The ERC wishes to acknowledge the ARO Technical review committee, shown in the picture above. (Standing from left to right: Bob Bill, (ARL/WASA), John Clarke (Caterpillar), Walt Bryzik (TACOM/TARDEC), Mark Valco (ARL/NASA), Nabil Hakim (Detroit Diesel Corp.), Arjun Tuteja (GM), Bill Anderson (Arberden Proving Grounds), Craig Savonen (Detroit Diesel Corp.); Seated, from left to right, Pat Flynn (Cummins), Dave Mann (ARO), Julian Tiskoff (AFOSR). The committee spent two days in August offering their assessment of the research program of the ERC. Their insights and suggestions continue to be very valuable feedback for the Center.

Myers-Uyehara Fund

The ERC’s gift fund, named in honor of the Engine Lab founders Professors Phil Myers and Otto Uyehara, continues to receive significant contributions from individuals and corporate matching funds. The fund is used primarily to benefit ERC students by providing opportunities that could not be paid from research funds. During the last year earnings from the Myers-Uyehara were used to provide travel expenses for 36 ERC students to attend the SAE Congress in Detroit and to bring three special seminar speakers to Madison. The special seminars listed below were presented last fall.

Professor Robert P. Lucht
Department of Mechanical and Industrial Engineering
University of Illinois

“Applications of Coherent Anti-Stokes Raman Scattering (CARS) Spectroscopy in Flames and Nonreacting Supersonic Flows.”

Professor Frederick L. Dryer
Department of Mechanical and Aerospace Engineering
Princeton University
“Recent Studies of Liquid Hydrocarbon Droplet Combustion Aboard the Columbia Space Shuttle”

Dr. Peter J. O’Rourke
Los Alamos National Laboratory
“New Directions in Three-Dimensional Computational Fluid Dynamics”
SAE 1998 Congress

The following abstracts are given as a preview to ERC papers to be published at the 1998 Congress in Detroit, February 23-26.

Modeling the Effects of Fuel Spray Characteristics on Diesel Engine Combustion and Emissions
Mark Patterson and Rolf D. Reitz
SAE paper 980131

A new spray model has been developed to improve the prediction of diesel engine combustion and emissions using the KIVA-II CFD code. The accuracy of modeling the spray breakup process has been improved by the inclusion of Rayleigh-Taylor accelerative instabilities, which are calculated simultaneously with a Kelvin-Helmholtz wave model. This model improves the prediction of the droplet sizes within a diesel spray and provides a more accurate initial condition for the evaporation, combustion, and emissions models. An improvement to the droplet drag model is also presented. This model accounts for the increased droplet drag due to the change in the droplet shape, as well as the increase in the frontal area of the droplet. The drag model affects the breakup process locally, producing a more realistic droplet size distribution, and therefore a more accurate calculation of the vaporization process. Through the introduction of this model the prediction of the pressure, heat release, and emissions produced by single and split injections can now be accurately modeled.

Multi-Dimensional Modeling of Fuel Films and Spray-Wall Interaction in IC Engines
Donald Stanton and Chris J. Rutland
SAE paper 980132

To help account for fuel distribution during combustion in diesel engines, a fuel film model has been developed and implemented into the KIVA-II code [1]. Spray-wall interaction and spray-film interaction are also incorporated into the model. Modified wall functions for evaporating, wavy films are developed and tested.

The model simulates thin fuel film flow on solid surfaces of arbitrary configuration. This is achieved by solving the continuity, momentum and energy equations for the two-dimensional film that flows over a three-dimensional surface. The major physical effects considered in the model include mass and momentum contributions to the film due to spray drop impingement, splashing effects, various shear forces, piston acceleration, dynamic pressure effects, and convective heat and mass transfer. In order to adequately represent the drop interaction process, impingement regimes and post-impingement behavior have been modeled using experimental data and mass, momentum and energy conservation constraints. The regimes modeled for spray-film interaction are stick, rebound, spread, and splash.

The spray-wall interaction and fuel film models are used to simulate evaporating sprays impinging on a flat surface. The vapor and liquid phase distributions are compared to exiplex fluorescence data. Additionally, the models are used to investigate the performance of a two-stroke, direct injection diesel engine with loop-scavenging. Numerical simulations compared well with experimental data for fuel film thickness, percentage of fuel that adheres to the wall and the spreading area of the film, as well as global engine parameters such as cylinder pressure. The film model provides a predictive tool for examination of wall wetting and secondary atomization characteristics at varying engine loads.

The Effects of Mixture Stratification on Combustion in a Constant Volume Combustion Vessel
J.D. Plackmann, T. Kim, and J.B. Ghandhi
SAE paper 980159

The role of mixture stratification on combustion rate has been investigated in a constant volume combustion vessel in which mixtures of different equivalence ratios can be added in a spatially and temporally controlled fashion. The experiments were performed in a regime of low fluid motion to avoid the complicating effects of turbulence generated by the injection of different masses of fluid which would be required to alter the mixture stratification. Different mixture combinations were investigated while maintaining a constant overall equivalence ratio and initial pressure. The results indicate that the highest combustion rate for an overall lean mixture is obtained when all of the fuel is contained in a stoichiometric mixture in the vicinity of the ignition source. This is the result of the high burning velocity of these mixtures, and the complete oxidation which releases the full chemical energy. The total energy release of stratified mixtures with a rich mixture near the ignition source were limited by the mixing of the rich products with the available oxidizer before the mixture cools below the temperature required for oxidation. These results suggest that for direct-injection engines operating at light load the target fuel distribution in the chamber is a homogeneous stoichiometric mixture near the spark gap, and that sufficient fuel mechanical mixing is necessary during the expansion stroke to promote mixing and oxidation of any rich combustion products.

Effects of Intake Port Angle on Large Scale In-Cylinder Flows
William Church and Patrick V. Farrell
SAE 980484

A set of experiments has been performed which were aimed at quantifying the effects of specific intake port geometry changes on large-scale in-cylinder motions. Using a modular engine with replaceable intake port blocks, 3 different intake ports were used and results obtained at 3 crank angles: BDC, 90° before TDC of compression, and at TDC of compression. For each port, in-cylinder flows were quantified using a pulsed laser and high-speed imager. The resulting images were analyzed using a particle-tracking scheme.

The results of the experiments indicate that there are significant differences among the flows produced by the ports, particularly at BDC. Nearer TDC, the differences among the flows diminish, but some differences in velocity and vorticity scale and distribution remain. Tumble ratios are shown, using a variety of tumble ratio calculation methods. In general, the methods give similar results showing moderate change in tumble from BDC to
90° BTDC, then a significant decrease to TDC.

Mass-Related Properties of Various Atomizers for Direct-Injection SI Engines
Jeffrey Hoffman, Farhan Khatri, and Jay K. Martin
SAE paper 980500

Mass-related properties for a variety of atomizers were estimated with the use of a mechanical transient pattrenator. The properties presented on a temporal and spatial basis are the axial liquid mass flux, liquid fuel to air ratio, liquid axial velocity. The data are presented in two formats. The first format consists of the mass-related properties that occurred radially between two planes positioned 2.0 cm and 2.25 cm along the atomizer axis. A second format consists of interpolated contour plots of the axial liquid mass flux for all four of the spray systems. Interpolated contours for the estimated liquid fuel to air ratio is included for one of the high pressure systems.

The atomizers used in the study consisted of three single-liquid high-pressure systems and one air-assist system. Three of the systems were operating with a volumetric delivery of 20 mm³ while injecting into ambient conditions. The fourth system was operating with a delivery of 15 mm³.

Average axial velocities were in the range of 0 and 2000 cm/sec. Mass flux and fuel to air ratio data exhibited large variations in magnitude and location. Ranges of 0 to 10 for the liquid fuel to air ratios, and 0 to 25 g/cm²/sec for the mass flux were observed.

Intake Flow Effects on Combustion and Emissions in a Diesel Engine
Tina R. Fuchs and Chris J. Rutland
SAE 980508

Using modified versions of the KIVA-II and KIVA-3 CFD codes, intake, compression, and combustion of a Caterpillar diesel engine was modeled. Seven variations on intake and two injection schemes were explored so that a detailed understanding of the effects of intake on various flow properties and their subsequent influence on combustion and emissions could be obtained.

The results revealed that, in many cases, one of three factors: swirl ratio, temperature, and turbulence, was dominant in describing a combustion or emission behavior. In addition, stratification of fuel and oxygen was found to be a result of high swirl ratios. This had a profound impact on combustion and emissions, especially for the split injection cases.

Two-Color Image of In-Cylinder Soot Concentration and Temperature in a Heavy-Duty DI Diesel Engine with Comparison to Multidimensional Modeling for Single and Split Injections
Gregory J. Hampsch and Rolf D. Reitz
SAE 980524

Two-Color imaging optics were developed and used to observe soot emission processes in a modern heavy-duty diesel engine. The engine was equipped with a common rail, electronically-controlled, high-pressure fuel injection system that is capable of up to four injection pulses per engine cycle. The engine was instrumented with an endoscope system for optical access for the combustion visualization. Multidimensional combustion and soot modeling results were used for comparisons to enhance the understanding and interpretation of the experimental data. Good agreement between computed and measured cylinder pressures, heat release and soot and NOx emissions was achieved. In addition, good qualitative agreement was found between in-cylinder soot concentration (KL) and temperature fields obtained from the endoscope images and those obtained from the multidimensional modeling. The imaging results were used in conjunction with modeling to explain why split injections are beneficial to reduce soot emissions and also why they may, under retarded timing conditions, increase soot emissions leading to the experimentally observed "soot catastrophe." The reason for the dramatically increased soot at retarded timings is shown in the images to be due to poor ignition and combustion of the late injected fuel pulses in multiple injection schemes. The present modeling results also suggest a feedback mechanism where high in-cylinder soot levels can lead to high radiative heat transfer which promotes fuel vaporization. This, in turn, results in more locally fuel rich combustion which enhances the formation of soot.

An Experimental and Numerical Study of Sprays from a Common Rail Injection System for Use in an HSDI Diesel Engine
Paul J. Tennison, Thierry L. Georjon, Patrick V. Farrell, and Rolf D. Reitz
SAE 980510

An experimental and numerical characterization has been conducted of a high-pressure common rail diesel fuel injection system. The experimental study was performed using a common rail system with the capability of producing multiple injections within a single cycle. The injector used in the experiments had a single guided multi-hole nozzle tip. The diesel sprays were injected into a pressurized chamber with optical access at ambient temperature. The gas density in the chamber was representative of the density in an HSDI diesel engine at the time of injection. Single, pilot, and multiple injection cases were studied at different rail pressures and injection durations. Images of the transient sprays were obtained with a high-speed digital camera. From these images spray tip penetration and cone angles were obtained directly. Also spray droplet sizes were derived from the images using a light extinction method (LEM).

The quantitative and qualitative information from the experimental measurements helped test extensively and assess spray models used in KIVA-II within the context of injection in a high-speed bore diesel engine. A breakup model which has been previously used successfully to predict spray behavior in heavy duty diesel engine was considered in this paper: Kelvin-Helmholtz and Rayleigh-Taylor instabilities were considered for modeling spray breakup, and a breakup length accounted for the intact core region. An additional drop collision regime (coalescence followed by separation for near head-on collision) was also tested in this study to see its importance in high pressure diesel sprays. Its effect is to reduce the droplet size by about 8% during
the injection. The computations are in fairly good agreement with the spray tip penetrations, and provide trends about drop sizes measurements.

**Powertrain Simulation Using Modular Components**

**Joseph W. Anthony and John J. Moskwa**

SAE 980926

Powertrain simulation is becoming an increasingly valuable tool to evaluate new technologies proposed for future military vehicles. The powertrain of the M1A1 Abrams tank is currently being modeled in the Powertrain Control Research Laboratory (PCRL) at the University of Wisconsin-Madison. This powertrain model is to be integrated with other component models in an effort to produce a high fidelity simulation of the engine vehicle.

**Team Paradigm**

Although not an ERC project, the Mechanical Engineering Department's student project on hybrid cars may be of interest to readers of the Newsletter. The project, guided by Professor Milestone and ERC Associate Scientist Glenn Bower, resulted in the following Congress paper.

**Design of a Charge Regulating, Parallel Hybrid Electric Future Car**


SAE 980488

Students, as members of Team Paradigm, at the University of Wisconsin-Madison have designed a charge regulating, parallel hybrid electric Dodge Intrepid for the 1997 FutureCar Challenge (FCC97). The goals for the Wisconsin "FutureCow" are to achieve an equivalent fuel consumption of 26 km/L (62 mpg) and Tier 2 Federal Emissions levels while maintaining the full passenger/cargo room, appearance, and feel of a stock Intrepid. These goals are realized through drivetrain simulations, a refined vehicle control strategy, decreased engine emissions, and aggressive weight reduction. The vehicle development has been coupled with 8,000 km of reliability and performance testing to ensure Wisconsin will be strong competitor at the FCC97.

**A Nice Exchange**

Professor John Moskwa had an exceptional opportunity to spend a sabbatical year in England at Cambridge and Ford starting last fall, but who would cover his teaching and research duties? As luck would have it Dr. Gordon Wright (picture at left) wished to cap a distinguished career in industry, where he had spent 20 years at Deere & Company and 10 years at Ford Motor Company, by becoming a professor of mechanical design. He had contacted U.W.-Madison for this purpose, because of his many past contacts with ERC faculty. As Gordon puts it, he wanted to spend a year as "Professor in Training" to prepare himself for this career change. As a result Gordon is occupying John's office in Madison and John is busy in England - a brief report from John is given below.

Gordon has been kept busy teaching a thermal systems lab course, advising the Future Car design team and working with Moskwa's graduate students. In addition he will also teach the senior capstone design course this spring. He says he is enjoying the experience very much despite the long hours.

**Moskwa In England**

Professor John J. Moskwa is on sabbatical in England for the 1997-98 academic year. He is keeping busy as a Visiting Scholar at the University of Cambridge, and is pursuing powertrain systems research with the Advanced Powertrain Group at Ford Motor Company's R&E Centre in Dunton.

His work at Ford focuses on addressing powertrain robustness issues in future vehicle system design. In Europe there are extreme market pressures to reduce vehicle costs, and one way to accomplish this is to reduce the number of non-essential, high-cost sensors in the powertrain systems. In doing this, there is a heightened need to assure the proper operation of these systems over the life of the vehicle. This is thought of in the industry as robustness to vehicle ageing, environmental factors, manufacturing variability, and influences from other systems or sensor faults. He has developed new methodologies for examining the robustness of powertrain systems, and for including robustness considerations earlier in the system design process.

Ford Motor Company is also making a major shift in their development process for future powertrain control systems, and has formed a partnership with MathWorks, Inc. (providers of the MATLAB, and SIMULINK, software). Ford is also using digital signal processing tools from dSPACE, GmbH (providers of rapid prototyping hardware) to integrate software and hardware in this powertrain control development process. These tools will form the basis for development of Ford's future powertrain system controls and diagnostics development, and the control strategies for vehicles introduced to the marketplace in future years. The robustness tools Professor Moskwa has developed will be coded in SIMULINK, 2 this year, and can be integrated with, used to analyze the output from other powertrain system models currently being developed at Ford's R&E Centre, as well as Ford's Scientific Research Lab. He will also be making a presentation of these new ideas at Ford's Forschungszentrum Aachen (FFA), which is Ford's European research laboratory in Aachen, Germany.

Professor Moskwa is collaborating with Professor Keith Glover at the University of Cambridge. Keith Glover and John Doyle are two of the top researchers in the world in H-Infinity multivariable control, and are authors of the Robust Control Toolbox for MathWorks', Inc. MATLAB, software. The research
group at Cambridge is exploring the transient emission characteristics of modern catalysts, and methodologies in how to control the engine/catalyst system with the goal of reducing vehicle tailpipe emissions. This is a systems-level research initiative funded by Ford which includes the catalysis research group of Professor Richard Lambert at the University of Cambridge. Another important researcher at Cambridge who is involved in this initiative is Professor Nick Collings. He is best known as the force behind Cambustion, Ltd.; a company that makes the fastest transient hydrocarbon analyzers available today.

A New SAE Fellow

The ERC is very proud that Professor Rolf Reitz will be honored by becoming an SAE Fellow this February at the Congress. His elevation to fellow grade is based on his many contributions to CFD modeling of engines and fundamental studies of spray phenomena. This honor adds to his many others, including authorship of two SAE Honoring Award papers.

ERC Hosts ASME Meeting

The Internal Combustion Engine Division of ASME held its 1997 Fall Technical Conference in Madison from September 28 through October 1. The ERC organized and hosted the conference, and over 150 people attended.

The theme of the conference was "Predictive Engine Design, Validation, and Experiment" which is in keeping with the work of the ERC. There were presentations made by a wide range of people from industry, universities, and US government facilities. There were technical sessions on engine design, combustion, and emissions; analytical and multi-dimensional modeling; engine controls, alternative fuels, and natural gas engines. Six presentations from the ERC highlighted the work in engine modeling and advanced diagnostics.

In addition to the technical sessions, there was a tutorial on Active Noise and Vibration Control given by Dr. Larry Eriksson of Nelson Industries. Professor Gary Borman gave the Soichiro Honda Lecture. The title of his presentation was "Pathways to Achieving a New Generation of Engines for Personal Transportation." On the final day of the conference there was a tour of the ERC facilities on the University of Wisconsin Campus. This was attended by approximately 60 people.

The ASME ICE Division meetings always include several social events. At the Madison meeting, there were several receptions and an honors banquet. In addition, there was a dinner at the recently completed Monona Terrace Convention Center situated on the lake front in downtown Madison. The Monona Terrace is based on original designs by Frank Lloyd Wright from the time he lived in and around Madison. There were also spouse trips that include a tour of the House on the Rock, several Wright Buildings, and Olbrich Botanical Gardens.

Reeve’s Returns to U.K.

Dr. Mark Reeves has recently finished a two-year post-doc at the ERC and is currently employed at Rover. During his stay at the ERC, Dr. Reeves worked with Mark Musculus and Prof. Pat Farrell to study NO fluorescence with the intention of developing methods to measure transient NO concentration in a diesel engine, under normal firing conditions.

The technique selected for investigation was 2-photon NO fluorescence. In this method, a NO molecule absorbs two visible photons (454 nm), and under the right circumstances, one UV (252 nm) photon is emitted. This method has several advantages in the engine environment, most significantly the laser probe beam is in the visible range, rather than in the UV as would be required for single photon fluorescence of NO. Visible light is much easier to handle in the laboratory, and UV probe beams are likely to cause a wide range of chemicals in the cylinder (fuel, soot, ...) to fluoresce, making accurate assessment of NO levels difficult to impossible. In addition, the probe and fluorescence frequencies are spread quite far apart, making the task of filtering out-probe beam scatter and Mie scatter easier. Finally, the fluorescence signal depends on the square of the probe laser intensity, making spatial localization straightforward.

The 2-photon method also has some disadvantages, including low signal levels which makes single shot imaging not possible with the hardware available to us; normally the 2-photon transitions can not be saturated, making quantitative measurements in the presence of quenching problematic, without in situ calibration.

The 2-photon method was tested in an NO cell to determine sensitivity, linearity, and the effects of oxygen quenching on the signal. With 6 mW of probe laser power (at 454 nm) concentrations as low as 200 ppm were easily identified, when no Oxygen was present. With oxygen, the signal level decreased dramatically; in air, for example, the NO fluorescence (at 800 ppm NO) signal falls to about 15% of its peak value in N. While full-field imaging was not possible with the hardware available, a line image could be obtained for low quench gas levels.

A series of single point tests were performed in a propane-air flame to measure NO in an atmospheric pressure combustion situation. Single point measurements were made at different equivalence ratios to illustrate the variation of NO production as the flame equivalence ratio was varied. The variation of NO with equivalence ratio was as expected, but in this kind of experiment, the variation of NO signal with equivalence ratio represents the combination of changes in local NO concentration and local quenching.

The instrumentation development and preliminary experiments performed by Dr. Reeves represent a very useful base of information to use in continuing development of this type of diagnostic tool. Hardware improvements and some develop-
ments in technique and in analysis of the experimental results should make this method a useful tool for NO measurement in the future.

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Georjon Returns to France

Thierry Georjon has just finished his 15 months stay at the ERC, which was within the context of his French national duty. His stay was sponsored by PSA Peugeot Citroen. Thierry has worked on diesel non-evaporating spray modeling efforts with Prof. Rolf Reitz.

He has studied sprays from a Common Rail injection System for use in a High Speed Direct Injection Diesel engine. The information obtained from the experimental results conducted at the ERC by Paul Tennisson was used to help test and assess spray models used in KIVA-II. A breakup model, which has been previously used successfully to predict spray behavior in heavy-duty engine was considered; Kelvin-Helmholtz and Rayleigh-Taylor instabilities were considered for modeling spray breakup, and a breakup length accounted for the intact core region near the nozzle. The predicted spray tip penetrations matched the experiments fairly well for all the 8 cases studied, which included two rail pressures (900 and 1200 bar) and multiple (pilot and split) and single injection cases. The prediction of the Sauter Mean Diameter was shown to be very sensitive to the details of the spray models, and only trends could be highlighted. The predictions were found to agree with measured drop sizes during the main part of the injection. Discrepancies were noted at the end of the injection that were thought to be due to droplet coalescence phenomena. Accordingly, Thierry studied the influence of additional regimes of collision on the structure of the diesel spray. The collision dynamics of liquid droplets was found to be important in dense sprays. For binary collisions between drops, the outcome may result in coalescence or separation (grazing) and the transition between these two regimes (that are considered in the KIVA-II code) is rather well established. However, other regimes have been identified in recent studies, such as coalescence followed by separation for near head-on collision (reflexive separation). The effects of this additional regime were considered and were only to give a very slight reduction of the droplet size. These results are summarized in the SAE Paper 980810.

However, neither drop satellite formation nor drop shattering were accounted for in these collision models. To address this shortcoming, Thierry has proposed a new simplified model of drop shattering collision. It is assumed that the two droplets that have collided with a sufficient collisional Weber number will be transformed into a cylindrical droplet. As this combined mass elongates under the impulse of the collision, based on Rayleigh linear jet breakup theory, some capillary wave induced disturbances can grow, and if the time needed for them to develop is lower than the time taken by the two ends of the cylinder to retract, they eventually break it. The equation of the dynamics of the 'cylindrical' droplet was derived and is conceptually similar to the DDB drop breakup model. The model was implemented into the KIVA-II code and the experiments on collisional behavior of hydrocarbon droplets of Calvin Hung from the ERC served as a basis of validation. These experiments consider the collision of two aerodynamically stable streams of droplets at three different intersection angles. Predicted size and velocity distributions of the children droplets obtained with the new shattering collision model were compared with the experimental results obtained by using a PDPA. Even though the sizes and velocities of the children droplets were somewhat over-predicted, the model seems to be capable of predicting atomization due to collision.

PCRL Update

Dr. Moskwa's research group in the UW Powertrain Control Research Laboratory (PCRL) have used the SIMULINK, and dSPACE tools for many years in the development of their transient dynamometer system, and in their powertrain system modeling research. Last year PCRL purchased a Combustion 2-channel fast-FID HC analyzer for analyzing transient emission behavior. This positions this laboratory at the forefront of transient powertrain research capability. Some important world-wide web links for further reading include:
- MathWorks, Inc.: <http://www.mathworks.com/>
- SIMULINK®/PCRL: <http://www.mathworks.com/industry/autosers.shtml>
- dSPACE: <http://www.dspace.de/>

More ERC News

Readers who wish to learn more about the ERC are invited to visit our Website: http://www.engr.wisc.edu/centers/erc

New Text Book

Mechanical Engineering Department Chair Professor Ken Ragland and retired ERC Professor Gary Borman have authored a text book on the application of combustion to practical devices. The book titled "Combustion Engineering and published by Mc Graw-Hill is to be available in February 1998.
1997 Graduates

Mark Casarella, M.S., 1997
"The Effects of Spray Characteristics on Combustion and Emission Performance of a Two-Stroke Direct-Injection Engine"

Michael Chan, M.S., 1997
"Modeling Multiple Injection, EGR, and Nozzle Hole Effects on D.I. Diesel Engine Emissions"

Chan-Teng Chang, Ph.D., 1997
"Experimental Study of Diesel Spray Characteristics and Atomization"

William Edward Church, M.S., 1997
"Effect of Intake Runner Angle on Tumble Motion Utilizing PTV in an Optically Accessible Engine"

Stephen Ciatti, M.S., 1997
"Spark Ignition Effects on Two-Stroke Cyclic Variability"

Richard John Donahue, Ph.D., 1997
"Experimental Studies on Ring Pack Design Parameters and The Analysis of Radial Ring Collapse"

Tina Fuchs, M.S., 1997
"Intake Flow Effects on Combustion and Emissions in a Diesel Engine"

Gregory Hampson, Ph.D., 1997
"A Theoretical and Experimental Study of Emissions Modeling for Diesel Engines with Comparisons to In-Cylinder Imaging"

Steven L. Miller, M.S., 1997
"Comparison of Motored and Fired Velocities in a Two Stroke Engine"

Marcus O'Brien, M.S., 1997
"Characterization of a Reaction Turbulent Shear Layer"

Scott Parrish, Ph.D., 1997
"Spray Characterization in a Motored Direct-Injection Spark-Ignited Engine"

Mark Andrew Patterson, Ph.D., 1997
"Modeling the Effects of Fuel Injection Characteristics on Diesel Combustion and Emissions"

John D. Plackmann, M.S., 1997
"The Effects of Mixture Stratification on the Combustion Process in a Constant-Volume Combustion Vessel"

David Schmidt, Ph.D., 1997
"Cavitation in Diesel Fuel Injector Nozzles"

Paul J. Schweiger, M.S., 1997
"A Study of Measured Versus Simulated Scavenging Flows in a Motored Two-Stroke Engine"

Stefan Simescu, Ph.D., 1997
"Experimental and Computational Studies of Combustion and Instantaneous Heat Transfer in a Ceramic Diesel Engine"

Herman Emil Snyder, Ph.D., 1997
"Efficient Liquid Atomization Using Gas Flows and Novel Micro-Machining Techniques"

Brad Tillock, MS., 1997
"Thermal Analysis Metrology for Air-Cooled Engines"