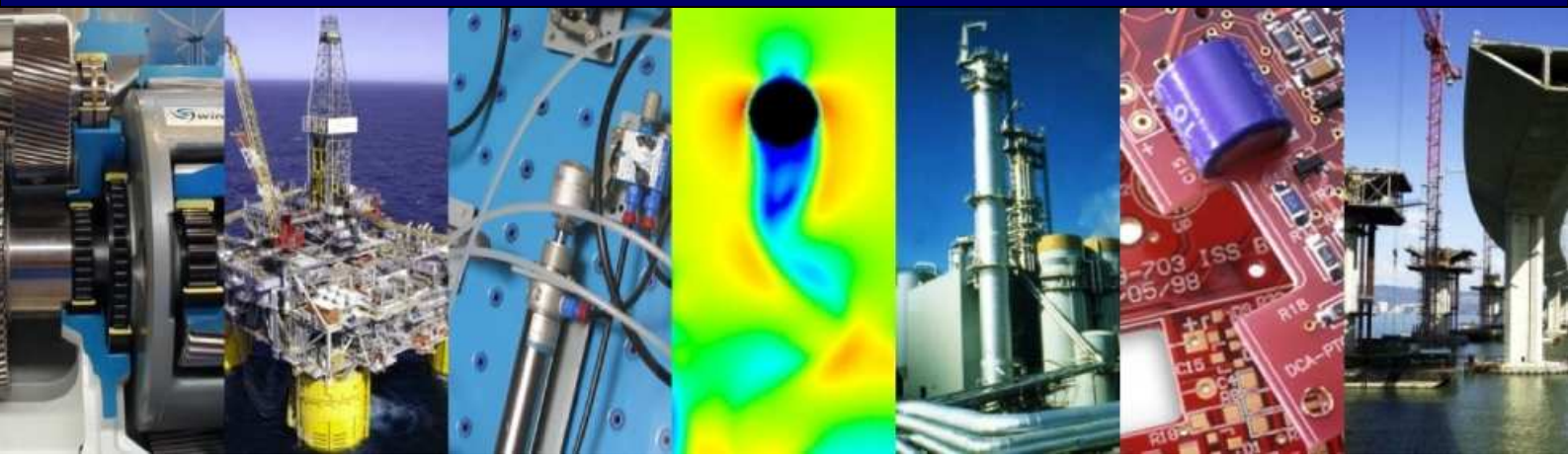


Curtin Engineering Faculty Research Colloquium

14th November 2006

Book of Abstracts

Curtin
University of Technology

FOREWORD

The inaugural Curtin Engineering Faculty Research Colloquium was conceived to provide an opportunity for postgraduate students in the engineering faculty to present their work to a wider audience. This, and future, colloquia are also as much about building social and professional ties between students and staff, to foster and maintain an active and exciting research culture.

This first event made a significant start along this path, and the following 28 abstracts highlight the diverse nature of 'engineering' research.

Finally, I would like to thank the postgraduate students who made up the organising committee; Owen Kruger, Agus Saptoro, Marjan Ladjavardi, Mark Rank, Mark Pitman, as well as support from Shevaune Espinos, without all of whom the CEFRC would not have happened.

Andrew King

SCHEDULE OF PRESENTATIONS

	Stream A Room 312:222	Stream B Room 312:207
9:00	Welcome	
9:05	A1	B1
9:25	A2	B2
9:45	A3	B3
10:05	A4	B4
10:25 - 10:50	Morning Tea	
10:50	A5	B5
11:10	A6	B6
11:30	A7	B7
11:50	A8	B8
12:10 - 1:20	Lunch	
1:20	A9	B9
1:40	A10	B10
2:00	A11	B11
2:20	A12	B12
2:20-2:50	Afternoon Tea	
2:50	A13	B13
3:10	A14	B14
3:30	A15	B15
3:50	Best Paper Award	
4:00 - 5:30	Closing Drinks	

STREAM A – LIST OF PAPERS

A1	M. W. Pitman	Optimal Swimming Modes of a Homosapien Performing Butterfly-Stroke Kick
A2	P. Jitsangiam	peformance, evaluation, and enhancement of red sand for road Materials
A3	A. W. Nugroho	The development of a porous Beta-Titanium alloy fabricated from blended elemental powders for biomedical application
A4	P. Utomo	Plane Strain Compression Testing On Overconsolidated Clays
A5	R. R. Gunawan	A Mechanistic study into the reactions of ammonium Nitrate with pyrite
A6	J. Darbyshire	An Improved Grid Connected Power Electronic Interface For Small Scale Wind Turbine Generators
A7	D.C. Riawan	Compensated P/I-Based Mppt Scheme For PV Modules Operated in a Wide Temperature Range
A8	G. A. Tetlow	A Numerical Model For Further Understanding of Obstructive Sleep Apnoea
A9	F. Nugraheni	A Model For Construction Safety Assessment
A10	A. M. G. Gillgren	Wireless Transmissions Through the Flow Path for Oil/Gas-Well Monitoring
A11	M. A. Akhtar	Hydrodynamic Study of Bubble Column Reactor Using CFD
A12	T. Waris	Variable Speed Diesel Power Conversion System Using a Doubly Fed Induction Generator
A13	P. C. Scarfe	Dynamic Memory Allocation for CMACs Using binary search trees
A14	X. Liu	Reliability Evaluation of a Wind-Diesel-Battery Hybrid Power System
A15	A. S. W. Tuck	A Repair Strategy for Timber Bridges using Composite Fibre Wrap

STREAM B – LIST OF PAPERS

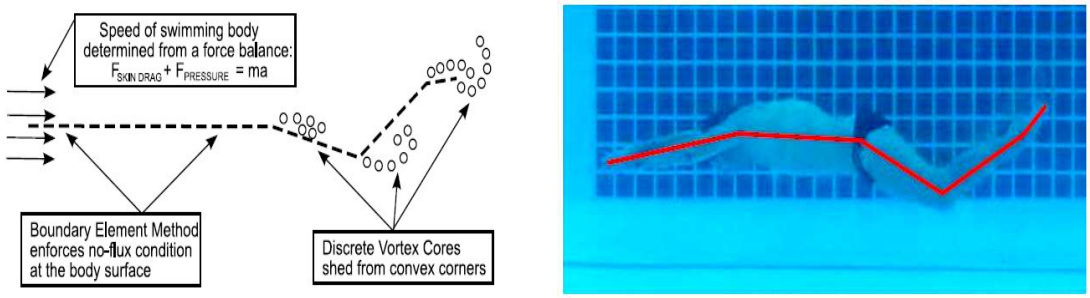
B1	Sudarisman	Flexural Behaviour of Hybrid Carbon-Glass Fibre-Reinforced Polymer (FRP) Matrix Composites
B2	K. Singh	Model Based Control of Nonlinear Processes
B3	A. Ulinuha	Optimal Scheduling of LTC and Shunt Capacitors in Distorted Distribution Networks
B4	Z. Song	The Behaviour of Suction Embedded Plate Anchors in Clay
B5	A. Foong Jun Li	Heat Transfer and Fluid Flow Characteristics in a Microchannel Heat Sink
B6	Novia	CFD Analysis of Multiphase Flow and Reaction In FCC Riser Reactors
B7	T. E. Agustina	Effect of Initial Solution pH and Lamps Configuration on the Photolysis of Winery Wastewater
B8	A. B. Nasir	Environmental and Economic Impacts of Fly Ash and Its Utilization as Soil Erosion Control and Soil Conditioner
B9	S. Nasir	Investigations into the Membrane Performance and Build-up of Solute in a Small-scale of Reverse Osmosis System
B10	E. H. Chang	Behaviour of Reinforced Fly Ash-Based Geopolymer Concrete Beams
B11	M. H. Parapari	Direct Conversion of Methane to Methanol
B12	C. Chuanwen	The study of the individual torsional mesh stiffness in gear transmission systems
B13	E. A. Oraby	Gold Leaching in Thiosulfate Solutions and its Environmental Effects Compared with Cyanide
B14		
B15		

OPTIMAL SWIMMING MODES OF A HOMO-SAPIEN PERFORMING BUTTERFLY-STROKE KICK

M. W. Pitman

Department of Mechanical Engineering

This paper outlines the development and application of a computational method that finds the most efficient two-dimensional swimming mode of a human performing fully submerged butterfly-stroke kick at high Reynolds number. The optimal solution of this non-linear problem is found using a Genetic Algorithm (GA) search method where possible solutions compete in a `survival of the fittest' scheme to `breed' the optimal solution.



(a) (b)

Figure 1: a) Schematic of the computational model used to represent the swimer. b) Video frame of a tagged swimmer performing submerged dolphin kick and deriving the kinematic variables from [1]

The swimming is modelled using Discrete Vortex Method (DVM) and Boundary Element Method (BEM) computational techniques. The BEM solves for the inviscid flow field around the two-dimensional body while the shedding of vorticies from joints where the curvature is high (ie. knee, waist and ankle joints) generate the vortex structures necessary for propulsion. A schematic diagram of the swimming model is shown in Figure 1a alongside a photograph of an actual tagged swimmer in Figure 1b.

The motion of the limbs is characterised by a displacement function which includes the possibility for simple harmonic or non-harmonic motion with a `rest' period in the kick. The finite number of joints means that a finite length parameter set can be developed which characterises the motion of the swimming body. This parameter set is fed into the GA to perform the optimisation based on a scoring function. In this case, the scoring function is simply the distance that the body swims in a set amount of time. The objective of the GA is to maximise this score for a set kicking frequency. This method opens a wider possibility for optimisation of a variety of systems that involve fluid-structure interactions, particulary the possibility of optimisation in the non-linear regime of prescribed motion coupled with compliant surfaces (such as rubbery flippers) that could further increase efficiency

References:

1 Lyttle, A. D., and Keys, M., 2003, *Computational fluid dynamics. A tool for future swimming technique analysis.* Coachesinfo.com, online.

PEFORMANCE, EVALUATION, AND ENHANCEMENT OF RED SAND FOR ROAD MATERIALS

P. Jitsangiam

Department of Civil Engineering

The Australia produces approximately 40% of the world's bauxite and over 30% of the world's alumina. Each year, about 25 million tonnes of bauxite residues are produced in Australia. The management and containment of large impoundment areas are costly. The sustainable use of coarse bauxite residues for road construction is an attractive option with a high potential for large volume reuse.

During the extraction of alumina from bauxite ore using the Bayer process, a fine residue is produced called Red Mud. In Western Australia, Darling Range bauxite deposits contain high levels of quartz, which results in a coarse residue fraction also being produced. This fraction has been termed Red Sand with a typical particle size in excess of 90 micron. Typically, red mud and red sand are produced in almost equal quantity. Processing of red sand can neutralise the residual caustic and lower the salt content as required.

This study focuses on whether red sand is a viable option for use as a road base material in Western Australia. The soil stabilisation technique, a pozzolanic- stabilised mixture, was used to improve the properties of red sand to satisfy minimum requirements of road bases. The intent of this stabilisation technique is to use potential by-products from industry in Western Australia as stabilising materials. A pozzolanic - stabilised mixture consisting of Class F fly ash, a by-product from a coal power station, and activators, the by-product from the quicklime manufacturing in terms of lime kiln dust, were employed to develop pozzolanic activity. Once the appropriate mixture of red sand, fly ash, and activators was established (based on a maximum dry density and a value of unconfined compressive strength), a set of laboratory testing was performed. These included an unconfined compressive strength test, a resilient modulus test, and a permanent deformation test. Comparisons were made between the stabilised red sand and the conventional road base material in West Australia (crushed rock added with 2% General Purpose (GP) Portland Cement). The results of this study show that the performance of the stabilised red sand is superior to that of the standard use material. Our findings indicate that stabilised red sand can provide improved performance when used as road base materials in Western Australia.

THE DEVELOPMENT OF A POROUS BETA TITANIUM ALLOY FABRICATED FROM BLENDED ELEMENTAL POWDERS FOR BIOMEDICAL APPLICATION

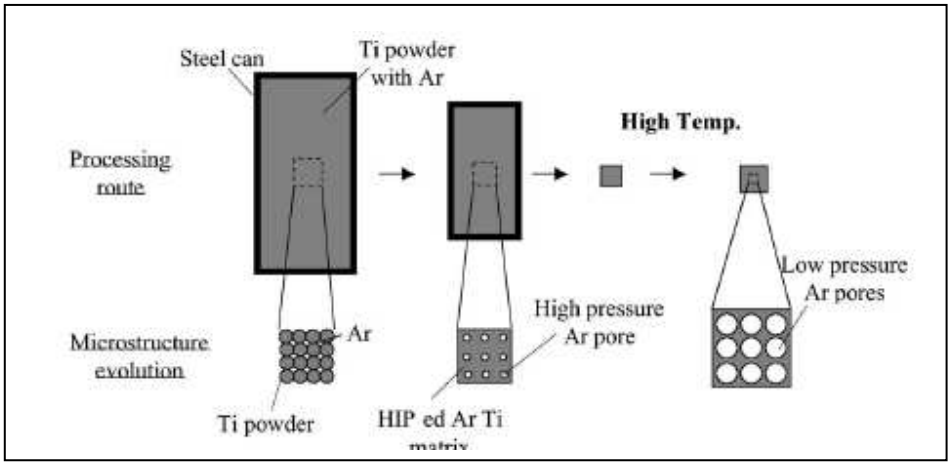
A. W. Nugroho

Department of Mechanical Engineering

In the application of biomaterials for hard tissue replacement, fixation is known to be a critical factor. The natural response of the human body to implanted metallic material is such that, frequently, fixation failure occurs. Therefore, developing appropriate biocompatible material forms has become a very important issue.

It has been well established that a porous structure in an implanted material can enhance bone ingrowth and bonding to adjacent tissue[1] hence improving fixation. In some cases this also coincides with a welcome change in mechanical properties, e.g. Young's Modulus[2]. Accordingly, both stress shielding and implant loosening could be reduced, and so fixation can be further enhanced. Certain titanium alloys commonly used as implant materials have been shown to include alloying additions, which while enhancing mechanical properties, have increased the cytotoxicity of the material.

Beta titanium alloys, however, are less prone to cytotoxicity[3]. This work has proceeded in order to develop, in of this group of alloys a fully porous material fabricated by novel powder metallurgy process based on pressurized pore expansion process. The process involves a sequence of blending elemental powders, pre-pressing, argon infusion, HIPping and expansion.



Schematic of porous Ti process

References:

1 S. Fujibayashi, M. Neo, H. M. Kim, T. Kokubo, and T. Nakamura, "Osteoinduction of porous bioactive Ti metal," *Biomaterials*, vol. 25, pp. 443-450, 2004.

2 C. E. Wen, Y. Yamada, K. Shimojima, Y. Chino, T. Asahina, and M. Mabuchi, "Processing of biocompatible porous Ti and Mg," *Scripta Materialia*, vol. 45, pp. 1147-1153, 2001.

3 E. Eisenbarth, D. Velten, M. Muller, R. Thull, and J. Breme, "Biocompatible of β-stabilizing elements of titanium alloys," *Biomaterial*, vol. 25, pp. 5705-5713, 2004.

PLANE STRAIN COMPRESSION TESTING ON OVERCONSOLIDATED CLAYS

P. Utomo

Department of Civil Engineering

One of the objectives in this research is to establish a newly proposed device (Figure 1) for obtaining shear strength parameters of geologic materials which is able to run the testing under plane strain condition. Because in the field, a lot of geotechnical structures are of plane strain condition (slope failures, retaining wall structures and strip foundations). Current most widely used device for this task is using axisymetric condition, which is the simplification of most of the real condition in the field.

The scope of works in this research is ranging from testing on overconsolidated clays, normally consolidated clays and unsaturated clays, currently, some testing results have been obtained from this new apparatus, which is testing on overconsolidated clays.

The hopes that might be the outcomes of this device such as: the improvement of quality of design parameters for plane strain geotechnical structures which is generated from the device that is easy to set up and less expensive to run the testings.

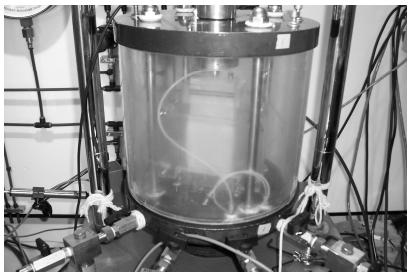
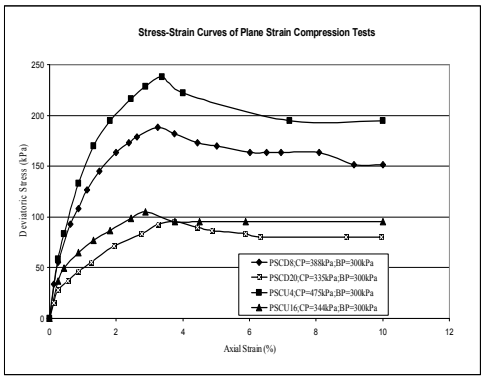


Figure 1. Plane strain apparatus

From Figure 2, it can be seen that the apparatus has been able to produce test results which are in reasonably good agreement with known soil mechanics concepts (shows dilatant behaviour of overconsolidated clays).



References:

1. Utomo, P. and Nikraz, H.R. (2006), *Behaviour of overconsolidated clays under plane strain testing*, Proceeding of 7th Australia – New Zealand Young Geotechnical Professionals Conference, Adelaide (18-21 October), pp. 236-242.

A MECHANISTIC STUDY INTO THE REACTIONS OF AMMONIUM NITRATE WITH PYRITE

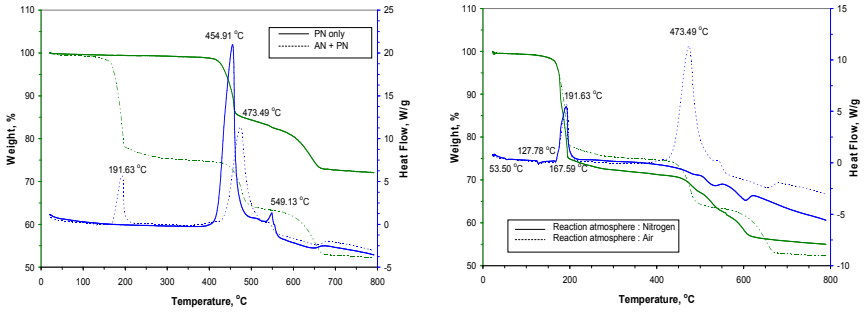
R. R. Gunawan

Department of Chemical Engineering

Centre for Fuels & Energy, Curtin University of Technology, Australia

In mining operations, the removal of overburden to expose the ores is achieved by rock blasting using ammonium nitrate – fuel oil (ANFO) explosives. However, ammonium nitrate based explosives, when charged into blasthole intercepting pyritic shale, may spontaneously explode without warning. This incident may cause loss of life, property and productivity and it has been reported to occur in various mines throughout the world. In this particular study, the reaction of ammonium nitrate with pyrite was studied using a simultaneous Differential Scanning Calorimetry and Thermogravimetric Analyser (DSC-TGA).

When a mixture of pyrite and ammonium nitrate is heated at a constant heating rate of 10 $K.min^{-1}$ from room temperature to 800^{o}C, two exothermic reactions occur at about 200^{o}C and 450^{o}C, respectively as shown in Figure 1. Online gas-analysis, including Enerac 3000 and a Draeger portable gas analysers, Chemiluminescence SO_2 and NO-NO_2-NO_X analysers, and a Balzers Thermostar quadropole Mass Spectrometer (MS) were employed in order to gain a better understanding on the reaction. In addition, the solid products of the reaction were also characterised using various method i.e. SEM with EDS, XRD and in-situ High Temperature XRD.



(a) **(b)**

Figure 1 **(a)** A comparison of mass losses and heat flows of the mixture of ammonium nitrate (AN) and pyrite (PN), and pyrite (PN) only in air ; **(b)** The effect of reaction atmosphere (nitrogen or air) during the interaction between ammonium nitrate and pyrite

The first exothermic reaction, which is not affected by the reaction atmosphere, is considered to take place between ammonium nitrate and pyrite. Based on the quantitative analysis of the gaseous and solid products of the reaction, a new overall reaction is proposed at the first exothermic peak of interest.

$$8FeS_{2\,(s)} + 28NH_4NO_{3\,(s)} \rightarrow 26NO_{(g)} + 13SO_{2(g)} + 3Fe_2O_{3(s)} + 30NH_{3(g)} + Fe_2(SO_4)_{3(s)} + 11H_2O_{(g)}$$

Furthermore the thermodynamic analysis shows that the proposed reaction is thermodynamically favourable. In addition, the second exothermic reaction is due to the oxidation of the remaining pyrite and the primary reactions products between ammonium nitrate and pyrite by atmospheric oxygen.

The knowledge of the proposed overall reaction will have some implications in the mining management to prevent the spontaneous explosion. This will include the development of inhibitors that may react with one of the key intermediate products of the reaction, and accordingly hinder the progress of the reaction between ammonium nitrate and pyrite. Alternatively, the new overall reaction provides means for modelling and prediction of practical processes where reactions of ammonium nitrate with pyritic shale leading to spontaneous explosion of ANFO are of concern, and hence, together with the chemical and physical properties of the blasthole and kinetics of the reaction, the occurrence of spontaneous explosion can be forecasted.

AN IMPROVED GRID CONNECTED POWER ELECTRONIC INTERFACE FOR SMALL SCALE WIND TURBINE GENERATORS

J. Darbyshire

Department of Electrical & Computer Engineering

The increasing demand for non fossil fuel based electricity sources is a driving force behind the advancement of renewable energy today. This presentation focuses on a new power electronic interface to the power grid for small scale wind turbines using a Maximum Power Point Tracking (MPPT) technique to obtain higher energy production at a wide range of wind speeds in such a way that the power quality of the generated electricity is of acceptable utility standards.

The wind turbine generator is a three phase permanent magnet synchronous machine (PMSM) which feeds into the wind turbine controller (WTC). The novel WTC rectifies the AC and a PWM controlled IGBT limits the dc voltage. This applies in high wind conditions that increase the turbine speed so also the generators output voltage. A full bridge high frequency transformer isolated buck converter is used to increase the dc link voltage, which allows the inverter to operate over a much larger range of wind speeds. The output inverter is a current controlled voltage source inverter (CCVSI) which when synchronized feeds power directly to the grid.

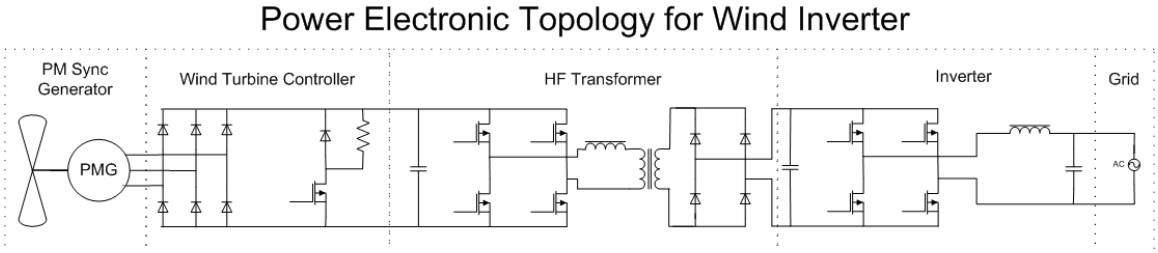


Figure 1 - Basic Interface Topology

The theoretical, simulated and experimental results and analysis of the system is presented. The theoretical section of this paper discusses the relationships between the wind speed and shaft speed and shows that there is an ideal operating point at which the power from the wind is maximum. This is combined with machine theory, and shows that for any PMSG the power coefficient (Cp) changes with respect to the angular frequency. The combination of these yields an optimal point where the machine can minimise machine losses, while maximising energy transfer from the wind. Continuously driving the PMSG to operate at this point is referred to as maximum power point tracking.

The MPPT is controlled using a novel parallel buck converter configuration coupled to a high frequency transformer. The transformer also provides galvanic isolation to the grid, a requirement for all systems in Australia (AS 4777).

COMPENSATED P/I-BASED MPPT SCHEME FOR PV MODULES OPERATED IN A WIDE TEMPERATURE RANGE

D.C. Riawan

Department of Electrical & Computer Engineering

Photovoltaic (PV) modules have non-linear characteristics described by its voltage-current (I-V) relationship (Fig. 1). At an optimum operating point of voltage and current, a PV module delivers its maximum power. The maximum power of a PV module depends on the irradiance level of sunlight and the module temperature (Fig. 2). This study demonstrates, through simulation and experimental verification, a simple method to extract maximum output power from a PV module in any irradiance level and temperature. The proposed maximum power point tracker (MPPT) is based on power-current (P-I) characteristics [1, 2] of a PV module considering temperature variation [3, 4]. This method has faster response and does not require short-circuit current or open-circuit voltage information of the module as required in constant current or voltage MPPT technique [5, 6]. Consequently, there is no power interruption during searching the optimum point which reduces the losses. Experimental results (Fig. 3&4) confirm the validity of the mathematical model and simulation of the proposed technique. Field test results show an improvement of the proposed MPPT scheme which can extract about 4% more energy from a PV module than the conventional constant gain MPPT.

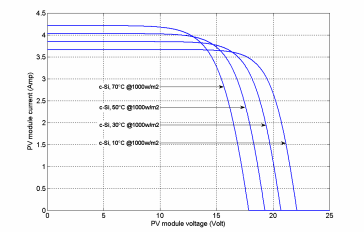


Fig. 1. I-V characteristic under different temperature.

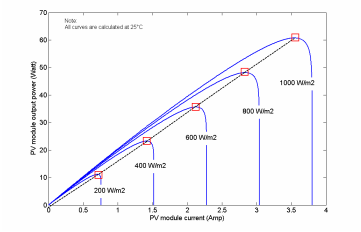


Fig. 2. P-I characteristic under different irradiance.

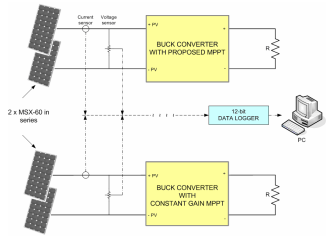


Fig. 3. Experimental setup.

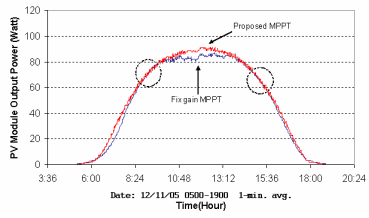


Fig. 4. Experimental result.

References

1 Pan C-T, Chen J-Y, Chu C-P, Huang Y-S. A fast maximum power point tracker for photovoltaic power systems. Industrial Electronics Society. IECON '99 Proceedings. The 25th Annual Conference of the IEEE 1999;

2 Duru HT. A maximum power point tracking algorithm based on Impp=f(Pmax) function for matching passive and active loads to a photovoltaic generator. Solar Energy 2005;

3 Park M, Yu I-K. A study on the optimal voltage for MPPT obtained by surface temperature of solar cell. Industrial Electronics Society, 2004. IECON 2004. 30th Annual Conference of IEEE 2004;3:2040-5 Vol. 3.

4 Mutoh N, Ohno M, Inoue T. A method for MPPT control while searching for parameters corresponding to weather conditions for PV generation systems. 30th Annual Conference of IEEE on Industrial Electronics Society 2004;3:3094-9.

5 Hohm DP, Ropp ME. Comparative study of maximum power point tracking algorithms using an experimental, programmable, maximum power point tracking test bed. Photovoltaic Specialists Conference, 2000. Conference Record of the Twenty-Eighth IEEE 2000;1699-702.

6 Masoum MAS, Dehbonei H, Fuchs EF. Theoretical and experimental analyses of photovoltaic systems with voltage and current-based maximum power-point tracking. IEEE Transactions on Energy Conversion 2002;17(4):514-22.

A NUMERICAL MODEL FOR FURTHER UNDERSTANDING OF OBSTRUCTIVE SLEEP APNOEA

G. A. Tetlow

Department of Mechanical Engineering

This presentation considers a simplified geometry of the human upper-airway as a means to gain further understanding of the effects of Obstructive Sleep Apnoea (OSA). OSA is a debilitating condition, which to-date eludes meaningful diagnosis, leading to low succuss rates in surgical intervention. Sufferers end up living with the problem or endure the side effects of the only available remedy, the Nasal Continuous Positive Airway Pressure (CPAP). The simplified geometry considered comprises a rigid channel containing a rigid splitter (hard palate) connected to a downstream flexible cantilevered plate (soft palate); see Fig 1.

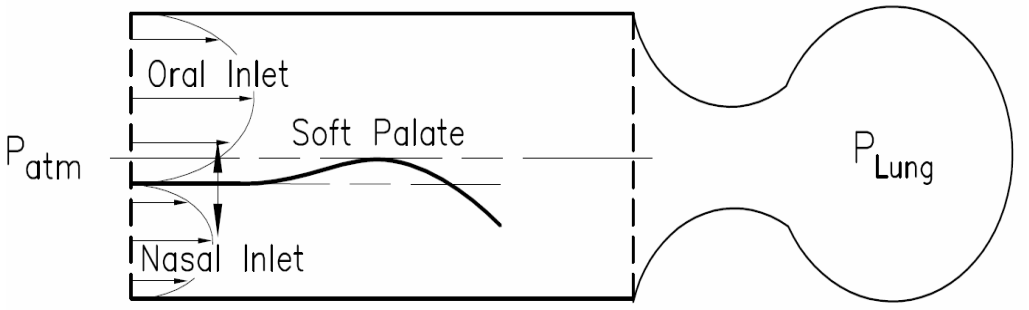


Figure 1. Simplified geometry of the human upper airway, including major anatomical features. The Pressure-Driven approach allows the inlet velocities to vary with airway resistance

Similar approaches Huang, (1995) have perforce only provided limited insights as to the underlying physics of the OSA dysfunction. The subtle differences of the numerical scheme developed in Tetlow *et al*, (2006) and utilised in this work provide understanding of the actual operational modalities of an airway. The modalities we consider and will report on are; one inlet passage closed, asymmetric positioning of the flexible plate and pressure driven flow as opposed the conventional approach of constant inlet velocities.

These modalities cover a wide range of airway behaviour providing understanding of which modes the airway is more or less stable. Clearly the implications of this work can be extended in the first instance to further 3D work incorporating the orthogonal motions on the pharynx that cannot be captured in a 2D model.

Our findings provide an explanation to the potential initiating instability of the soft palate in the airway that potentially results in collapse of the pharynx.

The presentation will include; background of the anatomical structures of the upper airway, details of the numerical scheme a comparison of the results of pressure driven to velocity driven and will consider the stability implications of one inlet channel closed versus open and asymmetric positioning of the flexible plate.

References:

1 Huang, L, 1995, *Flutter of cantilevered plates in axial flow*, J. Fluids Struct 9, 127-147.

2 Tetlow, G.A., Lucey, A.D., Balint, T.S, 2006, *Instability of a cantilevered flexible plate in viscous channel flow driven by constant pressure drop*, ASME Paper: PVP2006-ICPVT-11-93943

A MODEL FOR CONSTRUCTION SAFETY ASSESSMENT

F. Nugraheni

Department of Civil Engineering

In the construction industry, safety is an important, but often neglected, factor. Due to its nature construction is one of the most hazardous industries. Unsafe conditions, such as a hazardous project environment or an improper attitude of personnel, are often not detected before an accident occurs. A preliminary literature review also revealed that there is very little research that has focused on assessment of accident potential before fact. Based on this, there is a need to detect unsafe conditions before an accident occurs. To do this it is necessary for safety hazard recognition to be undertaken before and during construction and so identifying safe construction practices becomes very important.

Nowadays, the use of construction images has become very popular. As information sources, images recorded of the construction process provide significant information relating to the safe construction practice. However, there are a number of problems related to using images to determine if the construction practices being used are have a high level of safety or a low level of safety because of uncertain or inexact information collected by looking at that image.

To deal with the uncertain information from construction images, two theories that deal with uncertainty have chosen. It is initially based on Bayes' Theory and Fuzzy Logic Theory. By using Bayes Theory, from 20 construction images as an example, the result revealed that the images can be defined into two definitions of construction practice: eight images demonstrate a high level of safety, whereas 12 images demonstrate a low level of safety. Furthermore, by using Fuzzy Logic Theory, the eight images of a high level of safety can be classified into three classifications: a most likely safe practice, a fairly safe practice, and a most likely unsafe practice.

To make the result more useful all of the collected images, which are more than 400 construction images up to date, were kept into a database. This database was designed to be an open source database which is based on internet. To do this, PHP as a computer program for web design and MySQL as a computer program for database were chosen. In the database, each image has work identification based on safety attributes, description of the activities, hazard identification, and solution of the problem/hazard identified. By accessing this database, a user can find alternative solutions for his/her problem about particular activity in the ongoing construction project in the term of safety practice. This process called case-based reasoning (CBR). CBR means reasoning based on previous cases or experiences. In CBR, the primary knowledge source is a memory of stored cases. New solutions are generated by retrieving the most relevant cases from memory and adapting them to fit the new situations.

In summary, this study is proposed a model to assess safe construction practice using construction images. Construction images were defining and classifying using Bayes' Theory and Fuzzy Logic Theory. Further, to make the result useful for safety knowledge, the determined images were stored into database which is can be accessed by everyone and can be used as a source of information of safety practice.

References:

1 Giarratano, J and Riley, G, 1998, *Expert Systems: Principles and Programming*. 3ed. Boston: International Thomson Publishing Inc.

2 Kolodner, J, 1993, *Case-Based Reasoning*. Morgan Kaufmann Publishers, Inc. San Mateo, California.

3 Leake, D.B, 1996, *Case-Based Reasoning: Experiences, Lessons, and Future Directions*. Menlo Park, California/Cambridge, Massachusetts/London, England. AAAI Press/The MIT Press.

WIRELESS TRANSMISSIONS THROUGH THE FLOW PATH FOR OIL/GAS-WELL MONITORING

A. M. G. Gillgren

Department of Mechanical Engineering

Permanent downhole monitoring systems are becoming more prevalent in the oil/gas industry providing a method of optimising oil/gas production [1, 2]. However, the current systems are being limited by their expense, as they require expensive fibre optic cabling. This thesis looks at the implementation of waveguide theory to generate an intelligent well monitoring system. Unlike existing instrumentation, the system proposed in this paper would utilize the pipe itself, guiding radio signals along its length, through the oil/gas medium, creating a much simpler and cheaper method for transferring down-hole information back to the surface.

Waveguide theory is a well established communication technique [3-5], but the conditions of an operating oil/gas well are unique. The effect of the electromagnetic properties of the mediums, flow regime and any common discontinuities in the pipeline are explored. A method of exciting the waveguide, from a separated cavity in a purpose built sub (as to not disrupt the medium flow) is also presented. Thus far the system has proved successful in three phase flow, with high data rates such as video transfer achieved, creating possibilities for a new generation of monitoring systems.

References:

1 R. v. Flatern, "Older but Smarter," OilOnline, 2006.

2 P. Tubel, "Downhole Power Generation and Wireless Communications

3 for Intelligent Completions Applications," US Department of Energy, 2005.

4 H. R. L. Lamont, *Wave guides*, 3d ed rev. ed. London: Methuen, 1950.

5 S. F. Mahmoud, *Electromagnetic waveguides : theory and applications*. London: P. Peregrinus Ltd, 1991.

6 R. E. Collin, *Field theory of guided waves*, 2nd ed. New York: IEEE Press, 1991.

HYDRODYNAMIC STUDY OF BUBBLE COLUMN REACTOR USING CFD

M. A. Akhtar

Department of Chemical Engineering

Bubble column reactors have variety of applications in the chemical, biochemical and petrochemical industries due to their relative simple construction; favourable heat and mass transfer properties and low operating cost. The characteristics and hydrodynamics of bubbles, bubble size distribution, superficial gas velocity and gas distributor are few factors which govern the performance of these systems (Akhtar, 2006).

In this work the behaviour of bubble dynamics for a two and three-dimensional bubble column reactor has been investigated using VOF approach of CFD. The effect of gas distributor (hole size = 2-10 cm) and superficial gas velocity (1-10cm/s) on bubble size distribution, bubble rise velocity and its trajectory has been investigated for a 20 cm diameter and 1 m high cylindrical bubble column reactor.

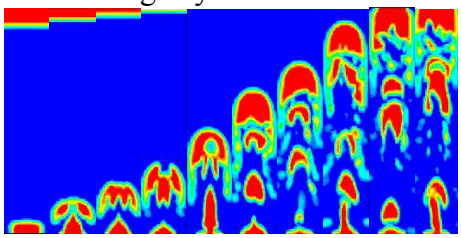


Figure 1. Bubble Column Simulations using VOF method

For the same hole-size (distributor), simulation results have indicated the formation of small size bubbles at low superficial gas velocity and relatively large size bubbles at higher velocities. Increase in the hole-size has shown similar behaviour. A decrease in rise velocity with decrease in hole-size was observed due to formation of small bubbles. With continuous supply of gas in stagnant liquid, a continuous stream of bubbles was produced (Figure1). The trailing bubbles were observed to move in a rectilinear manner at low superficial gas velocities (1.0 cm/s) while at higher superficial gas velocities these bubbles have exhibited a slightly zigzag or oscillatory behaviour. Bubble formation and coalescence phenomenon was also studied. In order to achieve quantitative validation of simulation results, volume-averaged gas hold-ups for various distributors were plotted as a function of superficial gas velocity. Predicted values of volume-averaged gas hold-up simulations have given a close agreement with the experimental work of Joshi et al. (1979) and Hikita et al.(1980) .as shown in Figure 2. Comparison of bubble rise velocity, bubble shape, and typical rise trajectories are also very well validated with the previous work in literature. In summary, this study examines the effect of distributor hole size and superficial gas velocity on bubble size distribution.

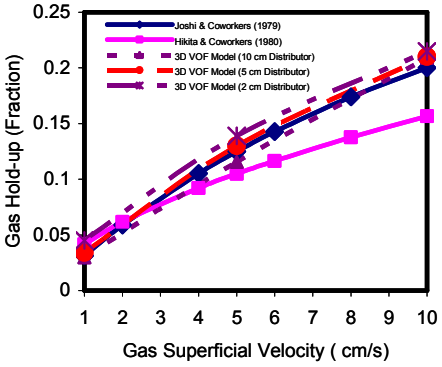


Figure 2 . Model Validation

References:

1 Akhtar, M. A., Tade, M. O. & Pareek, V. K. 2006, 'Two-Fluid Eulerian Simulation of Bubble Column Reactors with Distributors', *Journal of Chemical Engineering of Japan,* vol. 39, no. 8, pp. 831-841.

2 Hikita, h., Asai, S., Tanigawa, K., Segawa, K. & Kitao, K. 1980, 'Gas Holdup in Bubble Columns', *Chemical Engineering Journal,* vol. 20, p. 59.

3 Joshi, J. B. & Sharma, M. 1979, 'A Circulation cell model for bubble columns', *Trans Inst. Chem. Eng,* vol. 57, pp. 244-251.

VARIABLE SPEED DIESEL POWER CONVERSION SYSTEM USING A DOUBLY FED INDUCTION GENERATOR

T. Waris

Department of Electrical and Computer Engineering

Synchronous generator is used in conventional diesel generator (DG) system. The generator is directly connected to the ac load while DG engine's speed is being kept constant. As the result DG supplies the load at the constant frequency e.g. 50 Hz. However, load profiles are dynamic in nature and may vary dramatically as a function of time. Therefore, a conventional constant speed DG has to be heavily over-sized in relation to the prevalent load condition. Operation at an average load as low as 30% of the full capacity is common. In case of the light loads, the fuel economy of the DG is poor. This is caused by the fact that not all the fuel is burnt in the combustion chamber which causes excessive wear in the cylinder walls, cylinder glazing (wet-staking) and carbon build–up. These harmful and destructive conditions inflict severe deterioration in engine performance, and premature engine failure [1]. In large systems, this problem can be overcome by applying multiple DG set. However, in smaller application, multiple DG set operation is not practical or economical. The use of simple dummy load is common practice but the "dumps load "deliberately dissipate energy when the load demand is low. In the proposed system (Figure 1), the generator's speed varies following the load demand known as Variable Speed Doubly Fed Induction Generator (VSDFIG). The power electronic interface placed between rotor and grid enables to operate the DG set in variable speed constant frequency [2]. This reduces fuel consumption and emission level.

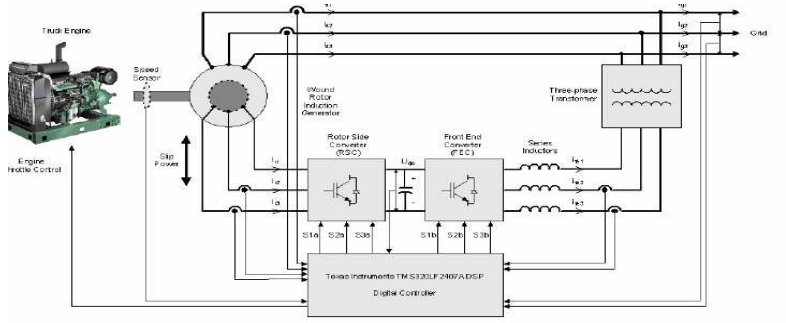


Figure 1. Proposed System: Variable Speed Doubly Fed Induction Generator (VSDFIG)

Successful development of the proposed system will be applied in remote diesel grid power system. The VSDFIG should improve the reliability, quality and efficiency of supply through the following significances such as considerable fuel saving; reducing maintenance cost as effect of wet-staking; extracting more power from the variable speed diesel gensets without exceeding the permissible torque; smaller capacity for the power electronic; smaller induction generator capacity is required. This scheme can be used as well by engines powered by methane (biogas) and bio diesel. Hence, it will contribute high penetration of renewable energy usage.

References:

1 J.B.Adriulli,A.E.Gates, H.D.Haynes, *Advanced Power Generating System for 21st Century: Market Survey and Recommendation for a Design Philosophy*, Oak Ridge National Laboratory, November 1999

2 R.Pena,R.Cardena,J.Clare,andG.Asher, *Control Strategy of Doubly Fed Induction Generators for Wind Diesel Energy System*, presented at IECON 02,2002

DYNAMIC MEMORY ALLOCATION FOR CMACS USING BINARY SEARCH TREES

P. C. Scarfe

Department of Mechanical Engineering

The CMAC (Cerebellar Model Articulation Controller) was designed by Albus [1] in 1975 as an adaptive controller based on the biological learning processes in the cerebellum, the part of the brain that controls fine motion in higher animals. The CMAC was originally designed to be used primarily as a controller for robotic actuators and consisted of static memory allocation using the common data storage method of hashing. Hashing has the natural ability to store sparsely populated data sets that exists in multidimensional hyperspaces into a single dimensional array of static size. While the CMAC with hashing produces acceptable results, noise at the output exists due to hash-collisions, this being a direct result of using hashing. While methods exist which can avoid this noise while still using hashing as the base memory mapping algorithm, hashing requires static memory allocation prior to any maturation of the CMAC during all future online training. While hashing holds its own advantages over other data storage methods, dynamic memory allocation has many attractive attributes which make it a feasible replacement.

The work that is presented here involves using binary search trees as the data storage algorithm instead of hashing in CMACs. In general practice, hashing is preferred over binary search trees for reasons such as having quick and fixed data insertion/search times. However for most fast hashing algorithms the data stored in the hash array is not guaranteed to map uniquely to every vector in the CMACs multidimensional input space. When these collisions are not accounted for, noise results at the CMAC's output. Binary search trees however have the advantage that they are dynamic, they can provide guaranteed worst-case performance (everything could hash to the same place even in the best hashing algorithm) and they support a wider range of operations making data handling more flexible [2]. In addition they always produce clean data at the CMAC's output, having the natural property of assigning a unique data storage node for every used input space vector.

Integrating binary search trees as the memory storage algorithm in the CMAC is the first challenge to be undertaken here. Taking the widely known University of New Hampshire CMAC code [3], hashing has been removed and binary search trees have been implemented in its place. Preliminary testing shows comparative results between hashing to binary search trees. Each method has their own advantages and disadvantages which are yet to be analyzed in depth. This work provides a suitable dynamic solution when requiring CMAC usability in adaptive robotic systems where the memory requirements can grow and/or shrink depending on the systems requirements and where the output is required to be clean.

References:

1 Albus, J. S, 1975, *A new approach to manipulator control: The cerebellar model* articulation controller (CMAC). Transactions of the ASME: Journal of Dynamic Systems, Measurement, and Control, pp. 220:227.

2 Sedgewick, R, 1990, Algorithms in C. USA, Addison-Wesley Publishing Company, Inc.

3 Miller, W. T. and F. H. Glanz, 1996, The University of New Hampshire Implementation of the Cerebellar Model Arithmetic Computer - CMAC. Durham, New Hampshire, Robotics Laboratory, University of New Hampshire.

RELIABILITY EVALUATION OF A WIND-DIESEL-BATTERY HYBRID POWER SYSTEM

X. Liu

Department of Electrical and Computer Engineering

Wind-diesel hybrid power system is becoming a popular form of electricity generation in remote and isolated areas for its low fuel cost and low greenhouse gases emission. The incorporation of wind power units into generation system brings significant impact to system reliability, especially capacity adequacy. Since wind is an unstable energy source, which fluctuates continuously, generation capacity adequacy is the principal issue of hybrid system planning and operation.

There are two mainstream approaches developed to evaluate wind power generation system: the Monte Carlo simulation and analytical method. The Monte Carlo simulation is flexible approach which can be utilised to most of the circumstances. However, its drawbacks are evident; complicated modelling processes and long computation time are the two main factors which prevent it from large scale industrial application, especially system planning. Although the analytical methods have many advantages, most of existing approaches cannot provide accurate and comprehensive description of wind speed scheme and wind turbine operation characteristics, which lead to undependable results.

Wind speed frame analysis is developed to overcome disadvantages of the existing analytical methods, and provide fast, simple and reliable solution for wind power system reliability evaluation. By utilising discrete frames on wind speed distribution, the approach can model wind turbine with high accuracy, and the computation time is greatly shortened. At the same time, diesel generator model can be simply incorporated with this wind turbine model to tackle the reliability issues of hybrid power system.\

References:

1 R. Karki and R. Billinton, “Cost-effective wind energy utilization for reliable power supply,” IEEE Transactions on Energy Conversion, vol. 19, pp.435-440, June 2004.

2 R. Billinton, H. Chen and R. Ghajar, “A sequential simulation for adequacy evaluation of generation systems including wind energy,” IEEE Transactions on Energy Conversion, vol. 11, pp.728-734, December 1996.

3 R. Billinton, and H. Chen, “Assessment of risk-based capacity benefit factors associated with wind energy conversion systems,” IEEE Transactions on Power Systems, vol. 13, pp.1191-1196, August 1998.

4 X. Liu and S. Islam, “Reliability Evaluation of a Wind-Diesel Hybrid Power System with Battery Bank Using Discrete Wind Speed Frame Analysis,” Proceedings of the 9th International Conference on Probabilistic Methods Applied to Power Systems (PMAPS 2006), 11-15 June, 2006, Stockholm, Sweden.

A REPAIR STRATEGY FOR TIMBER BRIDGES USING COMPOSITE FIBRE WRAP

A. S. W. Tuck

Department of Civil Engineering

There are a large number of bridges constructed from timber which form an important part of the road network systems in many parts of Australia. However, timber, like concrete, suffers from deterioration and degradation resulting from natural causes such as infestation by wood boring insects and infection by wood-destroying fungi. Increases in vehicular usage and loads also result in the need to strengthen the timber capacities.

Currently, there had been various methods of repair and strengthening methods, consisting of using heavy steel plate bonding, concreting around deteriorated timber elements and even replacement of the total timber sections with new timbers or steel.

The research objective discusses the feasibility of replacing some of the traditional methods of repair with the use of new strengthening technique utilising carbon fibre polymer wrap for timber bridge elements. Carbon fibre polymer wrap system has potential advantages of being lightweight and easy to install, non-corrosive, flexible and can be formed around any shape and sizes, and has high strength to weight ratio.

However, there are several factors involved for the timber strengthening work as follows:

- Economical type of arrangement and type of repair scheme.
- Feasibility of repair.
- Prediction of strengthened timber capacity using theoretical analysis approach and load test findings.

References:

1. Tshirren S., [2003]. *Strengthening of Jarrah Halfcaps with externally bonded carbon fibre fabric*. Final Year Project Report, Dept of Civil Engineering, Curtin University, Perth.

FLEXURAL BEHAVIOUR OF HYBRID CARBON-GLASS FIBRE-REINFORCED POLYMER (FRP) MATRIX COMPOSITES

Sudarisman

Department of Mechanical Engineering

In this project, the performance in terms of mechanical properties of hybrid FRP composite materials containing carbon and glass fibres in epoxy matrix will experimentally be optimised through the production of higher specific flexural strength and specific flexural modulus hybrid FRP composites. Improvements in this field will result in weight saving, and furthermore, fuel consumption reduction and load carrying capacity increase, of structures using such materials. Due to their superiority, i.e. excellent mechanical properties, light weight, corrosion resistance, impact resistance, and outstanding fatigue strength, composite materials are commonly used in various applications, such as automotive and aircraft industries, aerospace engineering, marine structures, civil and electrical engineering, and sporting goods [1-5]. Some parts or structures in engineering applications bear flexural loading, such as the rotor blades of helicopters and wind turbines, propellers, wings and some other parts of aeroplanes, leaf springs, axels, and reinforcement of civil engineering structures.

Carbon and glass fibres will be used in this research. Epoxy resin is considered to be the main candidate material for the matrix because it possesses better wetting for the proposed fibres so that it will result in strong fibre-matrix interface bonding and better load transfer among fibres and possesses superior properties compared to other resins [6]. Testing will be performed according to ASTM D790-00 [7] and ASTM D6272-00 [8] test standards for TPB and FPB tests, respectively. In addition to the flexural strength and flexural modulus, fibre contents, void content and fibre alignment will also be assessed through analysing the scanning electron micrographs of fracture surfaces and optical micrographs of through the thickness failure areas. These three variables will then be utilised in analysing the failure mechanism and flexural properties of the hybrid CFRP.

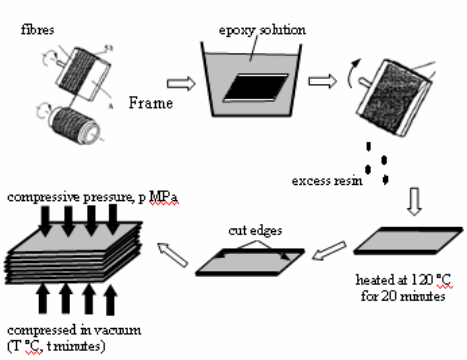


Figure 1. Schematic illustration of material fabrication

References:

1 Spencer, B.E., Composites in the sporting goods industry, in S. T. Peters (Ed.) Handbook of Composites, **Second Ed**., London, Chapman & Hall, (1998) 1044-1052.

2 Barbero, E.J., Construction, in S. T. Peters (Ed.) Handbook of Composites, **Second Ed**., London, Chapman & Hall, (1998) 982-1003.

3 Hulatt, J., L. Hollaway, and A. Thorne, The use of advanced polymer composites to form an economic structural unit, *J. Const and Building Mater* **17** (2003) 55–68

4 Denton, D.L., Land transportation application, in S. T. Peters (Ed.) Handbook of Composites, **Second Ed**., London, Chapman & Hall, (1998) 905-915.

5 Krumweide, G.C., and E.A. Derby, Aerospace equipment and instrument structure, in S. T. Peters (Ed.) Handbook of Composites, **Second Ed**., London, Chapman & Hall, (1998) 1004-1021.

6 Berthelot, J.-M., Composite Materials: Machanical Behavior and Styructural Analysis, New York, Springer, (1996) 15-20.

7 ASTM D 790-00, Annual Book of ASTM Standard, Vol 08.01, Conshohocken, ASTM International (2002) 147-55.

8 ASTM D 6272-00, *Annual Book of ASTM Standard*, Vol 08.03, Conshohocken, ASTM International (2002) 923-31.

MODEL BASED CONTROL OF NONLINEAR PROCESSES

K. Singh

Department of Chemical Engineering

Most of the processes in chemical process industries are nonlinear in nature. During the past 20 years much advancement has been made in process model based control (PMBC) of these processes. The PMBC finds its popularity because of its prediction capability in real time online control. With the advent of high computational capability of the computers, there is a growing trend of PMBC applications in the process industries. Qin and Badgwell (2003) present an overview of commercially available model predictive control (MPC) technology.

In this research, model based control has been applied on Fischer-Tropsch (FT) reactor and fluidized catalytic cracking (FCC) unit. FT reactor is used in gas-to-liquid (GTL) technology for the production of synthetic fuels from *syn-gas* ($CO+H_2$) (Vosloo, 2001) . The reactor temperature is an important controlled variable which directly affects the product selectivity; however it is difficult to control around unstable steady state in the multiplicity region. The nonlinear model predictive control (NMPC) is found to show good control performance in this type of reactor as compared to PID control and dynamic matrix control (DMC).

Fluidized catalytic cracking (FCC) is one of the main processes in petroleum refining. Its function is to crack heavier hydrocarbons into lighter and more valuable products (Khandalekar and Riggs, 1995). A nonlinear dynamic model of FCC unit is used to examine the performance of different control methodologies such as PID, model predictive control MPC and NMPC. It is shown that NMPC is able to capture a wide range of operating points of FCC unit as compared to PID control and linear MPC.

References:

1 Khandalekar, P. D. and Riggs, J. B., 1995, *Nonlinear process model based control and optimization of a model IV FCC unit*, Computers & Chemical Engineering, volume 19, Issue 11, pp 1153:1168.

2 Qin, S. J. and Badgwell, T. A. 2003, *A survey of industrial model predictive control technology*, Control Engineering Practice, volume 11, Issue 7, pp 733:764.

3 Vosloo, A. C., 2001, *Fischer-Tropsch: a futuristic view*, Fuel Processing Technology, volume 71, Issue 1-3, pp 149:155.

OPTIMAL SCHEDULING OF LTC AND SHUNT CAPACITORS IN DISTORTED DISTRIBUTION NETWORKS

A. Ulinuha

Department of Electrical and Computer Engineering

The constantly changing of electricity demand leads the operation planning of distribution system to be quite complicated. This may result in voltage violation and power losses escalation. Adaptable enhancement is therefore required for voltage profile improvement as well as losses reduction. This essentially consists of optimal scheduling of Load Tap Changer (LTC) and shunt capacitors for the next 24-hour period. The extensive and ever increasing applications of nonlinear loads have introduced harmonic distortion problems in distribution system and including them in the optimal planning is therefore necessary. Disregarding harmonics may lead the planning to generate unacceptable results due to increased distortion levels, further voltage violation, and additional power losses. However, taking harmonics into account will significantly burden the computation charge.

Optimal scheduling of LTC and shunt capacitors is a multi-phase decision-making problem with discrete variables and nonlinear objective function. The interdependence between the switched devices results in complicated scheduling. On the other hand, the large problem dimension leads the computation to encounter "dimensional exploration disaster". The fulfilment of maximum allowable switching constraints will further weigh the computation down as this can only be confirmed after evaluating all of possible scheduling over the optimization period. Unfortunately, simplifying the problem will severely reduce the optimization benefits. In addition, involving harmonics will lead the computations to be very intense, as the calculations need to be extended for harmonic frequencies.

The aforementioned complexities highlight the necessity of employing the most suitable optimization methods for the problem in hand. Genetic Algorithm (GA) is selected to solve the optimization problem, while a relatively fast and accurate Decoupled Harmonic Power Flow is developed and used as the backbone of calculations. GA is justified due mainly to its capability of simultaneously scheduling the switched devices overcoming the interdependence problem. In addition, the encoding ability of GA enables checking the fulfilment of switching constraints prior to performing calculation for any possible solution. This will greatly reduce the computation burden due to unnecessary calculations for the ineligible solutions. For further improvement, Fuzzy is incorporated into the existing GA, using the mode of "Fuzzy convex decision making" to form a multi-objective optimization problem. The ability of Fuzzy providing soft restrictions for objective achievement and constraints satisfaction enables the collaborated methods to simultaneously maintaining the promising solutions while still improving it.

Successful applications of the proposed methods for 30-bus and IEEE 123-bus distribution systems exhibit the effectiveness of the proposed methods generating the schedule that simultaneously minimizing losses, improving voltage profile and suppressing harmonic distortion. Comparisons with the results of optimization with the ignored harmonics indicate the significance of taking harmonics into optimal scheduling problem. Improvements of solution due to integrating Fuzzy into the existing GA are also indicated by comparing the result generated by the GA alone with that given by the hybrid methods. These include the better voltage profile improvements, higher energy saving and lower harmonic distortions. While involving harmonics significantly elongate the computation time, combining Fuzzy into the existing GA slightly increase the computation time.

THE BEHAVIOUR OF SUCTION EMBEDDED PLATE ANCHORS IN CLAY

Z. Song

Department of Civil Engineering

In recent years oil and gas mining has moved into increasingly deeper water in search of undeveloped fields. As water depths exceed 500 m conventional offshore foundation systems become inefficient and ineffective in stabilising platforms and floating production storage units. The trend of supporting structure design in deep water has been to install catenary and taut leg mooring systems. Consequently, many types of anchoring systems are being developed and used in order to withstand large mooring forces. The SEPLA (Suction Embedded Plate Anchor) is ideal for use in this situation.

The behaviour of SEPLAs is discussed in three aspects: Separation depth, rotation behaviour and effect of suction installation.

Continuous vertical pullouts of anchors were simulated in numerical analysis conducted using Remeshing and Interpolation Technique with Small Strain model (RITSS). Plate anchors with fully attached base and vented base were considered. It was found that the anchor embedment depth where suction force at the anchor base was lost was a function of normalised soil strength ratio $s_u/\gamma'B$ or $s_u/\gamma'D$. For anchors embedded deeper and more shallowly than the separation depth, bearing capacity factors were calculated using different formulas suggested.

The rotation behaviour of anchors was studied to confirm the loss of embedment during vertical pullout when SEPLAs were installed vertically. In numerical analysis, large deformation finite element analysis was used. Physical model testing of plate anchors were conducted in transparent clay at the Centre for Offshore Foundation Systems (COFS), at the University of Western Australia using transparent soil. Results show the loss of embedment can be expressed as a function of eccentricities ratio and thickness ratio of the anchors.

Finite element analysis and centrifuge test of plate anchors in disturbed soil were also conducted. In finite element analysis, the disturbed zone was simulated up to the fully disturbed zone in a caisson. Centrifuge tests of suction embedded plate anchors in normally consolidated clay were conducted in transparent soil and Kaolin clay. Results show a loss of bearing capacity up to 20 % of that for an anchor in disturbed soil. The loss of bearing capacity of anchor depends on both the size of the disturbed zone and the reduced soil strength in the disturbed zone. The numerical results agree well with the centrifuge test data.

HEAT TRANSFER AND FLUID FLOW CHARACTERISTICS IN A MICROCHANNEL HEAT SINK

A. Foong

Department of Mechanical Engineering

Efficient removal of internally generated heat in microelectronic components is a critical design consideration for improving the operational reliability of electronic products. Over the past decade, internal heat dissipation requirements have exponentially increased due to high-powered and high-density microelectronic circuitry in modern devices. Facing this challenge, traditional cooling techniques, such as fan-cooled heat sinks, have become grossly inadequate and impose limits on product design. Worldwide efforts are being made in heat transfer research to develop innovative cooling techniques that have the potential to deliver high-heat flux rates for microelectronic applications. The concept of microchannel is identified as a highly viable practical alternative for meeting the future cooling needs of advanced electronic applications.

Very narrow fluid passages with physical dimensions in the order of several hundred microns to 0.1μm qualify as microchannels. For reasons yet to be established, they exhibit vastly different flow characteristics compared to macro-scale passages and deliver extremely high heat transfer rates that are not normally feasible with conventional cooling methods. Incorporating an array of embedded microchannels, highly effective heat sinks are designed for dissipating internal heat generated by electronic circuitry.

Intensive research is being conducted in microchannels to understand the governing principles and to improve thermal performance of microchannel heat sinks. According to Palm [1], it is estimated that the use of microchannel heat sinks will increase by 10-fold within the next five years owing to its recognised cooling potential. In this proposed research, a carefully formulated study will be conducted to examine the mechanics of microchannel flow for a range of parametric conditions extending current knowledge. This investigation will entail extensive computational fluid dynamics (CFD) modelling of microchannels that incorporates conventional and novel channel geometries, and a thorough examination of parametric influence for optimised thermal performance. A test rig will be developed and experiments will be carried out to validate numerical predictions and to better understand complex nature of microchannel flows. Heat transfer and pressure drop correlations will be obtained through experimental and numerical validations, and design tools are developed for microchannel heat sinks.

References:

1 Palm, B., *Heat Transfer in Microchannels*, Microscale Thermophysical Engineering, vol. 5, pp. 133-175, 2001.

CFD ANALYSIS OF MULTIPHASE FLOW AND REACTION IN FCC RISER REACTORS

Novia

Department of Chemical Engineering

A commercial CFD code FLUENT 6.2 was used to simulate three-dimensional, multiphase flow and cracking reactions occurring in FCC riser reactors under various operating conditions. The conservation equations of mass, momentum and energy together with the equation of turbulence, and chemical species for each phase were solved using finite volume method. The model demonstrated the capability of CFD to describe and predict the flow field in the riser. The model also predicts the temperature, the enthalpy of each phase and yield of gasoline along the riser height. The predicted results indicated that most of the complex mixing phenomena occur in the first 3 to 5 meters of the riser reactor length.

The complex flow pattern of the riser reactor has an impact on gasoline distribution, especially at the feed injection zone. A low gasoline mass fraction occurs in the area of the feed inlet nozzles. Furthermore, higher concentration of gasoline can be found in the upper region of the riser. As expected, the temperature decreased significantly from the bottom to the top of the riser. The maximum temperature drop of the solid phase occurs close to the riser entrance due to higher heat of cracking reactions at the bottom. The trend of the temperature distribution along the riser height is in agreement with reported results by Pareek et al. [1].

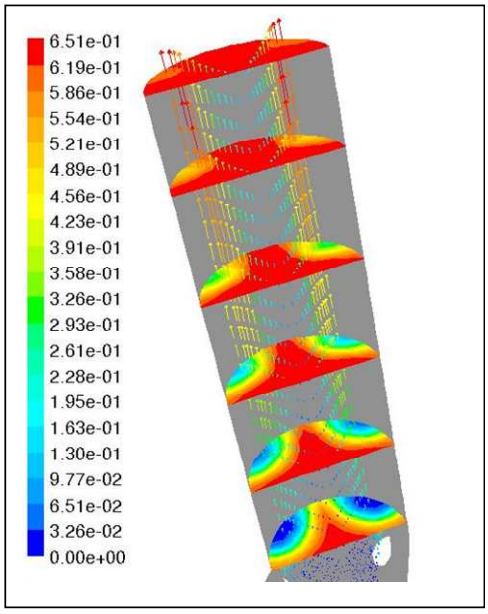


Figure 1: Contours of gasoline mass fraction and solid velocity vectors.

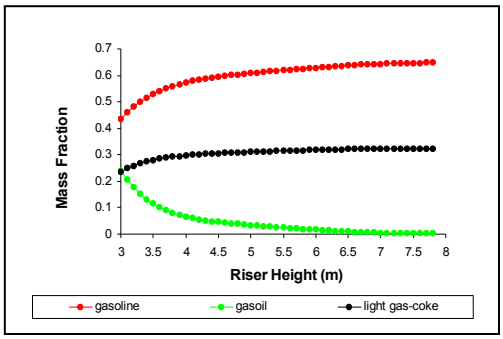


Figure 2: Yield distribution of product and reactant

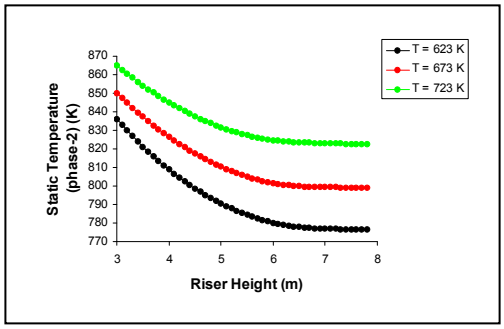


Figure 3: Temperature profiles.

References:

1 V. K. Pareek, A. A. Adesina, A. Srivastava, and R. Sharma, "Modeling of a non-isothermal FCC riser," Chem. Eng. J., vol. 92, pp. 101-109, 2003.

EFFECT OF INITIAL SOLUTION pH AND LAMPS CONFIGURATION ON THE PHOTOLYSIS OF WINERY WASTEWATER

T. E. Agustina

Department of Chemical Engineering

Winery wastewater typically has a pH of 3-4, with a COD of 800-12800 mg/l. The BOD levels may be as high as 5000 mg/l. Wastewater with high levels of BOD combined with chlorine from a chlorinated water source can produce a known cancer-causing disinfection by product, trihalomethanes, which will contaminate the groundwater. Thus it is essential to treat the wastewater appropriately before discharging it into the environment. Alternatively, advanced oxidation processes (AOPs) based on various techniques offer a great potential for wastewater treatment. Photolysis process as one of the ultraviolet (UV)-driven AOPs was applied in this study.

In this study, an annular photocatalytic reactor system was designed to investigate remediation of winery wastewater. The outer chamber of the reactor was made of stainless steel with commercial UV lamp suspended in an inner glass assembly.

The photolysis of winery wastewater was studied by using UV radiation at different initial solution pH values. The average reaction rate of winery wastewater, in terms of total organic carbon was found to be highly dependent on the initial solution pH. It was found that the average reaction rate increased with higher number of lamps and the optimum distance between two lamps was 8 cm apart.

ENVIRONMENTAL AND ECONOMIC IMPACTS OF FLY ASH AND ITS UTILIZATION AS SOIL EROSION CONTROL AND SOIL CONDITIONER

A. B. Nasir

Department of Civil Engineering

Fossil fuels are used in modern power plants throughout the world to produce electrical energy. The inorganic residue, that remains after pulverized coal is burned, is known as 'Coal combustion byproducts'. Coal combustion byproducts (CCBs) rapidly accumulate and cause enormous problems of disposal because landfill space is becoming increasingly expensive and limited (Gangloff, et al, 2000). CCBs are becoming a matter of utmost significance in Australia that needs an urgent attention. The Australian coal-fired power stations produce over 8 million tonnes of fly ash every year. Approximately 10% of this is incorporated into cement and concrete; the rest ends up in unsightly ash dams. (Majko, 2005).

Fly ash consists of all the elements present in soil except organic carbon and nitrogen (Kumar, et. al. 2000) so it can be applied to the soil as an amendment to the coastal areas of Australia where most of the soils are sandy. When the fly ash is added to the soil, its silt to clay size particles gives the binding strength to the soil to tolerate the destructive shearing forces of water runoff and ultimately minimize the erosion. It also improves the water holding capacity, cation exchange capacity and adds to the soil nutrients, as it has trace elements. So the appropriate mixture of fly ash can not only control water erosion but also condition the soil and makes it suitable to be utilised for gardening / horticulture and agriculture applications.

The objective of the research done was to study erosion control properties of fly ash when incorporated into the soil in various mixes. Fly ash consists of all the elements present in soil except organic carbon and nitrogen so it can be applied to the soil as an amendment to the coastal areas of Australia where most of the soils are sandy. When the fly ash is added to the soil, its silt to clay size particles gives the binding strength to the soil to tolerate the destructive shearing forces of water runoff and ultimately minimize the erosion. The erosion studies will be done through a field scale model of catchment to simulate the actual field conditions in the laboratory with different mixes of fly ash and different ARI. For studying potential environmental impacts, which includes effects on soil and water pollution, leaching behaviour of the fly ash / soil mixes will also be studied at various levels. This study will also evaluate the properties of fly ash as a soil conditioner for gardening and agriculture.

References:

1 Majko, R. M. 2005. *The Fly Ash Resource Center*. http://www.rmajko.com/flyash.html (Retrieved: 09 November 2006)

2 Kumar, V., K. A. Zacharia, G. Goswami. 2000. *Fly Ash Use in Agriculture: A Perspective.* Proceedings of 2nd International conference on flyash disposal & utilisation. FAM & CBIP, New Delhi, 2-4 February 2000. vol. 1 pp1-13. http://www.tifac.org.in/news/flyagr.htm (Retrieved: 04 October 2004).

3 Gangloff W. J., M. Ghodrati, J. T. Sims and B. L. Vasilas. 2000. *Impact Of Fly Ash Amendment And Incorporation Method On Hydraulic Properties Of A Sandy Soil.* Water, Air, and Soil Pollution. Vol 119. No 1-4. pp231–245

INVESTIGATIONS INTO THE MEMBRANE PERFORMANCE AND BUILD-UP OF SOLUTE IN A SMALL-SCALE OF REVERSE OSMOSIS SYSTEM

S. Nasir

Department of Chemical Engineering

This investigation discusses the effects of sodium chloride and calcium carbonate on spiral-wound membrane performance during reverses osmosis (RO) operation. Experiments were carried out in a small scale of RO (2 m3/d of capacity). The parameters chosen for this study include operating pressure and concentrations of sodium chloride and calcium carbonate.

Several feed water samples used for the experiments including, sodium chloride, calcium carbonate and combined between sodium chloride and calcium carbonate solutions at different concentration in raw water; groundwater and secondary effluent. For convenience, the solutions containing salts are hereafter referred to as simulated feed water samples. The variables considered for the tests are operating pressure (1,250 to 4,750 kPa), sodium chloride concentration (from 100 to 5,000 mg/L), the mixtures of sodium hydrogen carbonate (from 0.0005 to 0.002 M) and calcium chloride concentration (between 0.00025 M and 0.001 M). The simulated feed water samples were prepared by diluting sodium chloride, sodium hydrogen carbonate and calcium chloride mixtures, and sodium chloride and calcium carbonate mixtures into demineralized water in a polyethylene tank with a capacity of 1 m3. All experiments are performed at ambient conditions (typically 20 ± 0.5 oC). At the end of specified time (typically every 15 minutes), both permeate and reject samples are collected.

All the samples are subjected to various analytical techniques. Atomic Absorption Spectroscopy (Varian AAS type 110) technique is used to determine the sodium and calcium concentrations of both permeate and rejection streams. Samples are taken periodically 15 minutes and analysed by AAS using Natrium and Calcium lamp at wavelength of 489 and 422.7 nm respectively with the standard method (APHA-AWWA-WEF 1992). Total dissolved solids (TDS) and pH were determined by a Hanna pH-EC-TDS meter. The electrical conductivity is measured using a Yokogawa SC 82 conductivity meter.

Results indicated that there is no significant effect on membrane performance for sodium chloride with concentration below 1,200 mg/L and applied pressure lower than 2,250 kPa. However, experimental runs at high operating pressures appears to affect both build up of sodium and calcium on the membrane surface and the overall membrane performance. For typical small scale of RO used in this experiment, build up of solute significantly decreased with applied pressure due to turbulence in bulk solution. The osmotic pressure of solution also strongly affected the permeate flow rate in particular for relatively higher sodium concentration. Hence, due to higher osmotic pressure there is no permeate flux when sodium chloride concentration greater than 5,000 mg/L and applied pressure lower than 1750 kPa.

An attempt has been to made to perform an economic assessment for the desalination of tested samples. Estimates of energy consumption for desalting of sodium chloride, combined sodium and calcium carbonate solutions were found to be in the range of 1.11-3.42 and 1.5 –6.3 kwh/m3 respectively. For groundwater and secondary effluent, they are estimated to 1.2 - 3.0 and 1.29 - 3.54 kWh/m3 respectively. Unit cost for desalting of sodium chloride solution, sodium chloride and calcium carbonate, ground water and secondary effluent are $ 1.95-2.38, 2.96-3.57, 1.89-2.81 and 1.99 –3.03 respectively.

In RO plants, unit cost of water production from feed water is primarily governed by the energy required for pumping raw water. Energy cost for RO plants can also be reduced by increasing the total capacity. Normally, a typical small scale RO unit (as the current one used for experimental investigations) has at least two pumps namely feed transfer pump and high pressure pump. Based on the experimental results, it appears that the characteristics of feed water samples affect the membrane performance and it should also be considered in an attempt to reduce the unit cost.

BEHAVIOUR OF REINFORCED FLY ASH-BASED GEOPOLYMER CONCRETE BEAMS

E. H. Chang

Department of Civil Engineering

Geopolymer Concrete, concrete without cement, is an environmental friendly material that uses fly ash-based geopolymer paste as the binder. As a relatively 'new' material, geopolymer concrete offers benefits as a construction material for sustainable development as it utilises industrial by products such as fly ash and has very low rate of CO_2 emission, a greenhouse gas.

Curtin University of Technology Geopolymer Concrete Research Group has conducted studies on this new material since 2001. The past research investigated the short and long term properties, mix design process, the creep and shrinkage behaviour, the sulfate resistance, and the flexural behaviour of reinforced beams and columns. The results from these studies have shown that fly ash-based geopolymer concrete possesses high strength, undergoes very little drying shrinkage and low creep, and shows excellent resistance to sulfate attack. Also, the flexural strength of reinforced geopolymer concrete beams and columns can be predicted using the design provisions contained in the current codes and standards.

The present study forms the fourth part of the ongoing research on fly ash-based geopolymer concrete at Curtin University of Technology and is aimed to explore the shear and bond behaviour of fly ash-based geopolymer concrete beams in which value will be added to the understanding of the behaviour of geopolymer concrete structural members. This study is carried out in two stages:

1. Stage One: Shear behaviour of fly ash-based geopolymer concrete beams
2. Stage Two: Behaviour of Lap-Spliced Reinforcing Bars Embedded in Fly Ash-Based Geopolymer Concrete

The results outcome on the study of shear behaviour of reinforced fly ash-based geopolymer concrete beams with web reinforcement is presented. The experimental program consisted of testing of nine geopolymer concrete beams with the longitudinal tensile reinforcement ratio and the shear reinforcement ratio as test variables. The test results gathered included shear cracking loads, failure loads, cracking patterns, load-deflection curve of the geopolymer concrete beams. The analytical works dealt with the calculation of ultimate shear strength and shear cracking strength using existing methods currently available for Ordinary Portland Cement (OPC) concrete. Correlation of experimental and analytical results is briefly presented.

DIRECT CONVERSION OF METHANE TO METHANOL

M. H. Parapari

Centre for Fuels and Energy

The high, and still rising, world crude oil prices in recent years have drawn attention to the potential to develop previously uneconomical natural gas reserves, such as associated or stranded gas. Among the gas utilisation options, GTL is an emerging technology that will encompass the ability to convert natural gas, mostly from fields that are remote from major markets, into high-value liquid products, such as higher hydrocarbons and oxygenates. Because of its properties and key role as a chemical feedstock and fuels in the future, methanol has become one of the most interesting options in GTL technologies. Currently, an indirect process via syn-gas route, an energy intensive process, is used in the commercial production of methanol. On the other hand the direct methane to methanol has advantage of cost effectiveness and potential of low level of by-products.

Comparison of direct and indirect methods shows the clear, in principle, advantages of the direct method. However, the direct method has not yet been commercialized and there is a need to improve the understanding of the reactions and processes involved. Therefore, this study is aimed at establishing an effective and favourable method to direct production of methanol from natural gas via partial oxidation of methane.

For this process to be practically feasible, strategies like reaction mechanism study, modelling, process design and catalyst/reactor innovations need to be devised. Clearly, the strategies to improve methanol yields should be to identify the optimum reaction conditions to maximise the methanol yield and methods to terminate the reactions at the maximum methanol yield. In this research thermodynamic and kinetic modelling by CHEMKIN software has been done to refine the best reaction conditions. They are low temperatures, moderate to high pressures, low residence time to minimise further oxidation of methanol, using appropriate sensitisers like NOx, reducing the negative effect of the reactor wall by using glass lined reactors, using separate feed component streams during preheating to minimise undesired reactions, quenching the reactor effluent in order to minimise further oxidation of methanol, and innovative techniques for the selective activation of methane (O_2-splited reactors). To realise the mentioned strategies two pilot plants are designed and constructed, low pressure reactor with different injection point of O_2/NOx and high pressure quartz lined reactor up to 5 MPa and 600 ºC.

Thermodynamic modelling using 17 species showed that direct partial oxidation of methane to methanol is not a thermodynamically controlled process but should be a kinetically controlled system. Therefore in practice it needs to be far from reaching thermodynamic equilibrium. Also Kinetic modelling based on 60 radicals with more than 500 elementary reactions reflected that low T and CH_4/O_2 ratios but high P enhance methanol yield. However significant amount of O_2 needed to keep high methane conversion. Therefore oxygen is injected in different points to keep low O_2 concentration with enough oxidant and the selectivity increased up to 7% in comparing with an ordinary reactor. The effects of several experimental conditions, i.e., T (350-550 ºC), P (0.1-5 MPa), CH_4/O_2 (5-30) and NO concentration (0-5000ppm) on the feed conversion and product selectivities were examined residence time of 20-120s. Running of high pressure reactor shows that raising pressure, increases methanol selectivity by 10-20% and decreases reaction temperature by 100 ºC. Therefore energy efficiency will be enhanced by this improvement.

THE STUDY OF THE INDIVIDUAL TORSIONAL MESH STIFFNESS IN GEAR TRANSMISSION SYSTEMS

C. Chuanwen

Department of Mechanical Engineering

This research project was aimed at investigating the relationship between the static individual torsional mesh stiffness and the static transmission error of gears in mesh. This also included the investigation of the individual torsional mesh stiffness, that has been used in recent years for predicting transmission error. This research work will contribute to a better understating of the fundamental mechanisms of the generation of vibration and noise in gear transmission systems.

The research work for this project has two main parts. The first part was measuring the static transmission error of the gears through a series of experiments. The second part was to use ANSYS to calculate the theoretical static transmission error of a well developed finite element analysis (FEA) model of individual torsional mesh stiffness in the same conditions as the experiments. The validity of the theory of individual torsional mesh stiffness was investigated through a comparison between the experimental results and the FEA modelling results. The work included experiments, finite element analysis modelling, and statistical data analysis.

The final results of this research project show that individual torsional mesh stiffness theory can effectively predict transmission error in gear transmission systems. However, some improvements need to be made to both the theory and the experiments.

GOLD LEACHING IN THIOSULFATE SOLUTIONS AND ITS ENVIRONMENTAL EFFECTS COMPARED WITH CYANIDE

E. A. Oraby

Department of Civil Engineering

For the last century, cyanide leaching has been the dominant process used for the recovery of gold and silver. However, there are increasing environmental concerns over the use of cyanide, resulting in the study of alternative lixiviants used in gold leaching. There are many alternatives to cyanide such as thiosulphate, iodine, thiourea, thiocynate, and aqua regia, etc. But the most promising alternative to cyanidation is thiosulphate leaching.

Thiosulphate leaching system mainly consists of thiosulphate, ammonia, and copper so that the chemistry of thiosulphate system is complicated due to the simultaneous presence of these active reagents. Form pervious studies, it was found that copper II enhances the dissolution of gold and silver but also it has a side effect on increasing the consumption of thiosulphate. Oxygen can oxidise Cu(I) to Cu(II) but it also enhances in the decomposition of thiosulphate, hence the thiosulfate system is complex and there is a wide range of conditions affecting the leaching of gold. In particular the leaching of silver and gold/silver alloys has received little attention in the previous studies. However, many silver and gold ores do not contain the pure metal but a mixture. Gold is almost always associated with silver, so what is actually being leached is a gold silver alloy. The aims of this research are to determine the ammoniacal thiosulphate leaching characteristics and mechanism for pure gold and pure silver and then extent the research to gold silver alloys (4, 8, 20, and 50 wt % silver) to investigated the effect of silver percent on the gold leaching by studying the kinetics and the electrochemical aspects of the leaching reactions in the thiosulfate leaching system. Also in this study, the environmental impacts of cyanide on gold leaching will be compared with the environmental impacts of the thiosulfate system. Finally compare the thiosulphate leaching characteristics of the various gold/silver ores with the cyanide leaching characteristics.