CHAIR’S MESSAGE

John Hedrick

I would like to take this opportunity to update you on some changes to the ASME organization, strides that the Internal Combustion Engine Division is making to offer the highest value to our technical conference attendees, and the Division’s efforts to increase student participation.

ASME has recently moved its headquarters from 3 Park Avenue to 2 Park Avenue in New York City. While this does not sound like much of a change, it represents a large change for ASME. The new ASME facility has 100,000 square feet of office and meeting space (30,000 square foot more space than their old facility) that can accommodate up to 300 staff. This new facility offers ASME the opportunity to increase the staff from the current level of 250 and gives ASME the space to meet ever expanding demands and opportunities. If you are interested in more information about the new ASME headquarters, you can read an article about the new facility at http://www.rew-online.com/2013/02/20/engineers-move-to-100000-sf-headquarters/

There also has been a major revamping of the ASME.org website. The new website has an enhanced home page, better site navigation, and a number of new community features that allows users to:

• Register with the website.
• Create professional profiles.
• Connect with other ASME group members that share similar technical interests.
• Join and then follow various technical Groups within ASME.

Registering as an ASME.org participant is free and open to everyone; you don’t have to be an ASME member to become a participant on the website. It is hoped that this new ASME website will assist you with your professional development. There is a video that helps explain the new ASME website at https://www.asme.org/career-education/media/training/video-asmeorgs-new-community-features.

A lot of work has been done inside the ICE Division to offer the highest value to our technical conference attendees. This process started 2008 when the ICED Executive Committee made a number of changes to the Division’s conference model to increase the technical value of the conferences. These original changes focused on:

1. Increasing international conference participation by holding an overseas conference once every three years (in the spring).
2. Increasing the technical relevance of the conferences by holding one fall technical conference every year in North America. Other changes that have been put in place by the ICED Executive Committee, in the past 5 years, are:

• The process to fast track outstanding technical papers to the Journals associated with the Division.
• Offer more technical panel discussions at the conference.
• Offering excellent lunch time industry presentations.
• Increasing student participation.

The outcome of these changes has been impressive. The attendance of the conference has been increasing and the increase in quantity and (more importantly) the quality of the technical papers has been impressive.

Students of Mechanical Engineering are the future of the IC industry and our ASME Division. Recognizing that student attendance has been historically low, efforts have been made to increase student participation. These efforts have focused on reducing the conference registration rate for Student ASME Members and offering an Undergraduate Mechanical Engineering Students Presentation competition.

Prof. Will Northrop of University of Minnesota is the Chair of Student Presentations. Prof. Northrop, and a small team of reviewers, review and accept 1000-word abstracts and draft presentations submitted by undergraduate students. The top two presentations are selected and the authors are invited to the Fall Technical Conference where they give the Undergraduate Student presentations at the Tuesday lunch at our technical conference. As a participant of the conference, they get to attend other presentations and network with other attendees that work in the field of IC engines. The student’s continued on page three
Past Chair’s Message

Steve Ciatti

It has been an honor to serve as the IC Engine Division Chair for the past year and a half and I look forward to the upcoming year to serve in the role of Past Chair. The year has gone rather quickly! The six years that I have served on the ICED Executive Committee have passed swiftly. It seems only a short time ago that I attended my first ICE conference in 2001 hosted by Argonne National Laboratory (coincidentally my new employer) and the conference took place directly after 9/11 - which created significant challenges regarding attendance and security for our attendees. I gave a presentation based upon my doctoral dissertation work from the University of Wisconsin-Madison and I left the conference with a very good impression about this new group of engine people.

Several Argonne researchers were already ASME members (my supervisor, Raj Sekar, is an ASME Fellow), so I was highly encouraged to continue to participate in ASME ICED. I began by reviewing papers and chairing conference sessions. After the conference in Erie, PA in 2003, I joined the Board of Associates and took a more active role in the division’s activities. Eventually, I was asked to join the Executive Committee. This year, the accomplishments of the ICED Executive Committee and the Board of Associates have included some significant events. The 2012 Fall Technical Conference, hosted by Westport Innovations, Inc. in Vancouver, BC, was a highly successful conference! The conference had an excellent keynote speaker in Dr. Patric Ouellette, from Westport Innovations, who discussed a very timely topic, “Technology Choices for Up-and-Coming New Applications of Natural Gas as an Engine Fuel” and a strong technical program consisting of roughly 100 technical papers and presentations. The conference was also very well attended with 199 registrants. In addition, one of the lasting items of which I am very proud is the effort of ICED to invest in the future of engineering by providing university students with discounted registration at our conferences. As these students interact with engine professionals from around the globe, their business and career opportunities will be greatly enhanced by their participation – supported by ICED.

Holding a conference every three years outside North America has continued to be a goal of the Executive Committee to serve a broader membership. The next international conference is tentatively planned to be in Beijing, China in the spring of 2015, hosted by Tsinghua University. As I move forward in my own career, I have found that building these international relationships will be critical to the engineering profession and to the future of the IC engine research/operation. As outgoing Chair, there is no greater honor than to work with a fine group of engine professionals. I would like to thank my employer Argonne National Laboratory for their support of ICED conference attendance and allowance to serve you as an ICED Executive Committee member. A year ago, in my message as incoming Chair, I urged you to increase your participation in the ICE Division by attending our conferences, volunteering for numerous divisional activities and/or hosting a conference. There are numerous changes, both regulatory and market-based, happening all over the world that are heavily dependent upon energy and transportation. The IC Engine community will become even more vital to these changes – and the ICED community will be there to help you navigate these technological changes with access to the latest research, product development and personal networking with the engine community.

Incoming Executive Committee Member Robert M. Wagner

Dr. Robert Wagner is the Director of the Fuels, Engines, and Emissions Research Center at Oak Ridge National Laboratory and on the faculty of the Bredesen Center for Interdisciplinary Research and Graduate Education at the University of Tennessee. His interests and expertise include low temperature combustion, combustion instability phenomena, thermodynamics, and adaptive controls. He has also led several efforts to improve the integration of diverse disciplines including high performance computing, neutron sciences, and material sciences to further the development of advanced transportation technologies.

Robert is a member of several government-industry technical teams and working groups that provide guidance to DOE in developing technical roadmaps and establishing and meeting long-term efficiency goals. He is a Fellow of the Society of Automotive Engineers (SAE); past Chairman of the SAE Combustion & Fuels Committee; and an organizer for multiple SAE international symposiums on high efficiency transportation technologies. He is also a member of the Executive Committees of the SAE Powertrain, Fuels, and Lubricants activity and the DOE sponsored U.S.-China Clean Energy Research Center on Clean Vehicles. Robert is an Associate Editor of the SAE International Journal of Engines and on the editorial board of the International Journal of Engine Research. He has authored over 100 technical publications, a book chapter, and two patents. He is also a frequent invited speaker on the topics of high efficiency combustion, engine instabilities, adaptive controls, and the long-term outlook of high efficiency transportation technologies.

Robert is looking forward to the challenges and opportunities of this new position with the division. He hopes his background and experience with other technical organizations will help him contribute to the ASME tradition of excellence in fostering dialog among international experts to accelerate the development of the next generation of high efficiency engines.
Fall 2012 Technical Conference a Success in Vancouver

Timothy Jacobs and John Hedrick

The IC Engine community descended upon the recent host of the 2010 Winter Olympics, Vancouver, British Columbia, as it attended ASME Internal Combustion Engine Division's 2012 Fall Technical Conference. The conference, held at the Sheraton Wall Centre in downtown Vancouver, was hosted by local natural gas engine manufacturer Westport Innovations, Inc and featured over 100 technical presentations attended by nearly 200 attendees. After the warm welcoming reception on Sunday (September 23, 2012), the technical program officially began on Monday with keynote presentation delivered by Dr. Patric Ouellette, Vice President and Chief Technology Officer for Westport Innovations. Dr. Ouellette's presentation focused on the progress made in natural gas technology for transportation applications and the future direction and challenges facing this growing and important industry.

Following Dr. Ouellette’s opening presentation, the technical program continued with five parallel technical tracks that between Monday and Tuesday featured 93 paper presentations. Integrated within the two day technical program were the awardee presenters of the Undergraduate Student Presentation Competition, an expert panel on natural gas for IC engines, and the Tuesday Luncheon Industry Speaker. The winners of the Undergraduate Student Presentation Competition, Mr. F. Zak Tilocco from Kettering University and Mr. David Vuilleumier from University of California – Berkeley, presented their work during the Monday Luncheon. This is the second year of this successful program, coordinated by Professor Will Northrop (University of Minnesota) which has thus far provided paid expenses for three undergraduate students to attend the ASME IC Engine Division’s Fall Technical Conferences. The expert panel, organized by Dr. Apoorv Agarwal (Ford Motor Company), on natural gas for IC engines featured Professor Jim Wallace (University of Toronto) as moderator and Mr. Mark Dunn (Westport Innovations), Mr. Michael Iden (Union Pacific Railroad), and Dr. Riccardo Scarcelli (Argonne National Laboratory) as expert panelists. Finally, the technical program integrated the now-annual Tuesday Luncheon Industry Speaker by hosting Mr. Dick C. Kauling, Engineering Manager of the Gaseous Fuel Technical Resource Centre at GM Powertrain.

Plan to Attend the 2013 Fall Technical Conference in Dearborn, Michigan

Brad Zigler

The ASME Internal Combustion Engine Division is pleased to announce details of its upcoming 2013 Fall Technical Conference to be held October 13th-16th, 2013 in Dearborn, Michigan and hosted by Wayne State University. The venue for this year’s conference will be The Dearborn Inn. Initial interest has been outstanding, with the possibility of presenting a record number of papers. The technical program is planned to include the following:

1. Technical papers presented by leading researchers from around the world,
2. Keynote address by Tom McCarthy, Chief Engineer for Powertrain Research & Advanced Engineering at Ford Motor Company,
3. Two panel discussion sessions focusing on fuels and controls topic areas,
4. Presentations from undergraduate students who will compete through an international competition for awards to attend and participate in the conference,
5. Lunch presentation by Dr. Robert Wagner, Director of the Fuels Engines and Emissions Research Center at Oak Ridge National Laboratory,
6. Technical tours of Wayne State University, including the Center for Automotive Research.

The technical presentations, exhibits, and collegial atmosphere fostering networking, discussion, and collaboration that advance engineering and science for internal combustion engines. Reduced registration fees encourage student participation, offering employers a unique opportunity to recruit next-generation experts to their organizations. The Honors and Awards Banquet on Monday, October 14th is a special annual event to recognize the outstanding achievements and dedicated efforts of Internal Combustion Engine Division colleagues.

Registration will soon be open, with early-bird registration rates initially available through the 2013 Fall Technical Conference website: http://www.asmeconferences.org/ICEF2013/

For more information, please contact:

Administrative Questions
(including sponsorship or exhibitor opportunities):
Steve McConnell
Argonne National Laboratory
smcconnell@anl.gov

Technical Program Questions:
Bradley Zigler
National Renewable Energy Laboratory
brad.zigler@nrel.gov

Travel and lodging expenses are covered up to $1500. The only requirements are:
• The competitor must be an ASME student member.
• Be an undergraduate student on the date of submission.

In closing, I would like to thank all of the people that make my Chairmanship possible. These include, but are not limited to, Erin Dolan and Robert Powers of ASME, Dr. Frank Aboujaude (Former Chair and current Division Treasurer), Neil Blythe (Former Chair and current Division Secretary), Stuart Neil (Former Chair), the rest of the Executive Committee. Last, but not least, I would like to also thank the ICED Associates and all of the other volunteers that review papers, chair and co-chair technical sessions, and work hard to make our conferences excellent.
his presentation centered on the advancements made to integrate natural gas vehicles into the marketplace.

The technical program concluded on Wednesday with the technical tours of Westport Innovations, Inc. The technical tours continue to be popular, with over 100 attendees participating in the tours!

One key benefit of presenting research and engineering development with the ASME Internal Combustion Engine Division is the Division’s relationships with two ASME journals: *Journal of Engineering for Gas Turbines and Power* and *Journal of Energy Resources Technology*. Conference papers may be recommended for journal consideration if they embody clear demonstration of long-term impact / archival quality, and include discussion and indications of data uncertainty. Some papers of exceptional quality and impact are recommended for “fast-track” publication, which uses the high-quality conference reviews as substitutes for the journal reviews. For this conference, around 20 conference papers were recommended up to the journal for fast-track publication. Also continuing for this conference is the popular “paper type” designations of either scholarly research articles or engineering applications articles. These paper type designations increase the opportunities for authors to disseminate their work and offer improved broader impact of technological advancements to the IC engine community.

The conference also played host to the newly established US CIMAC NMA, a collection of North American based organizations who contribute to being participating members in CIMAC. The ASME IC Engine Division is a paying member of the US CIMAC NMA, and thus its primary members (associates) are eligible to receive the corresponding benefits. Details of such benefits are generally disseminated through the Associates Meeting minutes as well as through the Listserv (email distribution).

Finally, as is tradition with the Fall Technical Conference, the IC Engine’s Honors and Awards Banquet, organized by Dr. Abnash Narula (Wm. Nugent Company), was held Monday night and acknowledged many of the leading contributors to the Division and the IC engine community in general. The banquet began with Toastmaster Mr. John Hedrick (Southwest Research Institute) acknowledging the contributions of the Division chair, Dr. Stephen Ciatti (Argonne National Laboratory). Similarly, outgoing Division chair, Mr. W. Stuart Neill (National Research Council Canada) was recognized with the ASME Retiring Chairman Certificate. In recognition of excellent presentation, Mr. Benjamin Lawler (University of Michigan) received the ICE Division Speaker Award. Likewise, in recognition of excellent technical paper contribution, Drs. Uwe Wagner (Karlsruhe Institute of Technology KIT) and Ulrich Spicher (Institut für Kolbenmaschinen KIT) received the ICE Division Most Valuable Technical Contribution award.

The banquet also included the following awards, presented at the ICED 2012 Fall Technical Conference in Vancouver, BC.

**ICE Division Award Recipients**

The following awards were presented at the ICED 2012 Fall Technical Conference in Vancouver, BC, by Abnash Narula.

**Keynote Speaker Award**  
Dr. Patric Ouellette, Chief Scientist, Westpoint Innovations.

**ICE Division Speaker Award**  
Benjamin Lawler, University of Michigan.

**Richard S. Woodbury Award**  
Greg Gutoski, Fairbanks Morse Engine.

**Most Valuable Technical Contribution**  
Dr. Uwe Wagner, Karlsruhe Institute of Technology, Germany.  
Dr. Ulrich Spicher, Institut für Kolbenmaschinen Karlsruhe Institute of Technology, Germany

**Internal Combustion Engine Award**  
Dr. Nicholas Cernansky, Drexel University.

**Luncheon Speaker Award**  
Dick C. Kauling, Engineering Manager, General Motors Powertrain Division.

**Local Arrangements Award**  
Westpoint Innovations Inc.

**ASME Retiring Certificate**  
W. Stuart Neill, National Research Council, Canada.

**Recognition of Undergraduate Student Presenters at Conference**  
F. Zak Tilocco, Kettering University  
David Vuilleumier, University of California, Berkeley

In addition, our Special Congratulations go to Mr. Scott Curran, Second Prize winner of the ASME 2013 Old Guard Early Career Award.
CALL FOR PAPERS

Internal Combustion Engine Division ASME International
Invites Papers for the 2014 Fall Technical Conference
October 19 - 22, 2014
Columbus, Indiana, USA
Hosted by Cummins Inc.

Papers of high technical quality related to the development, advancement, and improved understanding of the internal combustion engine are sought for the ASME Internal Combustion Engine Division's 2014 Fall Technical Conference to be held October 19 - 22, 2014 in Columbus, Indiana and hosted by Cummins Inc. In addition to two days of technical presentation of accepted papers, the conference highlights networking activities among members of industry, government, and academia. This includes keynote speakers, student presentations, industrial tours, a banquet, and an overall collegial atmosphere to advance the state of the art of the internal combustion engine.

All offers relating to the internal combustion engine, or interfaces with internal combustion engines, are accepted for rigorous review by experts in the field. Specifically, accepted papers are generally grouped into one of the following technical tracks (with corresponding track chairs listed for contact):

- **Track 1: Large Bore Engines** (Dr. Thomas Lavertu, lavertut@ge.com)
- **Track 2: Fuels** (Professor Scott Miers, samiers@mtu.edu)
- **Track 3: Advanced Combustion** (Professor Kalyan Srinivasan, srinivasan@me.msstate.edu)
- **Track 4: Emissions Control Systems** (Dr. Stani Bohac, sbohac@umich.edu)
- **Track 5: Instrumentation, Controls, and Hybrids** (Mr. David Gardiner, dgardiner@nexumcorp.com)
- **Track 6: Numerical Simulation** (Professor Caroline Genzale, caroline.genzale@me.gatech.edu)
- **Track 7: Engine Design, Lubrication, and Applications** (Dr. Dan Richardson, dan.e.richardson@cummins.com)

Accepted papers that are presented at the conference will be archived on the conference proceedings CD. Presentation of papers at the conference requires payment of the registration fee (papers not presented at the conference are excluded from the conference proceedings CD, considered not published, and not archived). Accepted papers must transfer copyright to ASME, with certain exceptions noted. The ASME ICE Division's Presentation Policy and the ASME Copyright Policy are respectively available at:

- [https://www.asmeconferences.org/ICEF2014/PubPolicy.cfm](https://www.asmeconferences.org/ICEF2014/PubPolicy.cfm)
- [https://www.asmeconferences.org/ICEF2014/PubForms.cfm](https://www.asmeconferences.org/ICEF2014/PubForms.cfm)

Offerors may submit papers of two types: 1) scholarly research articles and 2) engineering application articles (with strict policy of no commercialization). Scholarly research article is meant to provide high-level details of original research centered on hypothesis-based reasoning and methodical approach to discovering new scientific and/or technical knowledge. Engineering application article is meant to be a public reporting of preliminary and / or novel engineering development. All papers will be reviewed appropriately per their type. Accepted articles of highest quality and with potential for long-lasting technical contribution may be considered for journal publication in ASME's Journal of Engineering for Gas Turbines and Power or Journal of Energy Resources Technology.

Please submit your 400-word or less paper offer / abstract by Friday, January 24, 2014 at the conference website:

[www.asmeconferences.org/ICEF2014](http://www.asmeconferences.org/ICEF2014)

For additional information or questions, please contact the technical program chair:

Dr. Robert Wagner, Oak Ridge National Laboratory, wagnerm@ornl

**IMPORTANT DATES:**

- January 24, 2014 400-word paper offer / abstract due
- March 28, 2014 Draft manuscript due for review
- June 15, 2014 Final manuscript, copyright, and author paid registration due
Incoming ICE Division Associates

We are pleased to welcome the following individuals as Associates to the ICE Division.
1. Mr. Munidhar Biruduganti – mbiruduganti@anl.gov
2. Dr. Sibendu Som – ssom@anl.gov
3. Dr. Marcis Jansons – mjansons@wayne.edu
4. Dr. P.K. Senecal – senecal@convergecfd.com
5. Dr. Usman Asad – uasad@ford.com
6. Dr. Samveg Saxena – samveg@berkeley.edu
7. Mr. Scott Curran – curransj@ornl.gov
8. Dr. Shahrokh Etemad – setemad@fairfield.edu
9. Dr. Fabrizio Ponti – fabrizio.ponti@unibo.it
10. Dr. Yuanhong Li – Li_Yuanhong@cat.com
11. Dr. P.K. Senecal – senecal@convergecfd.com
12. Dr. Patrick Kirchen – pkirchen@mit.edu
13. Ms. Lara Sherefkin – Lara.Sherefkin@cummins.com
14. Dr. Robert Prucka – rpucka@clemson.edu
15. Dr. Mark Patterson – Mark.Patterson@c-a-m.com
16. Dr. Robert Wagner – wagnerrm@ornl.gov

ASME ICE Division Sponsorship Opportunities for 2014

If you are benefiting from participation in the ASME Internal Combustion Engine Division, please consider the Division in your company's sponsorship plan for 2014. The Division offers numerous sponsorship opportunities for our upcoming 2014 fall conference in Columbus, Indiana, including:

- Welcome reception
- Undergraduate student presentations
- Meal or networking break
- Awards banquet
- General Division sponsorship

In addition, there are a limited number of spaces for companies to exhibit their products at our 2014 fall conference. Please contact Mr. Stuart Neill (stuart.neill@nrc-cnrc.gc.ca) for further details.

ICED Executive Committee Members (2013-2014)

CHAIR
Mr. John Hedrick
Southwest Research Institute

PAST CHAIR
Dr. Steve Ciatti
Argonne National Laboratory

VICE CHAIR (TECHNICAL)
Dr. Timothy Jacobs
Texas A&M University

VICE CHAIR (ADMIN)
Mr. Steve McConnell
Argonne National Laboratory

ASSISTANT VICE CHAIR (TECHNICAL)
Dr. Bradley Zigler
National Renewable Energy Laboratory

ASSISTANT VICE CHAIR (ADMIN)
Dr. Diana Grauer
Cameron

INCOMING MEMBER
Mr. Neil Blythe
GE Transportation

SECRETARY
Dr. Frank Aboujaoude
Fairbanks Morse Engine

TREASURER
Fairbanks Morse Engine

Excerpt of 2012 Fall Technical Conference Report

DieselNet attended many of the technical presentations at the 2012 Fall Technical Conference of the ASME Internal Combustion Engine Division. Following is a summary of their findings:

Locomotive engines

While the conference has evolved to cover all sizes and applications of internal combustion engines, large bore engines have traditionally received a lot of attention. This year, several large bore engine papers focused on emission control, a trend driven in part by the approaching US EPA Tier 4 (2015) locomotive emission standards, locomotive upgrade requirements under the voluntary agreements between railways and the California ARB and other local programs.

Paul Park of Caterpillar [Paper No. ICEF2012-92198] discussed SCR-based aftertreatment system designed for repowered locomotives to meet California low NOx targets. Five 2,240 kW (3,005 hp) PR30C line-haul Progress Rail locomotives equipped with the aftertreatment system have been operated in revenue service by Union Pacific. The aftertreatment module included 4 DOC catalysts (2x2), followed by urea injection and mixing and 16 SCR catalysts (4x4). All catalysts used metallic Emitec substrates, either round (606 mm diameter x 90 mm) or square (606x606x90 mm) with rounded corners, with 100 cpsi cell density. Resonance frequency analysis was used during the design process to ensure mechanical durability. Catalyst coating was supplied by BASF. The technical challenges included high percentage of idle in real operation and high SOF fraction of the PM emissions, especially at lower notches (98% SOF at idle, 72% at notch 1).

Dual DOC technology was used: a front DOC with high Pt on alumina, to provide protection from HC and the NO2 function, followed by a DOC with low Pt with Ce on alumina for SOF control. Vanadia-based technology was used for the SCR catalysts. The system included a 1,000 liter urea tank. High NOx conversions were achieved (87-90% above 1,000 C, 81-83% over the line haul cycle) with very low ammonia slip, even though the system did not include an ammonia slip catalyst. The control system utilized NOx sensors upstream and downstream of the catalyst module. The system controlled NOx, HC and CO emissions to below Tier 4 levels. PM emission reductions were 38-58%. Hence, with minor development, the system has potential for meeting Tier 4 standards in new locomotives.

One of the Progress Rail locomotives with the DOC+SCR system was evaluated at the Southwest Research Institute (SwRI) [92014]. The evaluation involved a field trial with data logging equipment installed and laboratory emission testing at 0, 1,500 and 3,000 hours. Cycle composite HC, CO, and NOx remained below Tier 4 limits, and PM remained at approximately half of Tier 3.
limits. Emissions remained stable, with the results from the 1,500-hour and 3,000-hour conditions similar to the 0-hour condition. NOx reductions during the field operation depended on the route and the percentage of idle, light- and heavy load operation. On average, NOx was reduced by 54% during the field trial. In total, the five PR30C-LE locomotives equipped with the aftertreatment system completed a cumulative 30,800 hours of revenue service through June 2012 without report of a major issue.

Development of a low emissions upgrade kit for EMD GP20D and GP15D switcher locomotives was discussed by Steve Fritz of SwRI [92128]. The 1,491 kW EMD GP20D locomotives are powered by Cat 3516B engines and the 1,119 kW EMD GP15D locomotives are powered by Cat 3512B engines, both units certified to Tier 1 emission standards. The upgrade kit was based on injection timing control, which was effective for NOx, but increased PM emissions. To control PM, a closed crankcase ventilation (CCV) system and a DOC were added to the kit. To further reduce PM, the DOC was replaced with a passive, catalyzed DPF in the final version of the upgrade kit that was certified to the EPA Tier 0+ emission standards.

In another talk, SwRI presented some initial results on a DPF retrofit kit for a 1500 kW multi-engine genset locomotive [92130]. The locomotive used for the project was BNSF1284, a 1,566 kW National Railway Equipment Company (NREC) model 3GS21B, powered by three Cummins QSK19 522 kW diesel-engine driven generator sets. The DPF was a catalyzed wall-flow filter supplied by GT Exhaust. It replaced the original muffler on each genset, with external modifications to the locomotive car body. With the DPF, PM emissions were at 0.016 g/kW-hr, or 60% below the Tier 4 limit. The locomotive accumulated 800 hours. The DPF performance will be tracked for 3,000 hours as required for California ARB verification.

While urea-SCR technology would likely provide the most fuel efficient locomotive solution, the introduction of SCR on locomotive engines would require an initial investment by the railways to develop urea infrastructure. Another problem is the sharing of locomotives between railways, which is a common practice in the North American rail industry. Unless SCR is universally adopted by all railways, the logistics of sharing locomotives would become much more complicated. For these reasons, EGR-based Tier 4 solutions are being developed in parallel to the SCR approach. EGR-based locomotive engines would most likely require particulate filters for PM control.

Union Pacific and Electro-Motive Diesel (EMD) [92167] shared their experience from the development of experimental EGR system on EMD SD59MX 2.238 MW freight locomotives. The project was started in 2008, with nine EGR locomotives and a tenth locomotive equipped with EGR and a whole-engine DPF delivered from late 2011 to mid 2012 and placed into service by Union Pacific in California. To make space for the EGR package, the locomotives, originally powered by 16-cylinder, Tier 0 engines, were repowered with shorter, 12-cylinder Tier 2 engines. The EGR package, which weighs over 1,800 kg, is supported by a steel structure bolted to the locomotive underframe next to the diesel engine. The EGR package includes a DOC+DPF system to ensure the gas re-introduced to the engine cylinders is clean. The cooled EGR is introduced back to the intake by a dedicated root blower. The whole-engine aftertreatment package on the tenth locomotive, including a DOC and a DPF, is located in a rooftop tray above the engine. The DPF system has been designed to include both a burner and an HC injection system for active regeneration. At a 10% EGR rate that was tested, the technology achieved a 42% NOx reduction with minor fuel consumption penalty and a 25% PM emission reduction on the Tier 2 engines.

Other Tier 4 oriented ideas presented by EMD included modified intake ports to improve scavenging [92046] and skewed injection for high swirl [92120]. The CFD investigation of the modified intake ports examined the possibility of achieving cooler, Miller like combustion in a 2-stroke engine. With raised intake ports and delayed exhaust valve closing, the temperature could be reduced by as much as 40°C. Future work will additionally consider EGR. The skewed injection study included some preliminary results with injecting fuel at different angles, along and against the swirl direction. While injecting against the swirl showed little benefit, injecting fuel with the swirl had potential for BSFC and soot reduction, but careful attention is needed to avoid wall impingement and spray interaction.

Locomotive upgrades are considered in many parts of the world. The Engine Development Directorate of the Indian Ministry of Railways [92208] has been developing an electronic fuel injection system for upgrading 4-stroke, 16-cylinder ALCO locomotive engines, originally equipped with a P-L-N injection system. Through the use of the electronic fuel system, BSFC could be reduced by 4% and smoke and PM at intermediate notches by as much as 70%.

**Combustion**

Traditionally, the conference program included a number of fine papers on combustion topics. ETH Zurich presented a fundamental study of the effect of post injections on diesel soot emissions using multi-color pyrometry [92075]. Among other things, they found that the time phasing of soot evolution has a significant impact on the optimal post injection dwell time. Soot reduction potential with post injection decreases rapidly when it is timed late in the soot oxidation phase. Soot oxidation can only be improved by induced turbulence from the post injection when it occurs near the in-cylinder soot peak.

Clemson University and the University of Michigan carried out cycle-to-cycle air fuel ratio calculations during transient engine operation using fast response CO and CO2 analyzers [92094]. For the engine tested (SI engine with low dilution), they found a maximum difference of approximately 10% compared to more conventional methods. The difference was expected to be higher with more charge dilution.

Advanced or low-temperature combustion papers could be broadly categorized as single and dual fuel approaches. In the single fuel approaches that were discussed, Lund University considered the possibility of using various multiple injection strategies to reduce the dependence on negative valve overlap (NVO) for expanding the load range of their partially premixed combustion (PPC). NVO has a negative impact on gas exchange efficiency and limits the in-cylinder temperature increase at low load. While there were some benefits of different injection strategies, hot residual gas from NVO significantly improved combustion efficiency and could not be substituted by a multiple injection strategy.

General Motors and Clemson University presented a paper on the effect of combustion chamber deposits (CCD) on low temperature combustion. Heat release timing and rate
from HCCI type combustion approaches is very sensitive to combustion chamber surface temperature. As CCDs accumulate, heat release timing and burn rate changes can lead to non-optimum performance. In order to better quantify the effect of CCDs, a reasonable estimate of cycle resolved CCD surface temperature and heat flux is required. While it is possible to measure temperature and heat flux at the CCD/metal interface, measurements at the CCD outer surface are much more difficult. This study presented a “lead-corrector” approach that could estimate the CCD outer surface temperature based only on the measurements at the CCD/metal interface and the thermal properties of the CCDs. The approach was then used to demonstrate that CCDs can cause a four-fold increase in the amplitude of cyclic combustion chamber surface temperature swings without a significant impact on cycle averaged wall temperature. These cyclic changes had significant impacts on heat release timing and burn rate.

Papers on dual fuel LTC approaches included two on Reactivity Controlled Compression Ignition (RCCI). In the first, the University of Wisconsin reported on direct cylinder injection of the low reactivity fuel instead of port injection and the use of a GDI injector for the diesel injection instead of a diesel common rail injector [92107]. The ability to control the timing of the low reactivity fuel allowed an additional option to control the phase of the combustion process while the GDI injector for the diesel offered a reduction in PM. Unburned HC and CO emission reduction should also be possible but further optimization work is required. In the second paper, Oak Ridge National Lab found improvements in maximum engine load as high as 20% with 20% ethanol added to the low reactivity fuel (gasoline) and 20% biodiesel added to the high reactivity fuel (diesel) [92192]. The increased octane of ethanol along with increased charge cooling could retard combustion phasing and allow the cylinder pressure rise rate to be lowered without adversely affecting CO and HC emissions. Biodiesel blends advanced combustion phasing without significantly increasing pressure rise rate to allow higher ratios of ethanol blends to be run stably without exceeding the pressure rise rate limit. The resulting expanded load range could enable a wider coverage of emission test cycles such as the US FTP by LTC and reduce the amount of mode switching that would be required.

Gaseous fuels

There were a number of papers on natural gas and other gaseous fuels in the technical sessions. These included papers on ignition, PM emissions and gas injection. Colorado State University reported some developments on their multiplexed laser spark ignition system for gas engines [92007]. Poor focusing of the laser spark through flexible fiber optics that direct the laser beam from the laser source to the combustion chamber is a significant challenge for this approach. CSU reported a significant improvement in the ability to focus the laser by using optical fibers with a thick cladding. The thick cladding seems to improve the quality of the contact between the core and cladding to minimize mode coupling and improve the ability to focus the beam in the combustion chamber. Woodward reported further developments on their passive pre-chamber plug [92030]. The aim is to develop a passive prechamber plug that will be suitable for lambda above 1.8. The current iteration is an improvement over that reported last year and about 1/2 of the penalty of going to these lean air-fuel ratios has been overcome. Patent application is ongoing and details of the plug are still unavailable.

Westport reported on the effect of a number of injection parameters on PM emissions from an engine with their HPDI fuel system [92162]. Carbonaceous PM emissions are formed during the HPDI combustion that originate mainly from natural gas (and not from the diesel pilot, as was once suspected). Some reduction in PM emissions, approximately 30%, was possible by reducing the separation between the diesel pilot and the natural gas injection events. This approach, referred to as Slightly Premixed Combustion (SPC) was also sufficiently tolerant of dilution that EGR rates could be increased to offset the resulting NOx penalty while maintaining the PM benefit. However, an increase in methane emissions of about 15% was noted. Further PM reductions would be required before DPF removal could be considered technically feasible.

Other topics

A team of researchers from AVL and partners reported on an investigation of the limits for NOx reduction using EGR [92199]. Non-road engines were the focus of the study, but a modified Euro V engine was used in the experiments. With the used test engine, NOx emissions could not be lowered below 0.6 g/kWh over the NRTC test without a significant deterioration in load response. Thus, EGR alone was not sufficient to meet the nonroad Stage IV limit of 0.4 g/kWh.

The high EGR rates required very high cooling power—approximately 43% of the brake engine power, compared to about 22% in typical Euro V applications.

Using their mobile chassis dynamometer facility, the West Virginia University evaluated drayage truck test cycles [92106] that were developed by TIAX and commissioned by the Long Beach and Los Angeles port authorities. The tested vehicle was a 2011 Class 8 Mack truck with DOC, DPF and SCR aftertreatment. Drayage cycles were run using two approaches: (1) as a series of shorter tests (called drayage activities) and (2) as a single continuous drayage operation cycle. Emissions calculated from integrated drayage activities were significantly higher than those measured over single continuous drayage operation, approximately 14% to 28% for distance-specific NOx emissions. This was likely explained by differences in the state of the SCR system (temperatures, adsorbed NH3). Relatively high NOx emissions were measured at some low- to medium-load segments, probably due to urea injection being shut off at the particular conditions due to insufficient temperatures.

CANMET researchers tested retrofit urea-SCR systems on underground mining vehicles [92034]. The project was conducted at the Sifto salt mine in Goderich, Ontario. Salt mines often have problems with NO2 exposures due to the large volumes and slow ventilation rates in salt mining. In the case of the Goderich mine, with production areas located underneath the bottom of Lake Huron, the problems are even more severe as ventilation air must be pumped over long distances under the lake. Two SCR systems were installed: one on a Cat 990G loader (SCR system by Tenneco) and one on a Cat 775D truck (Nett Technologies). Both systems provided similar NOx reduction efficiencies: 60-65% over the vehicle duty cycle and a peak reduction of about 80%. The Nett SCR package proved to be more robust and had fewer technical issues—after the trial, the mine ordered several Nett systems. The SCR technology had good acceptance at the mine.