Final Year Research Projects for the School of Mechanical & Chemical Engineering  
Semester 1, 2013

The Fluid Science Division of the Centre for Energy will offer up to 12 new project places in the first semester 2013 to undergraduate and postgraduate students.

To apply for one or more of these projects students should submit their preferences to W/Prof. Eric May (Eric.May@uwa.edu.au), W/Prof. Mike Johns (michael.johns@uwa.edu.au) or one of the other listed supervisors by 2 November 2012 in the first instance. The next round of projects will be allocated in late November based on a student’s academic record and the relevance of any prior study.

FSD-1: Avoiding cryogenic solids formation in LNG production.

Supervisors: W/Prof. Eric May, Dr Brendan Graham, Dr Thomas Hughes, W/Prof. Mike Johns

Positions available: 1

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. These projects aim to develop new predictive models to avoid shutdowns and improve plant efficiency. Process simulators cannot predict reliably the solid formation conditions because accurate data representative of high-pressure, multi-component systems are unavailable. Furthermore, there is virtually no information available about the nature of any of the cryogenic solids formed including, crucially, about the mechanisms of their growth and agglomeration. Students working on this project will help develop and conduct specialised, high resolution 3D NMR studies, calorimetry or laser scattering particle detection experiments. They will also contribute to new models for the onset conditions and kinetic behaviour of solids forming in high-pressure cryogenic liquids.

FSD-2: Measurements and modelling of thermophysical property data for high pressure, cryogenic natural gas processing.

Supervisors: W/Prof. Eric May, Dr Thomas Hughes, W/Prof Mike Johns

Places available: 1

The production of LNG is crucial to Australia as it is the only way we can participate in the global gas trade. Currently, 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. This research will improve the reliability of process simulators by anchoring their underlying thermodynamic models to data characteristic of realistic LNG fluids and conditions. Students working on this project will have the opportunity to measure new vapour-liquid equilibria, density, heat capacity, viscosity, surface tension or thermal conductivity data for binary and multi-component hydrocarbon mixtures and/or improve the property package models in process simulation software such as AspenTech HYSYS.
FSD-3: Developing advanced adsorption processes for enhanced gas separations and storage.

Supervisors: W/Prof. Eric May

Places available: 1

These projects will investigate either: (i) the use of novel, cryogenic pressure swing adsorption (PSA) processes to remove nitrogen and carbon dioxide from natural gas streams and thereby improve the efficiency and decrease the cost of liquefied natural gas (LNG) production, or (ii) the use of porous carbon adsorbents for the storage of natural gas for transport applications. Novel adsorbent materials will be identified and tested experimentally at temperatures ranging from cryogenic to ambient, and at pressures from 0.001 to 5000 kPa. The experiments will be designed to simulate operating conditions expected in an industrial LNG production facility or in a gas storage application including novel fuel tanks. Data from these experiments will be used in numerical models of the adsorption processes to evaluate the viability and efficacy of the separation or storage. Research outcomes of this project will be used to improve the design of LNG production trains, to treat contaminated gas reserves or to compare vehicles fuelled by adsorbed natural gas with those powered by gasoline, diesel, hydrogen fuel-cells and batteries.

FSD-4: CO\textsubscript{2} and N\textsubscript{2} capture with novel materials

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

Positions available: 1

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. N\textsubscript{2} capture from natural gas is increasingly important in the development of LNG projects where this component is energetically parasitic. This project will look at the use of novel materials for improved capture efficiency that are either solid adsorbents, including calixarenes, which are organic cage like molecules or liquid solvents, such as ionic liquids. The project will involve the design, construction and commissioning of apparatus for a solid bed adsorption system and an absorbing contact tower, which can operate over a wide range of temperature, pressure and gas flow conditions. Once the apparatus are constructed and tested successfully, they will be used to test the efficacy of the novel capture materials.

FSD-5 – A risk-based approach to natural gas hydrates in oil and gas production: studies of formation, agglomeration, inhibition and remediation.

Supervisors: Dr John Boxall, W/Prof. Eric May

Places available: 1

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. These projects aim to provide the knowledge needed for a risk-based approach to hydrate management by establishing quantitative measures to assess plugging potential, optimize inhibitor doses, and develop methods to detect hydrate formation and location using optical-fibres. 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-6: Novel breaking of water-in-crude oil emulsions

Supervisors: W/Prof. Mike Johns, Dr Einar Fridjonsson, Dr Brendan Graham, W/Prof. Eric May

Positions available: 2

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 (i) Optimising our unique Nuclear Magnetic Resonance (NMR) instrumentation for on-line emulsion droplet sizing; (ii) 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); (iii) efficient extraction of naturally occurring resins from crude oil that have been proven to significantly reduce emulsion strength and (iv) use of CO₂ for emulsion droplet disruption and encouraged coalescence.

FSD-7: Detecting and preventing desalination membrane biofouling.

Supervisors: W/Prof. Mike Johns, Dr Einar Fridjonsson

Positions available: 2

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 transmembrane pressure drop) of such biofouling development in ROMS, such that corrective actions can be initiated. In future we will expand the capability of this instrument such that faster velocities can be realized (using upstream excitation) and such that it can also provide a ‘time-of flight’ velocity measurement. 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. The fate and dispersion of such capsules in the sub-surface following their application is also considered via model experiments employing NMR transport measurements in rock cores.

FSD-8: NMR logging for sub-surface moisture determination

Supervisors: W/Prof. Mike Johns, Dr Einar Fridjonsson, Dr Paul Stannix

Positions available: 1

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.
FSD-9: Quantifying CO₂ storage capacity: studies of residual trapping & solution trapping.

Supervisors: W/Prof. Mike Johns, Dr Einar Fridjonsson, W/Prof. Eric May

Positions available: 1

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.

FSD-10: Enhanced gas recovery with super-critical carbon dioxide.

Supervisors: W/Prof. Eric May, W/Prof. Mike Johns

Positions available: 1

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.