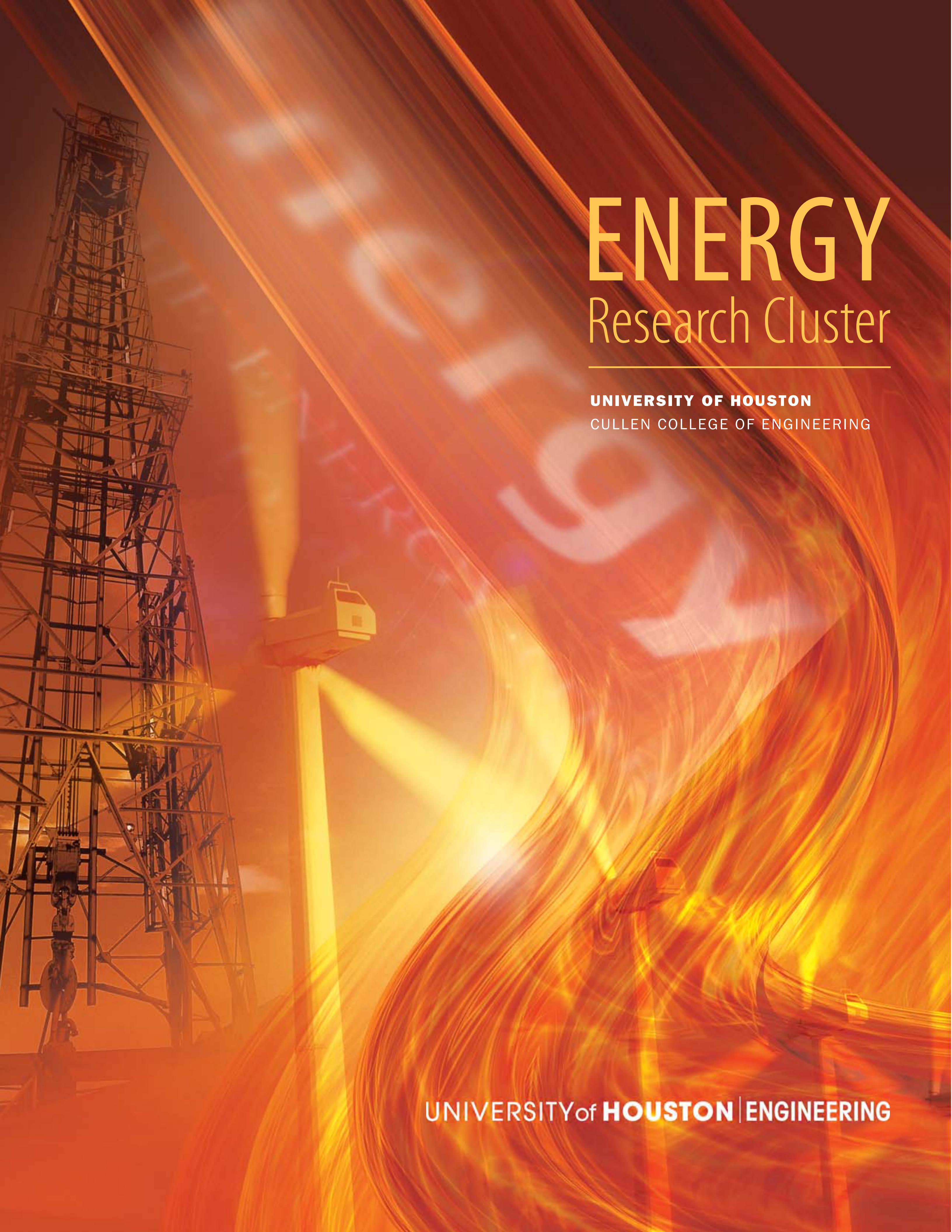


ENERGY
Research Cluster

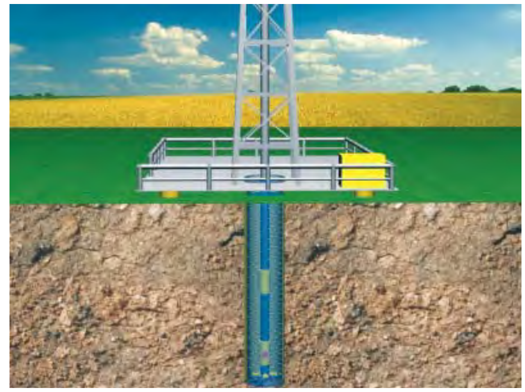
UNIVERSITY OF HOUSTON
CULLEN COLLEGE OF ENGINEERING

UNIVERSITY of HOUSTON | ENGINEERING

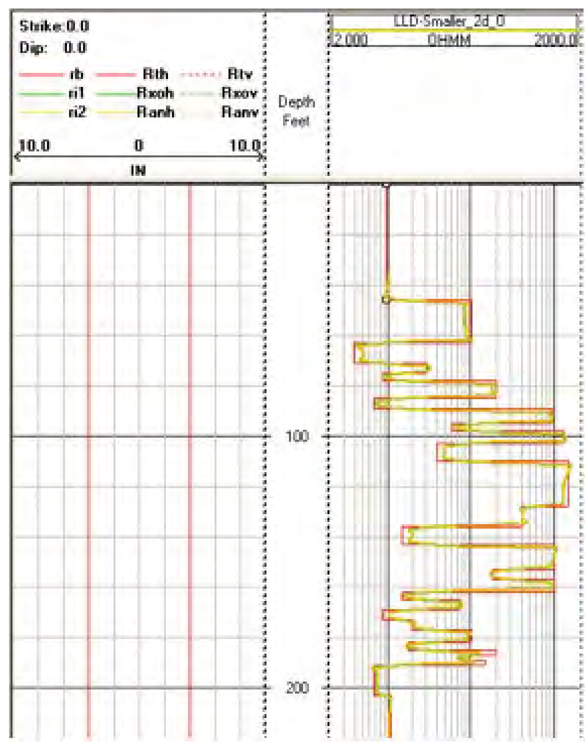
Well Logging

at University of Houston Cullen College of Engineering

The Well Logging Laboratory was established in 1979 with a research focus of well logging tools including theory, methodology, modeling, software algorithm, measurement, and hardware development. The mission of the lab is to provide an independent and non-biased research platform to oil and gas industries. Its goal is to apply academic research to oil and gas industries to solve resistivity well logging and related practical problems. The lab also manages API nuclear calibration facility, which is the only public open standard in the world. Current research projects are:



- 3D FEM simulation of LWD and tri-axial induction tools
- 2D, and 3D FDTD simulation for induction and LWD tools
- 1D inversion of tri-axial induction logs in anisotropic formations
- Well Log Inversion Interface
- Wireless telemetry systems
- 3D integral equation methods
- 3D mixing law – multi component and anisotropic formation
- Invasion profile inversion – diffusion equation 2D and 3D
- Seabed logging
- EM Tomography
- Fracture evaluation using triaxial induction logging data



It also serves as an education center for the industry. For the past 27 years, the Well Logging Laboratory has supplied industry with high quality graduate students—45 Ph.D., 57 MS, and 14 post doctoral fellows. In return, the laboratory has been supported by industry partners including BP, BakerHughes, Chevron, ConocoPhillips, CNLC, ExxonMobil, Halliburton, Pathfinder, Saudi Aramco, Statoil, Schlumberger, and Weatherford.

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Short Biography

Professor C. Richard Liu received a Ph.D. in Electrical Engineering from Jiaotong University, China in 1988. He also received a M.S. and B.Sc. from the university in Electrical Engineering in 1984 and 1982, respectively. He joined the department after the completion of his Ph.D. degree and was awarded tenure in 1997. He has been the principal investigator or co-investigator for 18 funded research projects, totalling over $4.5 million over the last two decades and currently directs the college's annual Well Logging Industrial Consortium, which attracts over 12 major oil and gas companies to the campus. His research interests include subsurface sensing, well logging, RF and microwave circuits, wireless telecommunications, ground-penetrating radar and EM tomography.

Selected Publications

- Lili Zhong, Jing Li, Ashutosh Bhardwaj, L. C. Shen, and Richard Liu, "Computation of Tri-axial Induction Logging Tools in Layered Anisotropic Dipping Formations", IEEE Transactions on Geoscience and Remote Sensing, August, 2007.
- Dagang Wu, Ji Chen, and Ce Liu, "Numerical evaluation of effective dielectric properties three-dimensional composite materials with arbitrary inclusion using a finite-difference time-domain method", Journal of Applied Physics, 102, 024107, July, 2007.
- Yumei Tang, Tsili Wang, and Richard Liu, "Multicomponent induction response in a biaxially anisotropic formation", SEG Annual Conference, San Antonio, Texas, USA, September 2007.

Stimulation of Carbonate Reservoirs

at University of Houston Cullen College of Engineering

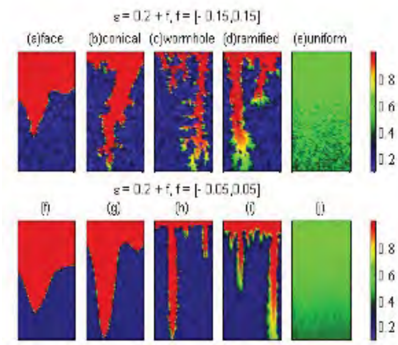
We have recently developed a two-scale continuum model to describe transport and reaction mechanisms in reactive dissolution of a porous medium, and used it to study wormhole formation during acid stimulation of carbonate rocks.

The model accounts for pore level physics by coupling local pore-scale phenomena to macroscopic variables such as the Darcy velocity, pressure and reactant cup-mixing concentration through structure-property relationships (that link the permeability, porosity and interfacial area to the evolving pore structure) and the dependence of mass transfer and dispersion coefficients to the local flow field and pore scale variables.

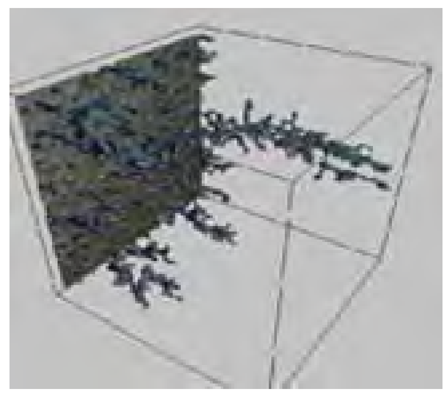
The gradients in concentration at the pore level caused by flow, species diffusion and chemical reaction are described using two concentration variables and a local mass transfer coefficient.

Numerical simulations of the model in two dimensions show that it captures the different types of dissolution patterns observed in the experiments. Scaling analysis was used to develop a formula for estimating the optimum injection conditions in terms of the overall dissolution rate constant and transverse dispersion coefficients.

Our current work deals with determining the influence of heterogeneities, mass transfer and reaction kinetics on the wormhole structure and density in 3-D and radial flow.



Effect of injection rate and heterogeneity on 2-D dissolution patterns



Wormholing patterns in 3-D

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Short Biography

Vemuri Balakotaiah is the John and Rebecca Moores Professor of Chemical and Biomolecular Engineering. His research interests are broad and include the areas of chemical and catalytic reaction engineering, multiphase flow, transport in porous media, biomedical engineering and applied mathematics. Working as a consultant to the Western Company of North America (acquired by BJ Services), he developed the widely used three-cell reactors for the cementing of oil and gas wells. His more recent work is aimed at development and analysis of optimal conditions for wormhole formation in the acid stimulation of carbonate reservoirs. He has served as a consultant to many companies including Dow, Exxon-Mobil, Schlumberger, Amgen, Creare Inc., and BJ Services.

Selected Publications

» M. Panga, M. Ziauddin, G. Ramkrishna and V. Balakotaiah, " A New Model for Predicting Wormhole Structure and Formation in Acid Stimulation of Carbonates", SPE paper # 86517 (2004)

» M. Panga, M. Ziauddin and V. Balakotaiah, "Two-scale Continuum Model for Simulation of Wormhole Formation in Carbonate Acidization", AIChE Journal, 51, pp. 3231-3248 (2005).

» N. Kalia and V. Balakotaiah, "Modeling and Analysis of Wormhole Formation in Reactive Dissolution of Carbonate Rocks", Chem. Engng. Sci., 62, pp. 919-928 (2007).

Polymer Grouts for Pipe-In-Pipe Applications

at University of Houston Cullen College of Engineering

Flow assurance and related thermal insulation of pipelines is an important part of exploitation of deepwater reservoirs. Insulated pipelines and bundles offer a reliable and cost effective solution for deepwater flow assurance. Flexibility of pipe-in-pipe (PIP) configuration in selection of geometrical parameters, pipe materials and insulation materials allows optimizing thermal and structural properties of pipelines for specific water depth and operation requirement.

As oil and gas field production shifts into deeper water, seawater temperature at the wellhead decreases nearly to freezing point, generating a variety of problems, such as hydrate formation, wax and paraffin accumulation in the pipelines.

One current strategy to mitigate these problems is to provide thermal insulation to subsea pipelines and risers to minimize heat loss from the system. A cased insulated flowline, pipe-in-pipe configuration, consists of a single production flowline concentrically located inside of a protective casing pipe (Fig.1) and the annuals filled with insulation material. Numbers of materials such as polyurethane foam, synthetic foam or ceramic microsphere cement have been used as insulators.

Full-Scale Test Configuration and Setup

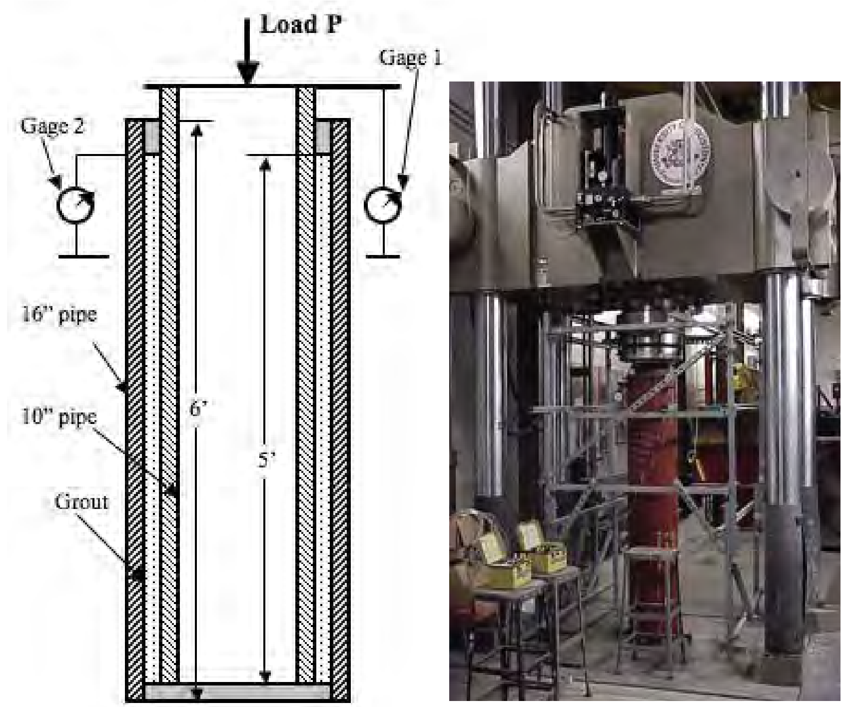

Figure 1
Gage 1 – measures total deflection of specimen
Gage 2 – measures deflection of 16" pipe

The design of PIP configuration requires optimization between the structural and thermal insulation needs of the pipeline. Some of the requirements of the material used in the annular space for PIP application are (a) relatively easy placement in the annular space (b) low thermal conductivity to avoid hydrate formation and reduction in fluid viscosity; and (c) high bonding shear strength with steel pipe to hold both pipes in position especially during installation and low density. The overall objective of this study was to investigate the effects of fillers (aggregates, sand and microspheres) on the bonding shear strength (with steel) and thermal conductivity of polymer grouts.

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Short Biography

Cumaraswamy "Vipu" Vipulanandan is the chairman and professor of civil and environmental engineering at UH. He is also the Director for the Center for Innovative Grouting Materials and Technology (CIGMAT). He received his M.S. and Ph.D. in civil engineering from Northwestern University and B.Sc. in civil engineering from University of Moratuwa, Sri Lanka. His current research interests are in the areas of pipelines, materials, geotechnical and geoenvironmental engineering. He has been principal investigator or co-principal investigator for 60 funded projects since 1984 amounting to over $5.5 million. His work has resulted in more than 150 refereed papers and over 100 presentations at national and international conferences. He was the keynote speaker at the International Workshop on Deep Foundations-2007 which was held in Japan.

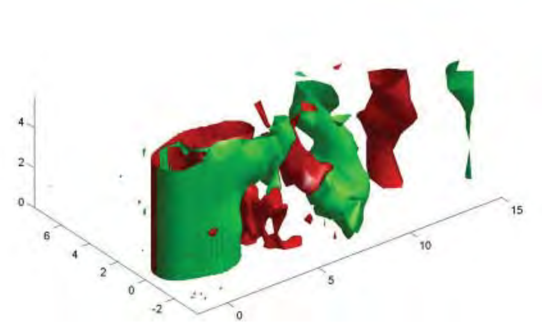
Selected Publications

» Vipulanandan, C., and Kulkarni, S. P. "Shear Bonding and Thermal Properties of Particle-Filled Polymer Grout for Pipe-in-Pipe Application," Journal of Materials in Civil Engineering , Vol. 19, No. 7, pp.583-590, 2007.
» Kulkarni, S. P. and Vipulanandan, C. "Hot Wire Method to Characterize the Thermal Conductivity of Particle-filled Polymer Grouts Used in Pipe-in-Pipe Application," Journal of Testing and Evaluation, ASTM, Vol. 34, No. 3, pp.224-232, 2006.

Flow-Related Structural Design

at University of Houston Cullen College of Engineering

The flow of ocean currents and waves past the long, slender structural members of offshore platforms has become a significant problem for the offshore industry as drilling for oil has moved into deeper and deeper water. The shedding of vortices from these long slender members causes an oscillating transverse force on the members. When the frequency of vortex shedding is near the natural frequency of the structural member, the member will begin to oscillate, possibly in both the transverse and in-line directions. This oscillation can cause fatigue damage to the structural member which, in the long term, can cause the member to fail, resulting in a very expensive down time for the platform. This phenomenon is called Vortex-Induced Vibration (VIV).



Large Eddy Simulation results for flow around a circular cylinder at Re=3900

Prof. Dalton has been active in the determination of forces, including VIV, on the structural members of offshore platforms for several decades, mostly through Computational Fluid Dynamics (CFD) methods. These studies have included wave and current forces on structural members in water not deep enough for VIV to occur or be a problem if they did occur and, more recently, VIV. Dalton's group, in the mid 90s, was able to calculate successfully the forces on a circular cylinder for Reynolds numbers to 45,000 using the Large Eddy Simulation turbulence modeling technique. At the time, this calculation was one of the few which could be done at such Reynolds numbers. Dalton's group also was the first to calculate the Honji Instability, which is the transition in flow pattern from 2-D to 3-D in the oscillating flow past a circular cylinder. This latter case represents a water wave moving past a stationary cylinder. This work is presently continuing.

Another effort by Dalton's group has been application of Strip Theory to VIV. Strip Theory involves dividing a long riser into short segments and calculating the flow field, hence the force, at the end of each segment. These forces are used as input to solve the Euler-Bernoulli beam equation, the result of which represents the riser oscillation. This approach reduces the 3-D problem to numerous 2-D problems, the results of which agree reasonably well with experimental data.

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Short Biography

Professor Charles Dalton joined the Department of Mechanical Engineering in 1965 following the completion of his Ph.D. from the University of Texas at Austin. He received his B.S. and M.S. in mechanical engineering from UH in 1960 and 1963, respectively. He has served the college in various capacities throughout his tenure, including associate dean for graduate studies from 1980 to 1998. His research interests include computational fluid dynamics directed toward unsteady flow past cylinders, including vortex-induced vibration. In 2002, he was honored as Engineer of the Year from the South Texas section of the American Society of Mechanical Engineers.

Selected Publications

» Al Jamal, H. and C. Dalton, "Calculation of Vortex-induced Vibration at Moderate Reynolds Numbers", J. Fluids & Structures, 19, 73-92, 2004.

» Al-Jamal, H. and C. Dalton, "The Contrast in Phase Angles between Forced and Self-excited Oscillations of a Circular Cylinder", J. Fluids & Structures, 20, 467-482, 2005.

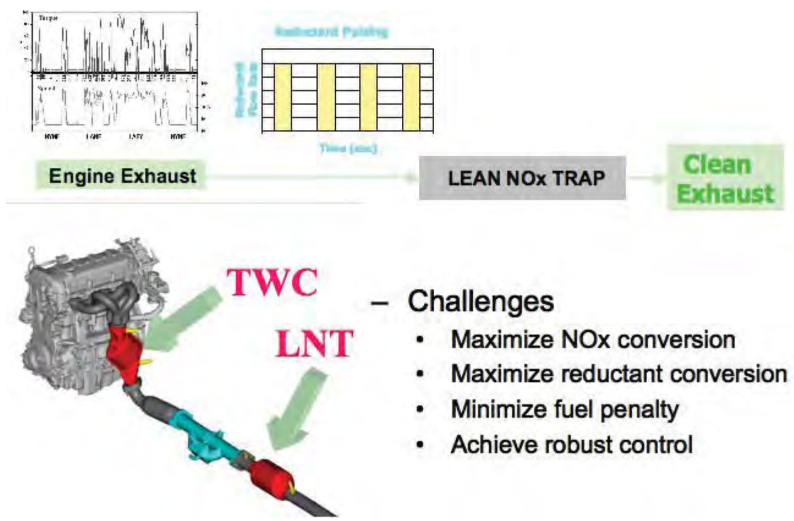
» Hu, J.C., Y. Zhou and, C. Dalton, "Effect of the corner radius on the near wake of a square prism", Experiments in Fluids, 40 (2006), 106-118.

» Rakshit, T., S. Atluri, S., C. Dalton, VIV of a Composite Riser at Moderate Reynolds Number using CFD, accepted, J. Offshore Mechanics & Arctic Engineering, 2007.

Emission Control for Lean Burn Engines

at University of Houston Cullen College of Engineering

Long-term growth in the use of more fuel-efficient and durable diesel/lean burn vehicles requires significant reductions in emissions of nitrogen oxides (NOx) and particulate soot. NOx storage and reduction (NSR) is emerging as a viable NOx emission abatement technology for these vehicles. The 'lean NOx trap' (LNT) is an adsorptive catalytic monolith reactor requiring periodic operation. In the first step, exhaust NOx is adsorbed onto the alkali earth site of a bifunctional supported precious-metal based catalyst. In the second step the nitrate is released and reduced by exhaust hydrocarbons, achieved by intermittent rich engine operation or fuel injection into the exhaust. A commercially viable NOx trap technology, will not only reduce the emissions of a key pollutant, but also reduce energy consumption and CO2 emissions.



Lean NOx Trap: Adsorptive Catalytic Reactor

The main objectives of this research are (i) to carry out fundamental studies of the transient kinetics of lean NOx trap regeneration on model Pt/Rh/Ba catalysts, (ii) to evaluate and compare the effect of different reductants on the LNT performance,(iii) to incorporate the kinetics findings and develop and analyze a first-principles based predictive LNT model for design and optimization, and (iv) to test LNT designs in a heavy-duty diesel vehicle dynamometer facility.

We utilize an array of experimental and theoretical tools, building upon the R&D we have carried out on the lean NOx trap during the past three years. We have demonstrated NOx conversion exceeding 80% with a sequence of a ca. 30-60 second lean storage period followed by a ca. 3 -10 second rich period on model supported Pt/Ba catalysts. The research spans fundamental studies of the catalytic chemistry under vacuum conditions on model catalysts, bench-scale reactor studies of monolith catalysts, and kinetic and reactor modeling to develop predictive, first-principles based computer codes for NOx trap optimization and control, and testing of prototype designs in the UH Diesel laboratory.

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Short Biography
Professor Mike Harold is chairman and Dow Professor of the Department of Chemical & Biomolecular Engineering. He earned his bachelor's degree in chemical engineering from Penn State University in 1980 and Ph.D. from the University of Houston in 1985. After receiving his Ph.D., he took research and teaching positions at the University of Massachusetts and the University of Twente in Holland until 1996. Harold then joined DuPont Company, where he served in supervisory positions over the R&D of polymers and fibers, intermediates and chemical process fundamentals. He left DuPont in 2000 to take his current position with the college. His research interests include reactive separation devices and material; multi-functional chemical reactor synthesis, analysis and design; microfabricated chemical system devices and materials; and selective oxidation chemistry, kinetics and reactors.

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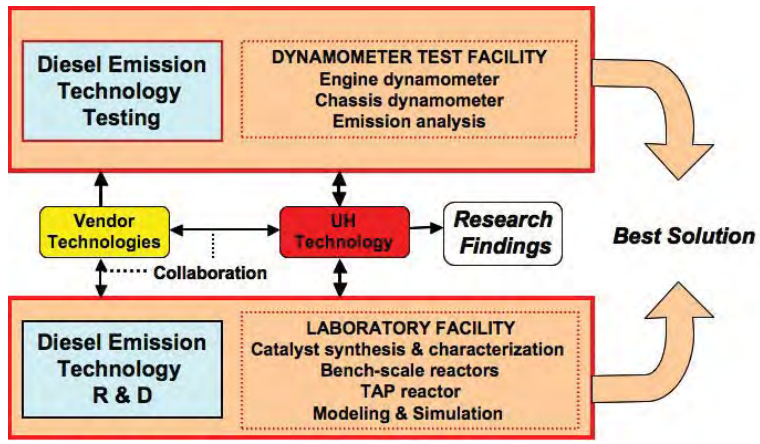
Vemuri Balakotaiah is the John and Rebecca Moores Professor of Chemical and Biomolecular Engineering. His research interests are broad and include the areas of chemical and catalytic reaction engineering, multiphase flow, transport in porous media, biomedical engineering and applied mathematics. Working as a consultant to the Western Company of North America (acquired by BJ Services), he developed the widely used three-cell reactors for the cementing of oil and gas wells. His more recent work is aimed at development and analysis of optimal conditions for wormhole formation in the acid stimulation of carbonate reservoirs. He has served as a consultant to many companies including Dow, Exxon-Mobil, Schlumberger, Amgen, Creare Inc., and BJ Services.

NOx and Particulate Soot Reduction

at University of Houston Cullen College of Engineering

The growth of diesel power in the U.S. critically depends on the effective abatement of diesel pollutants, NOx and particulate soot. The State of Texas is following a State Implementation Plan that requires a 90% reduction in the emission of NOx in the Greater Houston Area, an ozone non-attainment region. More stringent standards are expected for fine particulate matter in the next few years. There is a need to develop diesel emission control technology to take full advantage of the fuel efficient and durable nature of diesel vehicles, and to meet these standards. The development of retrofit technologies is especially critical given the replacement expense and low turnover rate of diesel equipment and vehicles.



UH Program: Spans R&D to Testing

The UH Diesel Research and Testing Facility is working with the City of Houston, the State of Texas and third-party companies to evaluate and develop retrofit technologies that reduce NOx and particulate soot from heavy-duty diesel vehicles. The state-of-the-art laboratory is equipped with a heavy-duty chassis dynamometer as well as an advanced analytical bench capable of measuring particulate matter and several gas components. Measurement of fuel consumption, a critical issue for assessing fuel penalties associated with various emission-control technologies, is also possible.

To date, the lab has evaluated ammonia-based selective catalytic reduction, exhaust gas recirculation and diesel-electric hybrid vehicles, among others. It has also conducted comparisons of of different fuel types (Texas Low Emission Diesel, biodiesels),and has more recently shown that biodiesel in combination with EGR can lead to a simultaneous 40% reduction in both NOx and particulate matter.

Discussions between UH and the Texas Commission on Environmental Quality are underway to expand the UH Diesel facility to become a state-supported laboratory to accelerate the identification, development, testing, and implementation of NOx reduction technologies in throughout the state.

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Professor Mike Harold is chairman and Dow Professor of the Department of Chemical & Biomolecular Engineering. He earned his bachelor's degree in chemical engineering from Penn State University in 1980 and Ph.D. from the University of Houston in 1985. After receiving his Ph.D., he took research and teaching positions at the University of Massachusetts and the University of Twente in Holland until 1996. Harold then joined DuPont Company, where he served in supervisory positions over the R&D of polymers and fibers, intermediates and chemical process fundamentals. He left DuPont in 2000 to take his current position with the college. His research interests include reactive separation devices and material; multi-functional chemical reactor synthesis, analysis and design; microfabricated chemical system devices and materials; and selective oxidation chemistry, kinetics and reactors.

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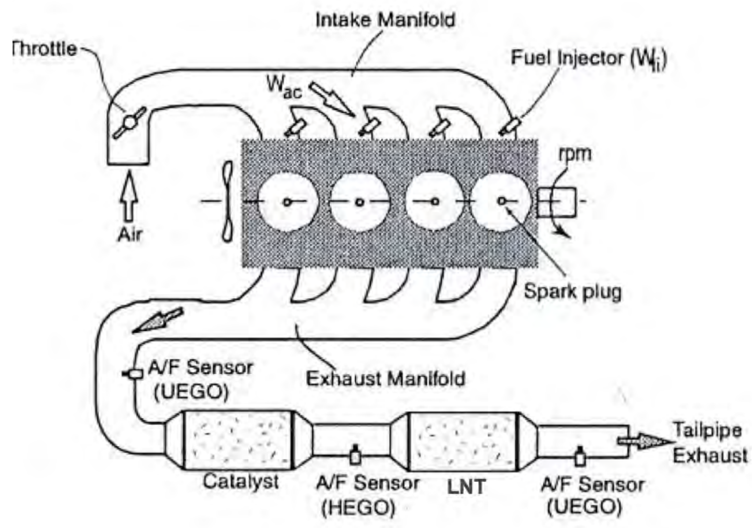
Short Biography
Adjunct Professor Charles Rooks joined the Chemical & Biomolecular Engineering Department in 2001. He holds a B.S. in chemical engineering from the University of Mississippi (1969) and an M.S. and Ph.D. from the University of Oklahoma in chemical engineering in 1971 and 1973, respectively. In addition to serving as a research and teaching professor, Rooks is the Director of the Undergraduate Research Laboratory and the Director of the University of Houston Diesel Vehicle Research and Testing Facility. His current research interests in the area of diesel emission controls include evaluating various strategies for the control of NOx, SOx and particulates in diesel exhausts. He and several colleagues are working with the City of Houston and others to evaluate the efficacy of various diesel emission reduction technologies from among the wide array of devices and technologies currently offered by various manufacturers.

Control Systems

at University of Houston Cullen College of Engineering

Modern engines have a plethora of variables and parameters that need to be regulated simultaneously according to demand, operating condition and external environmental factors. The regulation of these variables is essential for the minimization of consumed fuel and harmful emissions. The engine and the exhaust aftertreatment systems are highly interdependent based on coupled operational constraints and interconnected dynamics with conflicting performance objectives. Despite advances in engine and catalyst design, the simultaneous optimization and control of the integrated engine and aftertreatment system (allowed by recent developments in sensing and on-board computing) will be the enabling technology in achieving leaping progress in fuel economy and emission reduction. Drs. Grigoriadis and Franchek, in research sponsored by Federal agencies (National Science Foundation and the U.S. Army) and automotive and engine manufacturers (Ford Motor Company, General Motors and Cummins, Inc.), are developing and designing such multivariable engine and exhaust after-treatment control systems leading to ultra-clean and ultra-efficient vehicles.



Lean burn engine and catalyst configuration

A particular problem investigated is the optimization and control of lean burn engine operation. Lean burn operation takes place at high (lean) air-fuel ratios so the air-fuel mixture has considerably less amount of fuel compared to stoichiometric combustion resulting in improved fuel economy and higher combustion efficiency. However, in lean operation the three-way catalyst can no longer reduce NOx in the engine exhaust requiring the use of an additional trapping device (a lean NOx trap) placed after the TWC in the exhaust system. Such lean burn technology presents great challenges in terms of need for precise air-fuel ratio control, the accurate purge of the catalyst and the need for real-time monitoring of the overall system. Other sponsored research examines the design and implementation of multivariable adaptive robust controllers for diesel and gasoline engine air handling, fuel regulation and after-treatment control.

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Short Biography
Professor Karolos Grigoriadis joined the UH Department of Mechanical Engineering in 1994 after the completion of this Ph.D. in Aeronautics and Astronautics from Purdue University. He is currently the director of Cullen College of Engineering's Aerospace Interdisciplinary Studies Program and is the co-director of the Dynamic Systems Control Laboratory. His research interests are widespread and include feedback control systems analysis and design, modeling, identification and control of mechanical and aerospace systems, system optimization and optimal control, and design integration for engineering systems.

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Short Biography
Professor Matthew Franchek joined the UH Cullen College of Engineering in 2002 as the chair of the Department of Mechanical Engineering and director of the Biomedical Engineering Program. He received a Ph.D. in Mechanical Engineering from Texas A&M University in 1991 and joined the School of Mechanical Engineering at Purdue University as an assistant professor in 1992. While at Purdue, he served as the deputy director of the Electro-Hydraulic Control Research Center and received tenure in 1997. He was promoted to full-professor in 2001 before accepting his current role as the mechanical engineering department chair at UH.

Selected Publications

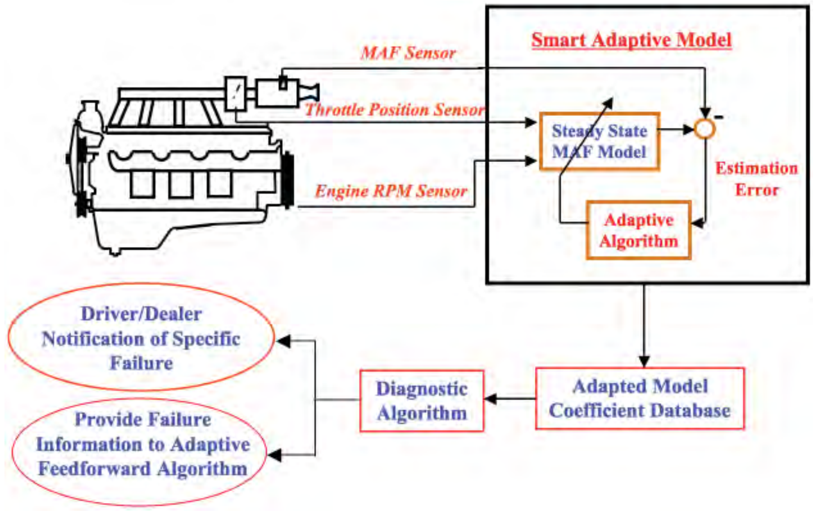
» Zhang, F., Grigoriadis, K. M., Franchek, M., and Makki, I., "Parameter varying Lean Burn Air-Fuel Ratio Control for IC Engines, ASME Journal of. Dynamical Systems and Control, Vol. 129, No. 4, pp. 404-414, 2007.

» Franchek, M. A., Mohrfeld, J., and Osburn, A. W., "Transient Fueling Controller Identification for Spark Ignition Engines," Journal of Dynamic Systems, Measurement and Control, Vol. 128, No. 3, pp. 499-509, 2006

» Anders, J. W., and Franchek, M. A., "An Instrumental Variable Approach to Nonlinear Model-Based Adaptive Control of Engine Speed," International Journal of Control, Vol. 78, No.1, pp. 29-44, 2005

Modeling and Model-Based Diagnostics

at University of Houston Cullen College of Engineering



Model-based engine prognostics and diagnostics

The development of analytical models that describe the dynamic behavior of internal combustion (IC) engines is essential for engine optimization and control leading to increased reliability, improved fuel economy and exhaust emissions minimization. Drs. Franchek and Grigoriadis have been developing mathematical methods and identification algorithms for the better description and understanding of the complex dynamic phenomena that characterize internal combustion engines. Research sponsored by the National Science Foundation and the Ford Motor Company focuses on a systems approach to modeling and optimization for ultra-clean and ultra-efficient internal combustion engines that exploits the interplay between the engine and the exhaust after-treatment systems thus harvesting the complete potential for improved and coordinated operation of the engine and the catalyst. It is expected that such systems-based interdisciplinary research can lead to up to 15 to 20% improvement on fuel economy with a guarantee of practically zero tailpipe emissions (PZTE).

The complexity of IC engines dictates the use of accurate and reliable model-based prognostics and diagnostics algorithms that monitor the onboard subsystem operations, identify performance degradation, anticipate impeding engine failures and assess the overall system's health. Current research projects sponsored by the U.S. Army and Cummins Engine Company seek to develop and implement novel diagnostics and prognostics methodologies such as Information Synthesis (IS). IS uses real sensor signals along with a virtual sensing environment to extracts system health information, compresses this information and prioritizes the vast amount of system data to realize smart IC engines that anticipate faults and performance degradation. Applications to diesel and spark ignition engine air-path and exhaust after-treatment fault diagnostics are examined. Additional sponsored research addresses the development of real-time engine torque estimation models and exhaust gas recirculation valve failure detection algorithms.

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Professor Matthew Franchek joined the UH Cullen College of Engineering in 2002 as the chair of the Department of Mechanical Engineering and director of the Biomedical Engineering Program. He received a Ph.D. in Mechanical Engineering from Texas A&M University in 1991 and joined the School of Mechanical Engineering at Purdue University as an assistant professor in 1992. While at Purdue, he served as the deputy director of the Electro-Hydraulic Control Research Center and received tenure in 1997. He was promoted to full-professor in 2001 before accepting his current role as the mechanical engineering department chair at UH.

Selected Publications

» Franco, J., Franchek, M. A., and Grigoriadis, K. M., "Real-Time Brake Torque Estimation for Internal Combustion Engines" Mechanical Systems and Signal Processing (In Press)

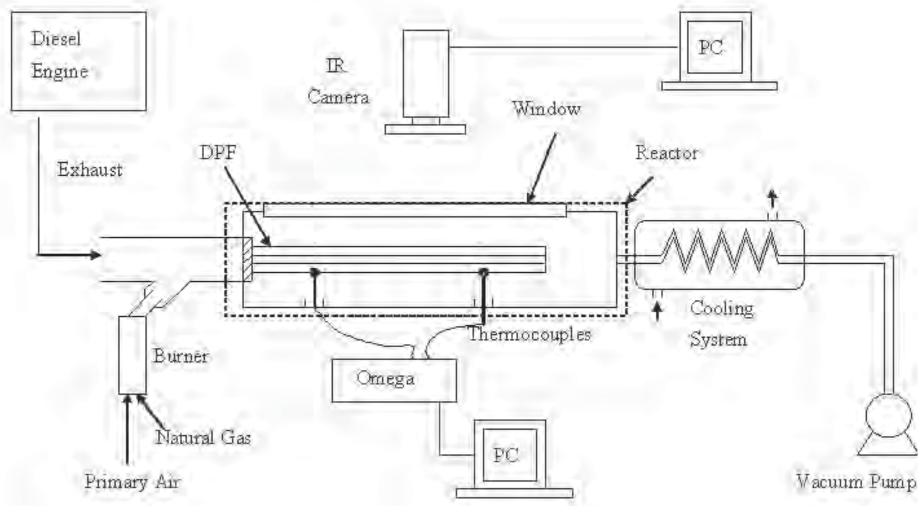
» Franchek, M. A., Buehler, P. J., and Makki, I., "Intake Air Path Diagnostics for Internal Combustion Engines," Journal of Dynamic Systems, Measurement and Control, Vol. 128, No. 1, pp. 32-40, 2007

» Mohammadpour Velni, J , and Grigoriadis, K. M., "Less Conservative Results for Delay-dependent H∞ Filtering for Time-delayed LPV Systems," International Journal of Control, Vol. 80. No.2,pp. 281-291, 2007.

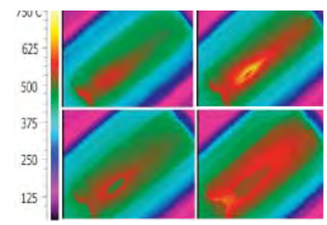
Diesel Particulate Filters

at University of Houston Cullen College of Engineering

Experimental Setup



The emission of diesel Particulate Matter (PM) is a serious health hazard, particularly in urban areas. The PM is removed from the effluent using ceramic Diesel Particulate Filters (DPF). The soot which accumulates in the filter channels has to be periodically combusted to prevent the build up of a high back pressure. Unfortunately, the temperature of the exhaust gases from the engine (~200 °C) is not sufficiently high to ignite the soot (ignition temperature of ~600°C). One scheme of igniting the accumulated soot is by post injection of diesel into the exhaust. In addition, a catalyst is deposited on the filter to decrease the soot ignition temperature. Past experience indicates that in some cases local hot zones that form on the filter surface during the PM combustion, damage the DPF due to melting and thermal stress cracking. A DPF has to undergo many regeneration cycles (about every 300 km.) during its mandated life of 120,000 km. At present it is not known what operating conditions and/or DPF modifications are needed to prevent this undesired hot spots formation.



IR Images (top on DPF)

Our research aims to provide an ability to predict the impact of the regeneration procedure and catalyst properties on the formation and dynamics of the moving temperature fronts during the soot combustion. This information is essential for a rational design of the DPF and developing a regeneration protocol that circumvents the formation of zones the temperature of which is sufficiently high to damage the DPF. The experiments are conducted in the system described schematically below and the spatio-temporal temperature is measured by an IR camera. A few IR images showing the growth and motion of a high-temperature zone are shown. The experimental data are used to help develop and test the validity of a mathematical model of the DPF regeneration.

We also conduct research on the development of novel catalysts which will be more economical than the expensive Pt, used in current commercial PDFs. We have already found several nanostructured complex oxides that decrease the ignition temperature to the level Pt does (~400 °C) and are less expensive. We developed a process for in situ deposition of these oxide catalysts on the cordierite DPF surface.

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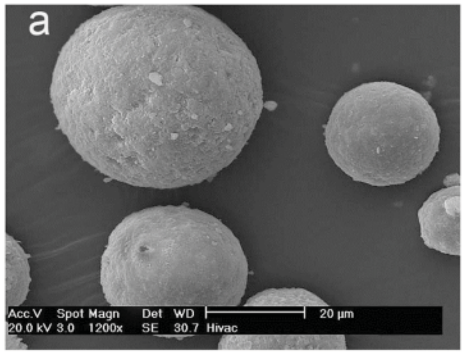
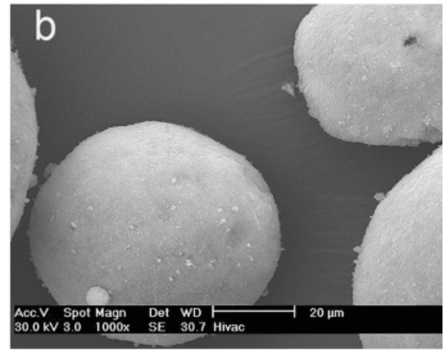
Short Biography
Prof. Dan Luss is the Cullen professor of Engineering. He earned his bachelor and M.S. degree in chemical engineering from the Technion Israel and his Ph.D. from the University of Minnesota in 1966. He joined the department of chemical engineering in 1967 and served as chair of the department for 22 years. His research is in the area of chemical reactor design and in recent years has conducted extensive research on hot zone formation in packed bed reactor and synthesis of complex oxides. He is the editor of a book series, a professional journal and serves on the editorial Boards of two journals. His research accomplishments have been recognized by several professional awards, including election to the NAE in 1984.

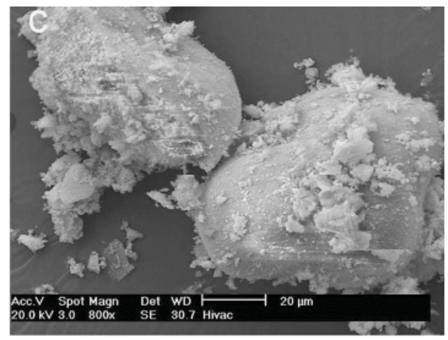
Refinery Particulate Matter Emissions

at University of Houston Cullen College of Engineering

Petroleum refining is an important industrial activity in the Houston, TX region which is home to approximately 25% of the U.S. refining capacity.







Along with a positive economic impact, this aggregation of refining and petrochemical manufacturing also affects the environment and public health negatively.

For example, epidemiological studies have revealed an increased incidence of chronic and acute respiratory health effects, eye irritation, sleep problems, headaches, etc. in communities living in the proximity of refineries.

Understanding how the various types of emissions, including gases and particles, from an integrated refining and petrochemical facility is crucial to better protecting public health.

Vital to delineating the relationship between emission and health impact is improved methods for source attribution. Our research has demonstrated that emissions of zeolite catalysts are the primary cause of lanthanum and lanthanides enrichment in atmospheric fine particles.

To achieve this, we developed novel and robust microwave-assisted acid digestion procedures prior to elemental analysis by inductively coupled plasma – mass spectrometry to measure lanthanum and lanthanides in fluidized-bed catalytic cracking catalysts as well as atmospheric fine particulate matter.

Further, in collaboration with Professor Matthew Fraser of Rice University, we have quantitated the concentrations of lanthanum and lanthanides in the troposphere at background levels and even tracked them to a local refinery following episodic emission events. On-going research is identifying the impacts of the energy-related operations and gasoline vehicles on Houston's air quality in terms of both coarse and fine particles.

This work is funded by the U.S. Environmental Protection Agency and the Texas Air research Center

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Short Biography

Shankar Chellam obtained his M.S. and Ph.D. degrees in Environmental Engineering from Rice University, and was awarded the American Water Works Association's Larson Aquatic Research Award for his doctoral research. Dr. Chellam chaired the American Water Works Association's Membrane Technology Research Committee from 1998 - 2001, and is the recipient of a 2002-2007 NSF CAREER award for membrane research. He received the UH Cullen College ofEngineering's Junior Faculty Research Award and Outstanding Teacher Award in 2003, 2004 and 2007respectively.

Selected Publications

» Kulkarni, P., S. Chellam, and M.P. Fraser, (2007). Tracking Petroleum Refinery Emission Events Using Lanthanum and Lanthanides as Elemental Markers for PM2.5. Environmental Science and Technology, 41 (19) 6748–6754.

» Kulkarni, P., S. Chellam, J.B. Flanagan, and R.K.M. Jayanty, (2007). Microwave digestion – ICP-MS for elemental analysis in ambient aerosols: Rare earth elements and validation using a filter borne fine particle standard reference material. Analytica Chimica Acta, 599 (2) 170–176.

» Kulkarni, P., S. Chellam, and D.W. Mittlefehldt (2007). Determination of Rare Earth Elements in Industrial Fluidized Bed Catalytic Cracking Catalysts using Inductively Coupled Plasma – Mass Spectroscopy. Analytica Chimica Acta, 581 (2) 247–259.

» Kulkarni, P., S. Chellam, and M.P. Fraser, (2006). Lanthanum and Lanthanides in Atmospheric Fine Particles and their Apportionment to Refinery and Petrochemical Operations in Houston, TX. Atmospheric Environment, 40 (3) 508-520.

Intelligent Oil Fields

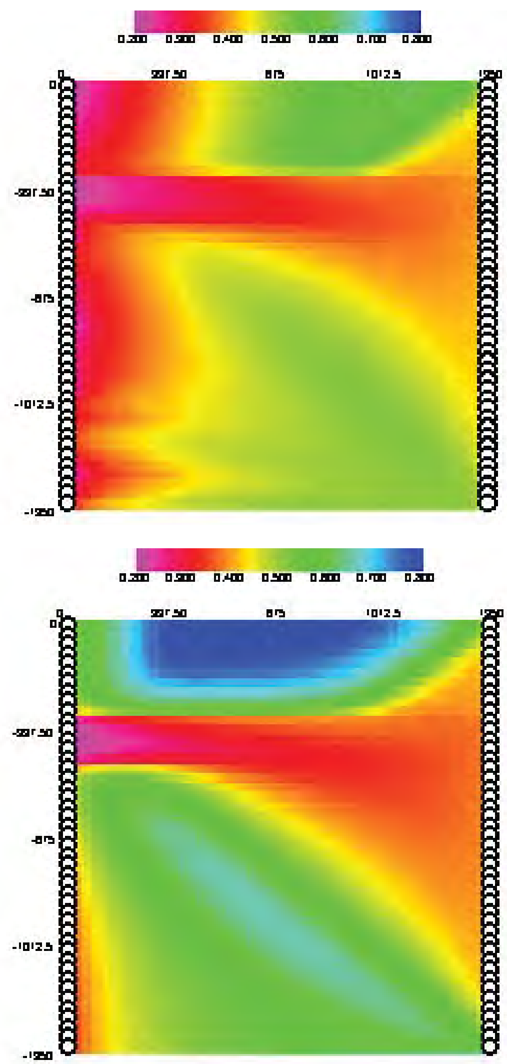
at University of Houston Cullen College of Engineering

Technological advances in the last few decades have been instrumental in enabling the oil industry to respond to ever increasing global demand for oil and gas. Now commonplace, seismic imaging and later directional drilling technologies were developed over a number of years and made possible the relatively reliable identification and production of hydrocarbon reserves that might otherwise have been infeasible to exploit, for technical or economic reasons. Recent technological trends in the oil and gas industry have been captured by the widely used term "intelligent oilfields" or related synonyms. The term refers to technological capabilities related to extensive collection and processing of data in real time, remote and real-time decision making across multiple time scales, and remote activation of hardware such as downhole valves. As was the case with previous technological advances, intelligent oilfield technologies rely on cross-fertilization between the oil industry and other industries. Many related technologies require extensive development before they can be used in the field, while others are already available for use.

Our research group works at the interface between systems and petroleum engineering towards the development of methods that can be used in intelligent drilling and production operations. Frequently in collaboration with our industrial partners, we develop and test methods up to the working prototype level. Recent projects and funding sources include the following.

» Hydrocarbon production optimization and control in real time (industry (US))
» Optimization and control of hydrocarbon well drilling (American Chemical Society; industry (Int'l))

Upon employment, students graduating from our research group are immediate contributors and rapidly advance to technological leadership positions.



Oil saturation at the end of standard (bottom) and optimal (top) production from a heterogeneous oil reservoir. Note the large amount of unproduced oil in standard production (blue area).

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Short Biography

Dr. Michael Nikolaou is currently Professor in the Department of Chemical Engineering at the University of Houston. He received a Diploma from the National Technical University, Athens, Greece, in 1984, and a Ph.D. degree from the University of California, Los Angeles, in 1989, both in chemical engineering. After holding a tenured faculty position at Texas A&M University and a visiting scientist position at MIT, he moved to the University of Houston in 1997. Dr. Nikolaou's research interests are in computer-aided process engineering, with emphasis on process modeling, monitoring, optimization, and control, and their applications to various industries, with recent emphasis on the energy industry. In addition to his extramurally funded academic research, Dr. Nikolaou has consulted extensively in industry. His former graduate students now hold successful positions in industry and academia in the US and overseas.

Selected Publications

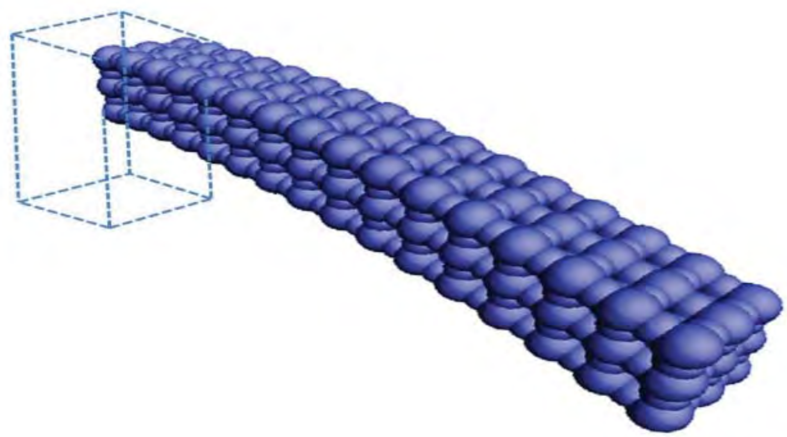
» M. Nikolaou, P. Misra, V. H. Tam, and A. D. Bailey, "Complexity in semiconductor manufacturing, activity of antimicrobial agents, and drilling of hydrocarbon wells: Common themes and case studies," Computers & Chemical Engineering, vol. 29, pp. 2266-2289, 2005.

» L. Saputelli, M. Nikolaou, and M. J. Economides, "Self-learning reservoir management," SPE Reservoir Evaluation & Engineering, vol. 8, pp. 534-547, 2005.

» L. Saputelli, M. Nikolaou, and M.J. Economides, "Real-Time Reservoir Management: A Multi-Scale Adaptive Optimization and Control Approach", J. Computational Geosciences, invited publication for Special Issue on Closed-Loop Reservoir Management, 10, 61-96, 2006.

Energy Harvesting: Piezoelectrics/Nanocapacitors

at University of Houston Cullen College of Engineering



Through quantum mechanical based atomistic and theoretical calculations we have discovered the emergence of size-dependent "giant" piezoelectricity at the nanoscale.

Our results indicate a peculiar (and tantalizing) scaling of the effective piezoelectric constants of certain types of nanostructures resulting in, for example, an increase in nearly 400 % for 400 nm tetragonal-phase piezoelectric BaTiO3 beams under bending conditions and the development of appreciable piezoelectricity in 5 nm nano-beams of the otherwise non-piezoelectric cubic-phase BaTiO3.

Our finding can be used to make piezoelectric "materials" without using piezoelectric materials. Alternatively, the large enhancement in piezoelectricity at the small scale is being used by use to create highly efficient energy harvesting devices for consumer and defense electronics.

Next generation advances in energy storage and nanoelectronics require capacitors fabricated at the nanoscale. High dielectric constant materials such as ferroelectrics are important candidates for those. However there is an order of magnitude drop in the capacitance in reality compared to what is expected at the nanoscale. This dramatic drop in capacitance is attributed to the so-called "dead layer" effect.

Our recent ab initio computations have clarified the basic mechanisms operative behind the dead-layer and we expect to suggest possible designs for next-generation high energy density nanocapacitors.

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Short Biography

Pradeep Sharma received his Ph.D. in micromechanics of materials (mechanical engineering) from University of Maryland at College Park in the year 2000. He also has background in solid state and mathematical physics. Subsequent to his doctoral degree, he was employed at General Electric R & D for more than three years as a research scientist. There he worked in two simultaneous programs on Nanotechnology and Photonics apart from basic research in problems of mechanics of materials. He joined the department of mechanical engineering at University of Houston in January 2004 as an assistant professor. His honors and awards include the Young Investigators Award from Office of Naval Research, Excellence in Research award from the University of Houston, and Texas Space Grants Consortium New Investigators Program Award. He is an associate editor of the Journal of Computational and Theoretical Nanoscience.

Selected Publications

» M.S. Majdoub, P. Sharma and T. Cagin, "Size-dependent super-piezoelectricity and elasticity in nanostructures due to the flexoelectric effect", Physical Review B, Accepted, 2008

» R. Maranganti and P. Sharma, "Length Scales at Which Classical Elasticity Breaks Down for Various Materials", Physical Review Letters, 98, 195504-1– 195504-4, 2007

» X.Zhang, P.Sharma and HT.Johnson, "Quantum Confinement Induced Strain in Quantum Dots", Physical Review B, 75, 155319-1– 155319-8, 2007

» N.D. Sharma, R. Maranganti and P. Sharma, "On the Possibility of Piezoelectric Nanocomposites without using Piezoelectric Materials", Journal of the Mechanics and Physics of Solids, 55, 2328–2350, 2007

Thin Film Photovoltaics on Flexible Substrates

at University of Houston Cullen College of Engineering

At present, over 90% of solar cells are manufactured with bulk silicon technology. Thin film Photovoltaics offer the advantage of a low-cost fabrication alternative for solar cells.

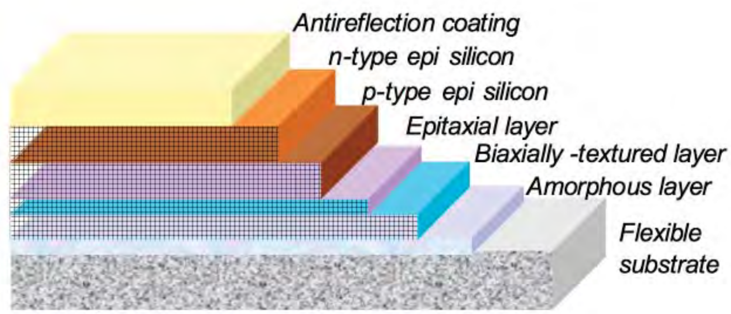
However, the efficiencies of thin film photovoltaics such as amorphous silicon, CdTe and CIGS (copper indium gallium diselenide) are lower than that efficiencies achieved with single crystal silicon (24%).

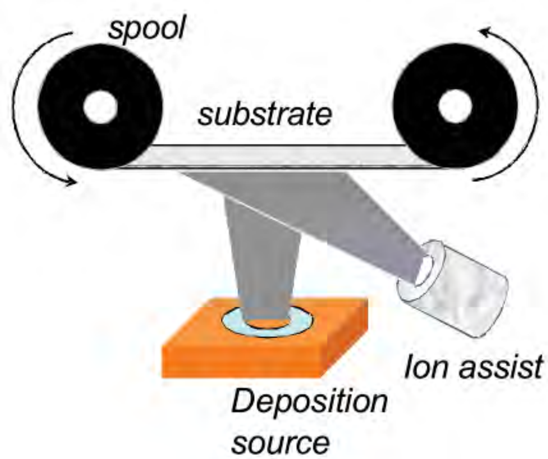
Amorphous silicon films are readily fabricated on glass and flexible substrates such as stainless steel and polymers but suffer from light-induced instability and reach steady-state efficiency levels of only 12%.

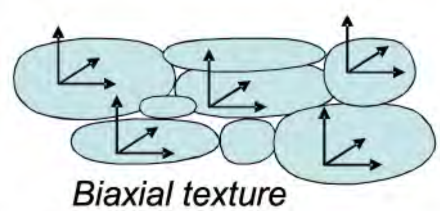
In this project, we are studying crystalline silicon films on flexible metal and polymer substrates. A key difference from the state-of-the-art is the use of biaxially-textured buffered substrates instead of conventional substrates. Using an ion beam assisted deposition (IBAD) approach, an excellent degree of biaxial texture is achieved in nano-scale films such as MgO on flexible substrates.

The biaxial texture provides a pseudo-single-crystallinity which is then transferred by epitaxial growth to crystalline silicon. A pseudo single crystalline structure enables achievement of higher efficiencies in the crystalline silicon film.

We are studying the influences of low angle grain boundaries on efficiencies as well as investigating further improvement to efficiencies using multi junctions and nanostructures.







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Short Biography

Professor Venkat Selvamanickam earned his M.S. (1988) in Mechanical Engineering, and Ph.D. (1992) in Materials Engineering, both from the University of Houston. He held R&D positions in industry from 1994 to 2008 up to the level of Vice President and Chief Technology Officer of SuperPower, a subsidiary of Philips Electronics. His current research interests include materials for energy applications such as superconductors, thermoelectrics, photovoltaics, batteries, and supercapacitors. He has published over 115 papers and holds 18 issued patents. Some of his awards include PECASE, R&D 100, and Superconductor Industry Person of the Year.

High Temperature Superconducting Wires

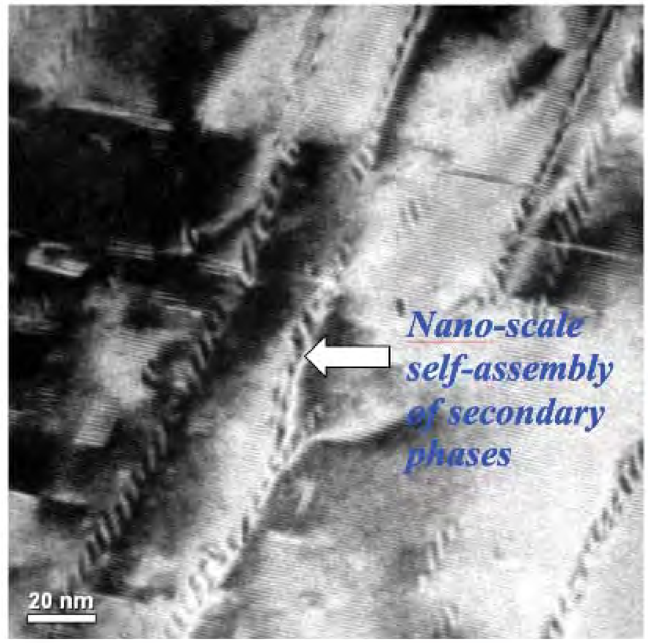
at University of Houston Cullen College of Engineering

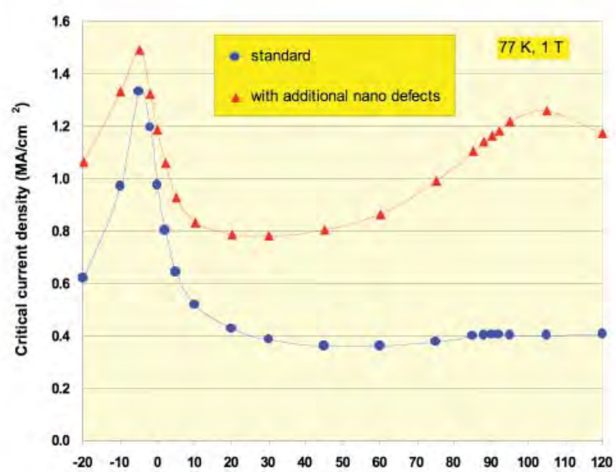
About 7% of electricity generated in the U.S. is lost during transmission due to resistance of conductors. Superconductors are a unique class of materials which can conduct electricity with no resistance. This property can be advantageously used to transmit electricity over long distances with minimal losses, increase the power produced or reduced the power used by electric equipment as well as reduce the size and weight of electric equipment.

When produced in form of a thin film, superconducting wires can carry up to 200 times more current than conventional copper wires of the same cross section. We use a metal organic chemical vapor deposition (MOCVD) process to deposit high quality epitaxial superconducting layers on biaxially-textured nanometer scale buffers atop high-temperature resistant metal substrates.

Our focus is to improve the critical current performance of the superconducting wires especially in high magnetic fields. Microstructural defects responsible for decrease in critical current density with increasing film thickness are studied and appropriate modifications are implemented to the MOCVD process and materials.

Additionally, nano-scale defects are introduced either in form of precipitates or self-assembly structures through appropriate compositional modification. These defects enable effective pinning of vortices resulting in higher current densities. Our goal is to achieve a critical current of 1000 A/cm in a 2.5 micron thick superconducting film, which is 50% better than the state-of-art today. Another goal is to achieve an isotropic critical current density with better than 50% retention at 77 K and 1 T, which is about 2 to 3 times better than the state-of-art today.





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Short Biography
Professor Venkat Selvamanickam earned his M.S. (1988) in Mechanical Engineering, and Ph.D. (1992) in Materials Engineering, both from the University of Houston. He held R&D positions in industry from 1994 to 2008 up to the level of Vice President and Chief Technology Officer of SuperPower, a subsidiary of Philips Electronics. His current research interests include materials for energy applications such as superconductors, thermoelectrics, photovoltaics, batteries, and supercapacitors. He has published over 115 papers and holds 18 issued patents. Some of his awards include PECASE, R&D 100, and Superconductor Industry Person of the Year.

Carbon Combustion Synthesis

at University of Houston Cullen College of Engineering

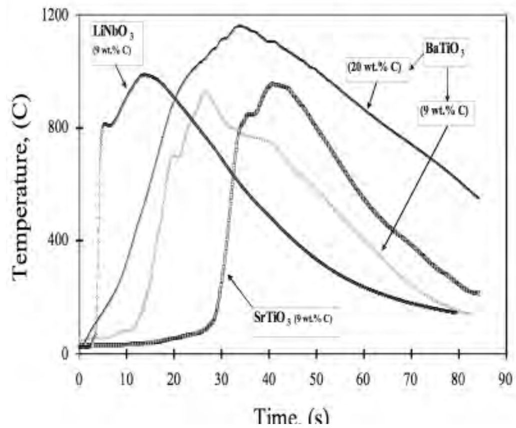
We developed a simple, economical and energy efficient synthesis of submicron and nanostructured complex oxides particles from inexpensive reactant mixtures referred to as Carbon Combustion Synthesis of Oxides (CCSO). In this process, the exothermic oxidation of carbon (~395 kJ/mol) generates a sharp thermal reaction wave (slope of up to 500 °C/cm) that propagates at a velocity of 0.1-3 mm/s through the solid reactant mixture (oxides, carbonates or nitrates) converting it to the desired product.

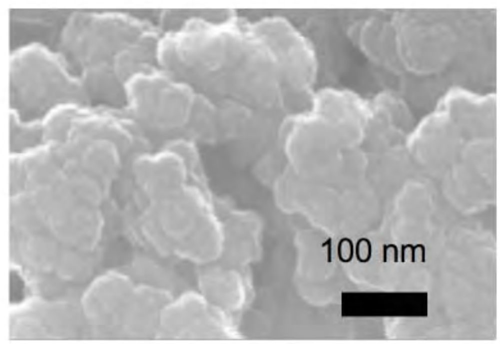
We used this new process to synthesize numerous oxide powders such as ferroelectrics ($BaTiO_3$, $SrTiO_3$, $LiNbO_3$), multiferroics ($HoMnO_3$, $BiFeO_3$), fuel cell component ($LaGaO_3$, $La_{0.6}Sr_{0.4}MnO_3$), rechargeable battery electrode materials ($LiCoO_2$, $LiMn_2O_4$), hard/soft magnetic composites ($BaFe_{12}O_{19}$, $CoFe_2O_4$, Ni-Zn, Mn-Zn-ferrites, $Y_3Fe_5O_{12}$), superconductors (Y123), diesel emission removal catalysts ($LaCrO_3$, $LiCrO_3$) and others. An important feature of CCSO is the extensive emission of CO_2. The associated convective cooling of the sample decreases the local temperature and prevents product partial melting and sintering. Thus, it enables synthesis of highly porous (~70%) powders having a particle size in the range of 50-800 nm with a surface area ~10 m^2/g. XRD-pattern, EDX, and Raman Spectroscopy of the as-synthesized products indicated that well crystalline single-phase particles were formed by the process. The (magnetic/dielectric) product properties are usually superior to those produced by other synthesis processes and are produced at a lower price.

The main advantages of CCSO technology are (i) It does not consume energy and circumvents the use of a high temperature furnace; (ii) Synthesis uses inexpensive raw materials, (oxides, carbonates, soot); (iii) The synthesis is completed in a very short time (order of seconds); (iv) The process is simple and the same reactor can be used to synthesize various oxides.

The University of Houston has filed US patent application for CCSO technology and is seeking a partner to proceed with the commercialization of this technology.

Temperature rise during synthesis of several oxides by CCSO





SEM of $BaTiO_3$ synthesizes by CCSO

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Short Biography
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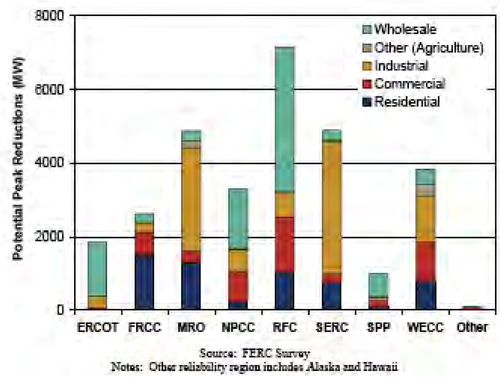
Electricity Conservation

at University of Houston Cullen College of Engineering

Demand Response Potential Peak Reduction by Region and Customer Class

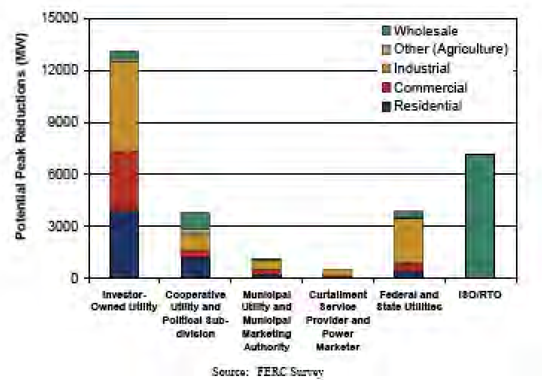


Analyzing services offered to Houston metropolitan area residential electric customers and determining if the implementing Demand Response Programs (DRP) is justified is the research task of this project.

The DRP represents measures taken to stimulate customers into reducing their energy consumption and, when the power grid needs, to reduce the power consumed. To reach these tasks, financial incentives or convenient selling prices are offered to customers. By implementing the DRP, benefits are gained by all participants: the electricity's price goes down and customers are paying less; the needed investments in generation, transmission and distribution are delayed; the fuel consumption and the pollution are reduced.

Implementing DRP requires the installation of new measuring, controlling, recording, and communication devices and systems that represent a large investment. Whether or not the investment is justified and is it compensated by the resulting benefit are the questions that need to be answered.

Demand Response Potential Peak Load Reduction by Type of Entity and Customer Class



The research shows that particular characteristics of CenterPoint (CNP) Energy's power grid, the stimulant position of its leadership, and the favorable inclination of Retail Electric Providers and Technology Units in the Houston area create needed conditions for the implementation of DRP. Also, that the Houston metropolitan area Demand Response Programs implementation for residential customers is justified based on its costs and associated benefits is also shown.

If in the initial stage a small size DRP is implemented in the Houston area, it is expected that the annual peak power and the annual energy consumed will decrease enough to be beneficial.

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Short Biography

Professor Ovidiu Crisan earned his M.S. and Ph.D. degrees in electrical engineering, in 1960 and 1972, respectively, from the Polytechnic Institute of Timisoara, Romania. He held positions ranging from assistant professor to professor at his alma mater from 1960 to 1984. He also served as visiting associate professor at the University of Wisconsin, Madison, in 1971 and 1973. He joined the University of Houston in 1984 as a visiting professor, and was tenured as professor with the college in 1991. His research interests include power systems components modeling and power systems operation and control. Presently, his focus is on voltage stability/voltage collapse research, with direct application to electric utilities.

Selected Publications

» O. Crisan, The Value of Conservation in Metropolitan Houston Residential Electricity Demand and the Role of Public Policy in its Realization, White Paper, Prepared for Direct Energy LP, Houston, Texas, August 2, 2007

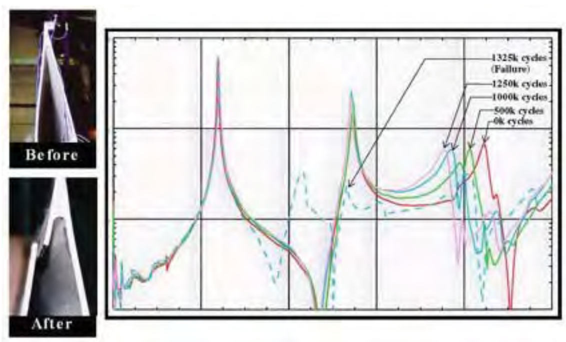
Structural Health Monitoring

at University of Houston Cullen College of Engineering

The Zimmerman group is involved in the analytical, numerical, and experimental aspects of Fault-Tolerant Intelligent Structural Systems (FTISS). Intelligent Structural Systems (ISS) are structures which integrate control and computational subsystems into a single structural entity. Ideally, ISS adapt their dynamic characteristics to meet performance objectives at any instant. FTISS, in addition, integrate the likelihood of structural and control component member failures in both the off-line design and on-line implementation of the system. The need for FTISS is critical for complex dynamic systems such as wind turbine farms, bridges and buildings, and satellites/space structures which are required to operate unattended for extended periods of time and/or are too intricate for human operators to discern problems.

In conjunction with NREL, we developed automated techniques to adjust physical parameters of a finite element model of the Canon Wind Eagle 300 rotor system to better match measured dynamic response (natural frequencies, damping ratios and modeshapes) and static deflection tests. Although demonstrated on a particular rotor, the methodology can easily be used with other rotor systems. The improvement of structural models enhances the prediction of aerodynamic performance and subsequent energy production. In conjunction with Sandia and NASA, we have developed autonomous methods to (i) detect the existence of structural damage, (ii) locate damage, and (iii) estimate the extent of damage. These systems utilize the change in global vibration characteristics, and thus require reliable vibration measurements. However, the change in measured vibrations could be caused by various failure modes related to the sensors. Recently, we have developed techniques which are able to distinguish between sensor and structural failures.

Vibration test of a blade performed in conjunction with Sandia National Laboratories at the US Department of Agriculture's Research Station in Bushland, TX.



Resonant fatigue testing of blade shows torsional mode frequency "tracks" very nicely the onset of fatigue

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Short Biography

Professor David Zimmerman joined the Department of Mechanical Engineering in 1993 as an associate professor. He earned his B.S., M.S. and Ph.D. in mechanical engineering from State University of New York at Buffalo in 1982, 1984 and 1987, respectively. Following the completion of his degrees, he joined the faculty at the University of Florida as an assistant professor in the Department of Aerospace Engineering, Mechanics & Engineering Science. After coming to UH, he launched the Dynamic Systems and Controls Laboratory and established the UH/NASA JSC Design Partnership. He was promoted to full professor at University of Houston in 2000 and appointed as the department's associate chairman. His research interests involve structural health monitoring of infrastructure (both civil and space), vibration testing methodology, structural model validation, fault detection of sensors, actuators and structures, biologically inspired optimization paradigms, MEMS modeling, and neural computation.

Selected Publications

» Zimmerman, D.C., Simmermacher, T., and Kaouk, M., "Model Correlation and System Health Monitoring Using Frequency Domain Measurements," Structural Health Monitoring: An International Journal, Vol. 4, No. 3, Sept, 2005, pp. 213-228.

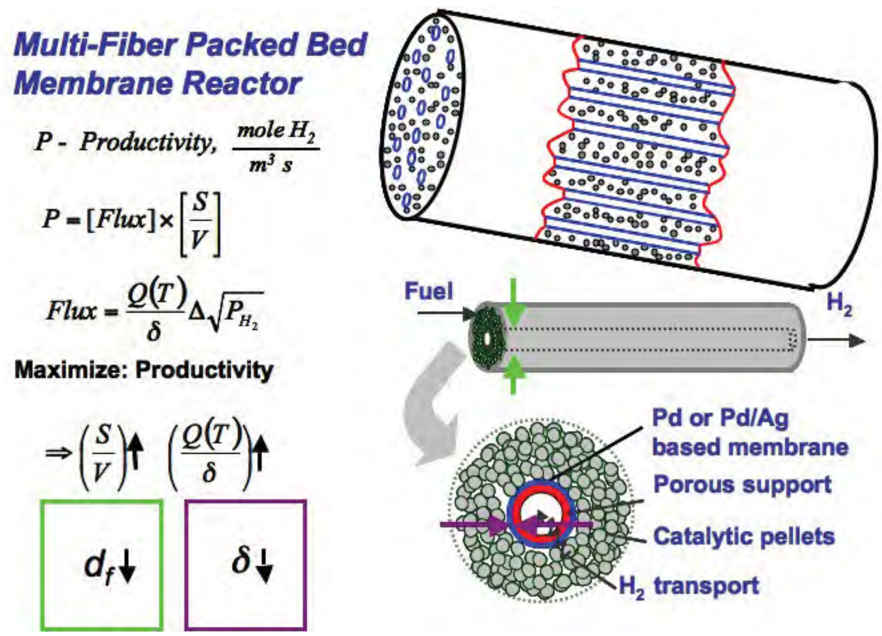
» Zimmerman, D.C., and Jorgensen, S.S.F., "Parallel Multi-Species Genetic Algorithm for Physics and Parameter Estimation in Structural Dynamics," AIAA Journal, Vol. 43, No. 10, October, 2005, pp. 2224-2231.

» Shen, S, and Zimmerman, D.C., "Failure Detection in Structures, Sensors and Actuators Using Realization Redundancy and Outlier Analysis", accepted by, AIAA Journal of Guidance, Control and Dynamics

Hydrogen Generation and Purification

at University of Houston Cullen College of Engineering

The development of cost-effective technologies for producing and/or storing high purity hydrogen is a hurdle for the widespread commercialization of efficient hydrogen-based fuel cells for use in distributed power applications. Our approach is to develop compact membrane reactors that combine fuel reforming (to hydrogen) with high temperature separation and purification. This avoids the need to store high pressure hydrogen but requires highly integrated, robust, and efficient units. To meet this need, we are synthesizing novel composite Pd-based hollow fiber and tubular membranes for high temperature and pressure hydrogen separation for both gas separation and membrane reactor applications. We combine the techniques of thin film processing of ceramic and metals, producing composite layered structures with unique properties.



Membrane Reactor for H2 Generation

Recently we have developed a "nanopore" Pd membrane reactor for converting fuels to high purity hydrogen. The "Pd nanopore" composite membranes are a novel class of H2 permselective membranes in which a thin layer of Pd is grown within the pores of a supported nanoporous layer. Ultrathin membranes are synthesized through a series of sequential boehmite sol slip casting and electroless plating steps on a porous ceramic hollow fiber support. The composite membranes exhibit very good permeation compared to conventional "top layer" Pd membranes at high temperature (up to 600 oC). Not only do the membranes exhibit high flux and permselectivity, they also exhibit superior long-term stability. The membranes have been applied in both high temperature separator and packed-bed membrane reactor configuration using both catalytic ammonia decomposition and methanol reforming as model reactions.

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Short Biography

Professor Mike Harold is chairman and Dow Professor of the Department of Chemical & Biomolecular Engineering. He earned his bachelor's degree in chemical engineering from Penn State University in 1980 and Ph.D. from the University of Houston in 1985. After receiving his Ph.D., he took research and teaching positions at the University of Massachusetts and the University of Twente in Holland until 1996. Harold then joined DuPont Company, where he served in supervisory positions over the R&D of polymers and fibers, intermediates and chemical process fundamentals. He left DuPont in 2000 to take his current position with the college. His research interests include reactive separation devices and material; multi-functional chemical reactor synthesis, analysis and design; microfabricated chemical system devices and materials; and selective oxidation chemistry, kinetics and reactors.

Selected Publications

» Harold, M.P., B. Nair, and G. Kolios, "Hydrogen Generation in a Pd Membrane Fuel Processor: Assessment of Methanol-Based Reaction Systems," Chemical Engineering Science, 58, 2551-2571 (2003).

» Lattner, J.R., and M.P. Harold, "Comparison of Conventional and Membrane Reactor Fuel Processors for Hydrocarbon-Based PEM Fuel Cell Systems," Inter. J. of Hydrogen Energy, 29, 393-417 (2004).1196, June 2004

Biodiesel

at University of Houston Cullen College of Engineering

Biodiesel fuel (BDF) is a renewable fuel derived from a number of vegetable oils that can be run neat or in blends with regular diesel. Because it is an oxygenated hydrocarbon, combustion results in reduced particulate soot/matter (PM), hydrocarbon, and carbon monoxide (CO) emissions.

In this project we explore cost-effective ways to exploit this feature of biodiesel to make it attractive for use in both older and new engines. Our current research focuses on low temperature NOx reduction on heavy-duty diesel vehicles using a system comprising a low pressure exhaust gas recirculation (EGR), various biodiesel fuel blends, and a diesel particulate filter. These components are currently available on the market and compose a system which can achieve good NOxand PM reductions for vehicles which have inherently low exhaust temperatures.

Exhaust gas recirculation (EGR) is a method in which a fraction of an engine's exhaust gas is returned to the combustion chambers, providing typical NOx reduction in the range of 25-50%. However, the improved NOx emission performance resulting from EGR also yields increased particulate soot that necessitates a suitably sized Diesel Particulate Filter (DPF) system.

The coupled elimination of NOx and particulate matter (PM) in diesel exhaust is investigated by combining biodiesel, exhaust gas recirculation (EGR), and diesel particulate filtration (DPF). EGR requires auxiliary particulate filtration due to the increased soot that is produced while the reliability of the DPF regeneration requires a minimum exhaust temperature and NOx:PM ratio. We employ a heavy-duty chassis dynamometer system to quantify the synergistic effects of biodiesel, EGR, and soot filtration for a vehicle having a low exhaust temperature. We have shown that biodiesel produces Up to 40% less PM with EGR than ultralow sulfur diesel (ULSD) produces without EGR. The overall decrease in PM and corresponding increase in the NOx:PM ratio has a beneficial effect on DPF operability due to a more favorable oxidation stoichiometry.

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Adjunct Professor Charles Rooks joined the Chemical & Biomolecular Engineering Department in 2001. He holds a B.S. in chemical engineering from the University of Mississippi (1969) and an M.S. and Ph.D. from the University of Oklahoma in chemical engineering in 1971 and 1973, respectively. In addition to serving as a research and teaching professor, Rooks is the Director of the Undergraduate Research Laboratory and the Director of the University of Houston Diesel Vehicle Research and Testing Facility. His current research interests in the area of diesel emission controls include evaluating various strategies for the control of NOx, SOx and particulates in diesel exhausts. He and several colleagues are working with the City of Houston and others to evaluate the efficacy of various diesel emission reduction technologies from among the wide array of devices and technologies currently offered by various manufacturers.