized. We are also developing a processing route to generate water-in-oil capsules where the inner water phase containing a molluscide; these are designed to overcome the auto-response of molluscs to adverse (i.e. molluscide solution) conditions and are readily deployed in water treatment facilities.

FSD-6: Carbon Capture and Sequestration
Supervisors: W/Prof. Mike Johns, W/Prof. Eric May
Positions available: up to 2.

Western Australia will soon be the world-leader in the geo-sequestration of carbon dioxide. Both the Gorgon project and the recently announced South West CCS Hub will store several million tonnes per annum of CO₂ in saline aquifers. Two of the most important but least understood mechanisms by which CO₂ remains trapped in these aquifers are known as residual trapping and solution trapping. Residual trapping relies on capillary forces to immobilize CO₂ “droplets” within the porous rock containing the aquifer. These capillary forces in turn depend upon two fundamental physical quantities that govern the flow of CO₂ and water (as well as oil and gas) in the subsurface: wettability and interfacial tension (IFT). Conventionally these are measured using optical imaging (and related analysis) of pendant drops of one phase in the other. In this project, equipment will be designed that allows such wettability and IFT measurements to be made for opaque fluids using Nuclear Magnetic Resonance (NMR) techniques to provide the necessary drop dimensions in-situ. Solution trapping relates to how much CO₂ can dissolve into the brine: this is a strong function of temperature, pressure and salinity. The models used to predict the CO₂ solubility in these brines are of limited accuracy; however we have recently demonstrated that simple NMR signal relaxation measurements can be sensitive to the CO₂ content of aqueous solutions. Students working on these projects will conduct NMR measurements analysing these storage mechanisms and/or investigate the thermodynamic and hydrodynamic models used to estimate CO₂ storage capacities.

Western Australia has several major offshore gas assets containing significant quantities of carbon dioxide. Scenarios for dealing with this CO₂ must be developed before these gas fields can be developed. One scenario involves the re-injection of carbon dioxide produced from one reservoir into the extremities of a different natural reservoir for the purpose of both CO₂ disposal and enhanced gas recovery. However, such a strategy is only viable if the probability of breakthrough by the re-injected CO₂ to the producing wells is small and the contaminated gas mixing zone remains small over the life of the asset. Simulating reliably this novel reservoir production scenario requires an improvement in our fundamental understanding of the hydrodynamic behaviour of supercritical CO₂ in heterogeneous gas and water-saturated rock. Students working on this project will have the opportunity to conduct and model CO₂ core-flooding experiments at the laboratory scale. The data and models will be used to determine the dispersion of CO₂ as a function of pressure, temperature, rock heterogeneity and saturation.