ERC NEWSLETTER

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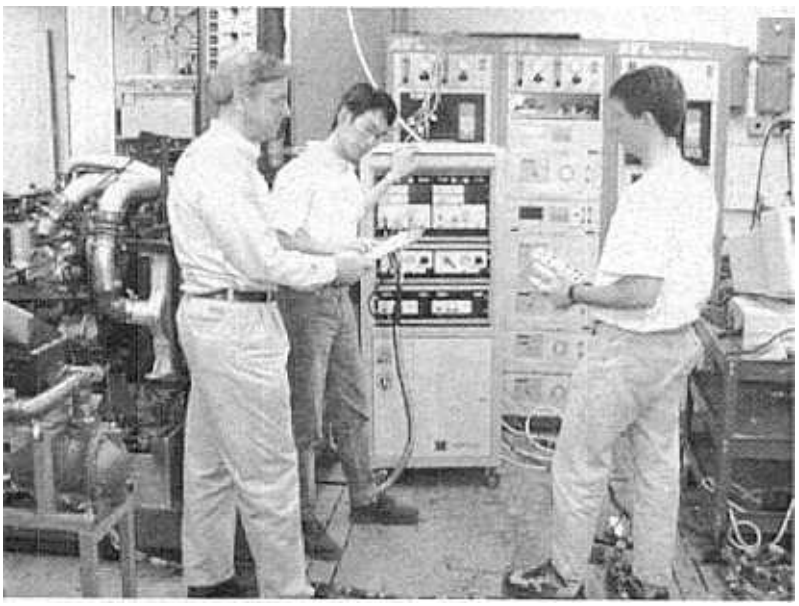
Principal Investigator Highlight:

Professor John Moskwa's Research is in the Powertrain Control Research Lab



All of Professor Moskwa's research occurs within the Powertrain Control Research Laboratory that he founded in 1989. There he and his graduate students focus on five principal areas: powertrain system dynamic modeling, multivariable and non-linear controls, nonlinear engine diagnostics, transient dynamometer test systems, and transient emissions. The PCRL is actually two labs, the DynoLab where the experimental research is done, and the SimLab where models and diagnostics are developed.

This work has been influential in the powertrain industry because of the lab's use of model-based control and rapid prototyping systems for design, strategy development, and calibration. Professor Moskwa's program in powertrain systems is unique because of the very high bandwidth engine test systems his group has designed and built, and because of the synthesis of these systems within overall transient control and emission measurement. This systems approach to the engine and powertrain sub-systems has proven to be extremely useful in formulating both control algorithms for specific goals and in fault detection and isolation.

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Most recently, Moskwa has been studying diagnostics and control of emission control systems for diesel engines. He is collaborating with Professors David Foster and Thatcher Root (Chemical Engineering) on the optimization of the overall diesel engine system to minimize exhaust emissions. This program involves both a dynamic system modeling component as well as an experimental component on a transient dynamometer.

In the classroom, Moskwa teaches two courses, Thermodynamics and Vehicle Design & Dynamics. For many years, he also taught Automatic Controls as well as other control courses. During the 1997-98 academic year, Moskwa spent a sabbatical in England as a Visiting Scholar at the University of Cambridge and also as Senior Technical Specialist with the Advanced Powertrain Group at Ford Motor Company's R & E Centre in Dunton. Additionally, this past year Moskwa received the Vilas Associate Award from the UW Graduate School.

Professor Moskwa has been with the UW's Mechanical Engineering Department since 1988, and he joined the ERC in 1994. In addition to his lab, he founded the College of Engineering's Hybrid Electric Vehicle program in 1991. He received his BSE and MSE degrees in mechanical engineering from the University of Michigan and his PhD from the Massachusetts Institute of Technology.

Prior to his decision to become an engineer, Moskwa worked as a diesel mechanic for the city of Detroit and studied music at several institutions including Boston University and the Cleveland Institute of Music. He served as Professor of Trumpet at the University of Guadalajara, and on the National Advisor Board for the Cleveland Institute of Music. He continues to play trumpet for special events at churches in the Madison area. ■

COMBUSTION IN ENGINES SEMINAR IS SEPTEMER 18-19

In cooperation with the UW Department of Engineering Professional Development, the ERC is co-hosting a seminar in Madison entitled "Combustion in Engines; Learn How to Optimize Engine Performance While Reducing Fuel Consumption and Exhaust Emissions." Instructors will be our own Professor David Foster and Assistant Professor Jaal Ghandhi. The seminar will provide a fundamental foundation for experienced engine development engineers. For more information and enrollment details, visit the website: http://www.erc.wisc.edu/seminars.html

DESIGN & MECHANICAL DEVELOPEMENT OF ENGINES SEMINAR IN NOVEMBER

In an expansion of last fall's three-day seminar, the ERC is scheduling a five-day seminar in "Design and Mechanical Development of Engines" November 6-10. The longer sessions will allow instructors to go into greater depth in each topic area, including examples of design practices and calculation methodology.

Since it may be difficult for many participants to schedule a five-day program on their calendars, the course has been designed as a series of one-day seminars that can be booked separately or together. The courses are entitled as follows: Development Overview and Engine Configuration, Cylinder Block and Head Design, Air Handling Systems, Engine Cooling and Lubrication, and Piston and Ring Design. For registration information, please visit the website: http://www.erc.wisc.edu/pdseminars/DesSerOutline.html ■

Academic Year 1999-2000 ERC Graduates

Congratulations to the following ERC students who received their degrees during the past academic year.

Paul Borthwick –PhD (Farrell)
Paul's thesis was "Fuel Injector Spray and Wall Impingement in a Diesel Engine."

Daniel Corgard – MS (Reitz)
Dan's thesis was "Effects of Alternative Fuels and Intake Port Geometry on High-Speed, Direct-Injection, Diesel Engine Performance and Emissions."

Ronald Donahue – PhD (Foster)
Ron did his work on "Detailed In-Cylinder Engine Data and Evaluation of the Potential for Combustion Control via Manipulation of Fuel and Combustion Chamber Gas Composition." He investigated the use of two-dimensional two-color optical pyrometry as a means of correlating events inside the cylinder during combustion to measure emission and performance of the engine. He performed further development of the two-color technique and applied the measurement and analysis technique to different engine operation conditions. He compared normal operation with that using an oxygen enriched fuel and operation with oxygen enriched intake air. He was able to observe different in-cylinder characteristics of temperature and soot distribution that correlated with the measured engine emissions.

Earlier Ron did his MS with Professor Borman as his advisor. Ron now works for Mercury Marine in Fond du Lac.

Li Fan – PhD (Reitz)
Li's thesis was "Multi-Dimensional Modeling of Mixing and Combustion of Direct Injection Spark Ignition Engines." He has taken a job with Ford Motor Company.

Kayhan Goney – PhD (Corradini)
Kayhan's thesis was entitled "Investigations of Internal Nozzle Multiphase Flow and its Effects on Diesel Sprays." Kayhan is now working at Detroit Diesel Corporation.

David Grupp – MS (Martin)
David's thesis was "Ignition System Characteristics, Conditional Ignition and Exhaust Port Timing Effects on Combustion for a Two-Stroke Engine." He is now working for Ford Motor Company in Dearborn, Michigan.

Yoshiya Ieda – PhD (Martin)
Yoshi is now working at NGK Spark Plug Manufacturing, Inc. in Wixon, Michgan. He did his thesis on "The Effects of Ambient Gas Composition and Temperature on Soot Oxidation Rates."

Eric Kurtz – PhD (Foster)
Eric has accepted a job with Ford in Dearborn, Michigan. His thesis was "Characterizing the Effects of Auxiliary Gas Injection on DI Diesel in which he investigated the ability to separate the soot NOx trade-off in diesel engines by inducing enhanced in-cylinder mixing during the combustion and expansion stroke. He determined that through use of an auxiliary gas injection he could promote soot oxidation without increasing the formation of nitrogen oxides. He identified and quantified the parameters important in enhancing the soot oxidation via enhanced mixing without affecting the NOx formation.

Chol-Bum Kweon – MS (Foster)
Chol-Bum is still at the ERC working toward his PhD. His MS thesis was "The Effects of Fuel Properties on High-Speed DI Diesel Engine Combustion."

Daniel Lee – PhD (Rutland)
Dan's thesis was entitled "Incorporating Advanced Combustion Models to Study Power Density in Diesel Engines." He is working for Fluent in Lebanon, New Hampshire.

Andreas Lippert – PhD (Reitz)
Andreas has gone to work for General Motors. His thesis was "Modeling of Multicomponent Fuels with Application to Sprays and Simulation of Diesel Engine Cold Start."

David Montgomery – PhD (Foster)
David has accepted a position with Outboard Marine Corporation in Waukegan, Illinois. His thesis was "Optimization of Heavy-Duty Diesel Engine Operating Parameters when Using Multiple Injections and EGR."

Lyle Pickett – PhD (Ghandhi)
Lyle's thesis was "Structure of a Reacting Shear Layer Using Hydrocarbon Fuels." He is currently doing a post doc at the ERC, but after August he will go to Sandia for another post doc.

Keith Richards – MS (Reitz)
Keith's MS thesis was "Multidimensional Intake Flow Modeling of HSDI Diesel Engines." He has stayed at the ERC to work for his PhD.

Brandon Rubenstein - MS (Martin)
Brandon has gone to work for Hewlett Packard in Fort Collins, Colorado. His thesis was entitled "Computational Fluid Dynamics Predictions of Volume Flow and In-Cylinder Flow Behavior with Comparison to Experiment."

Peter Kelly Senecal - PhD (Reitz)
Kelly is staying on in the ERC to do a post-doc. His research was on "Development of a Methodology for Internal Combustion Engine Design Using Math-Dimensional Modeling with Validation Through Experiments."

Kevin Sholes - PhD (Farrell)
Kevin has gone to Japan to work for the Traffic Safety and Nuisance Research Group. His thesis was "Dual-Reference-Beam Holographic Particle Image Velocitymetry."

Sebastian Strauss – MS (Martin)
Sebastian is now working for Outboard Marine. His master's thesis was entitled "Investigation of Fueling Strategies for the Transient Operation of a Small Four Stroke Engine."

Jay Strucel – MS (Martin)
Jay's thesis was "Thermal Energy Flows within Air-Cooled Engines." He is also working for Ford in Dearborn, Michigan.

Ed Suh — MS (Rutland)
Ed is now working at Delphi, Inc. His thesis was "Mixture Preparation in a Two-Valve Gasoline Direct Injection Engine."

Wenbo Wang – PhD (Moskwa)
Wenbo's research was on "Dynamic Powertrain System Modeling and Simulation with Applications for Diagnostics, Design and Control," with contributions including system modeling methodologies with applications to powertrain design, diagnostics and control. He has accepted a position with GM Powertrain in Milford, Michigan.

David Wickman – MS (Reitz)
David is remaining at the ERC to work toward his PhD. His master's thesis was "Modeling the Effects of Fuel Injection on Heavy-Duty Diesel Engine Performance and Emissions."

James Wiedenhoefer – MS (Reitz)
James's thesis was "Finite Element Modeling of I.C. Engine Component Temperatures." He is also continuing at the ERC to work for his PhD. ■

ERC Faculty, Staff, and Student News

Dr. Colin Garner is visiting the ERC from Loughborough University in the UK. He is presenting several seminars on work at Loughborough as well as helping out with one or more of our projects.

Professor Emeritus Phillip S. Myers recently traveled to Friedrichshafen, Germany, to work with MTU Engine Company (a subsidiary of Daimler Chrysler). He has been consulting with them for five or six years on upgrading the power rating of one of their engines from 1500 HP to 2750 HP. During this last visit, the engine passed its 1000 hour test.

John J. Moskwa has been promoted to full professor. Additionally, he has received an invitation from the associate dean of the Beijing Institute of Technology to come to China in September to give a series of lectures on powertrain systems at their university. Faculty at BIT have a strong interest in developing collaborative research with ERC's powertrain lab, and a group of faculty from there visited our lab earlier this year. ■

The following piece is reprinted from "Wisconsin Week," a newsletter for University of Wisconsin faculty and staff. It also appeared in the online versions of Daily University Science News, Discovery.Com, Financial Times, and Wissenschaft (in German). Peter Senecal just finished his PhD at the ERC and is now doing his post-doc.

BUILDING BETTER ENGINES THROUGH NATURAL SELECTION by Brian Mattmiller

MADISON - Could Charles Darwin's rules of evolution help engineers design high-performance engines of the future?

Computer models developed at the University of Wisconsin-Madison are doing just that, by using genetic algorithms to simultaneously increase fuel efficiency and reduce pollution.

Peter Senecal, a post-doctorate engineer at UW-Madison, created the computer models to help sort through literally billions of combinations of factors that determine engine performance - a task too enormous for conventional computer simulations.

Senecal says the most important advance is in improving pollution emissions without sacrificing fuel efficiency, and vice versa. Normally, engine designers who concentrate on solving one problem end up with major tradeoffs in the other.

The results to date have been dramatic. Using a Silicon Graphics supercomputer at UW-Madison's Engine Research Center, Senecal created a diesel engine design that reduces nitric oxide emissions by three-fold and soot emissions by 50 percent over the best available technology. At the same time, the model reduced fuel consumption by 15 percent.

Six engine performance measures were studied, including fuel injection timing, injection pressure, and amount of exhaust recirculation. The simulation was then reproduced experimentally in a real diesel engine housed at the ERC. "We found that the agreement was excellent between what was measured in the lab engine and what the computer predicted," Senecal says.

Senecal's research will be published in an upcoming issue of the International Journal of Engine Research. He will also give an invited presentation Wednesday, June 21, to the Society of Automotive Engineers international meeting in Paris.

His work also is turning heads in the engine manufacturing industry, which faces major new federal pollution control mandates by the year 2002. Caterpillar Inc., a Peoria-based manufacturer of diesel engines for trucks and heavy equipment, is funding Senecal's post-doctorate work that will focus on improving the geometry of engines.

Senecal says genetic algorithms have been developed in recent years for other engineering challenges, such as designing bridges and airplane wings. "I kind of stumbled onto this in the literature, and wasn't sure if it would work for something as complex as engine design," he says.

Here's how it works: Senecal begins with five "individuals," which are defined as one distinct set of the six engine parameters. Four of the individuals are randomly selected and the fifth is the baseline, or best known set of parameters.

Next, a computer model is used to weed out the best parameters of the first group. The two fittest "parents" are then allowed to "reproduce" and a new generation is formed, complete with "mutations" that represent marked improvements over the previous generation. The process is continued through successive generations until the computer identifies the most "fit" member of the group.

Senecal says this process narrows the field of potentially one billion calculations on the computer down to 200 to 250 of the best possibilities. The computer can accomplish in weeks what would otherwise take decades to run.

Mechanical engineering Professor Rolf Reitz, Senecal's Ph.D. thesis advisor, says the computer model is extremely versatile and could be used for all types of engines. While current work focuses on questions like fuel injection and air intake, studies of engine hardware are just beginning.

Reitz says the typical engine piston, for example, has not been fundamentally improved upon for decades. Yet engineers have no idea whether a different geometry could produce much better engines.

If engine manufacturers want a more powerful engine, or a more durable engine, one can program the genetic model to find those traits, too. "If you want your children to be long jumpers, high jumpers or sprinters, you can specify these attributes with this program," Reitz says.

The diesel engine industry faces a U.S. Environmental Protection Agency mandate to cut nitric oxide emissions in half by 2002. Wisconsin's small engine industry, also facing pollution-control deadlines, also has initiated a research program at UW-Madison using the genetic model. ■