SAE 2013 High Efficiency IC Engine Symposium

Technical Session Schedule

As of 04/20/2013 07:40 pm

Sunday, April 14

Advanced Combustion Concept - Near Term - Covering OEM and Engine Manufacturers Prespectives - Part 1

Session Code: ***HEE1***

Room Venetian Ballroom ***Session Time:*** ***1:00 p.m.***

Organizers - *Zoran S. Filipi, Clemson-ICAR; Robert M. Wagner, Oak Ridge National Laboratory*

Moderators - *Zoran S. Filipi, Clemson-ICAR*

Time	***Paper No.***	***Title***
1:15 p.m.	***ORAL ONLY***	***Near Term Combustion System Development and the Influence of Transmissions, Drive Cycles and Fuels*** *All Light Duty OEM's are continuously working to satisfy our customer¿s desire for improved fuel economy, performance and value. The benefits of various engine technologies may well depend on the rest of the vehicle powertrain as well as the drive cycle and fuel characteristics. New combustion system technologies must be developed as part of the vehicle system. This presentation will provide some context for the new combustion and engine technologies that will be required for further improvements in CO2, efficiency and performance as well as some of the challenges inherent in the new technologies and approaches.* *Eric W. Curtis, Ford Motor Co.*
2:00 p.m.	***ORAL ONLY***	***Turbocharger Speed Evaluation via On-Board Acoustic Emission Analysis*** *In this work an innovative sensing chain for the rotational speed evaluation of an automotive turbocharger is presented. The turbocharger angular velocity is detected in real time through the acoustic signal processing, based on a frequency estimation algorithm. Starting from presented works, the acquisition chain and the algorithm are optimized for the implementation on board the Engine Control Unit (ECU). The aim of activity was a trade off between a good accuracy of speed detection and calculation effort.* *<p>After a description of the algorithm working principle, the results of the online evaluation are presented. In particular the algorithm performance has been assessed on different vehicles: Passenger Cars (equipped with a Euro 5 diesel and gasoline engines) and Light Commercial Vehicles, in both controlled condition (roll test bench) and normal road condition. The performance of speed tracking algorithm is good in all the range of turbocharger operating conditions and it is comparable with standard sensor.* *Matteo De Cesare, Magneti Marelli SpA Powertrain Division*

Sunday, April 14

Advanced Combustion Concept - Near Term - Covering OEM and Engine Manufacturers Prespectives - Part 2

Session Code: ***HEE1***

Room Venetian Ballroom ***Session Time:*** ***3:15 p.m.***

Organizers - *Zoran S. Filipi, Clemson-ICAR; Robert M. Wagner, Oak Ridge National Laboratory*

Moderators - *Zoran S. Filipi, Clemson-ICAR*

Time	Paper No.	Title
3:15 p.m.	ORAL ONLY	**Approaches for Efficiency Improvements of IC Engines** Presentation will highlight technology developments leveraged to meet emission requirements while improving the engine efficiency. Recent efforts have focused on improving engine efficiency while designing aftertreatment devices to handle the engine emission reduction. As both emissions and efficiency targets become more demanding, we are becoming more aware of the necessity to develop technologies that can raise efficiency while limiting the engine out emissions. Improvements in the understanding of the gas exchange process, heat management, spray and combustion chemistry are providing pathways for improving the power plant performance. William De Ojeda, Navistar
4:00 p.m.	ORAL ONLY	**Higher Efficiency or Further Downsizing: Example from Large Bore Medium Speed Engines** Large bore 4-stroke medium speed engines for marine and power generation have several opportunities to reach high brake efficiency. Large cylinder displacement, often operated at fixed speed and high load conditions, enables both high thermodynamic and gas exchange efficiencies. However, other aspects as specific investment cost, which drives downsizing, and operating costs, dependent on the fuel costs and operating profile of the power plant, have an impact on the customer¿s preference. There is a tradeoff between higher brake efficiency and higher load via further downsizing, for each power plant application and its specific operating conditions. Downsizing has been the dominating factor in the past, while higher efficiency and operating flexibility is gaining focus with changing fuel prices. Jari Hyvonen, Wartsila Finland Oy
4:45 p.m.	ORAL ONLY	**Dedicated EGR: A Low Emissions, High Efficiency Solution for SI Engines** The use of cooled EGR as a mechanism to reduce the sources of inefficiency in gasoline engines has gained greater acceptance over the past few years. However, cooled EGR also presents some challenges in the pursuit of high efficiency engines. In particular, the use of cooled EGR can result in a reduction in burning velocities and increase in hydrocarbon emissions from the engine. One way to improve on the performance of cooled EGR applications is to add syngas / reformate to the intake charge, which will improve the mixture qualities and promote better knock resistance and improved flame propagation. However, traditional methods of syngas generation have proven to be unsuitable in the past. Here, a new method of generating and using syngas is proposed. One cylinder of the engine is dedicated to EGR production such that 100% of the exhaust from that cylinder is used as EGR. This enables the dedicated cylinder to be run rich of stoichiometric, which produces a significant amount of CO and H2. The fuels are then re-circulated into the engine, improving burn rates, knock tolerance, engine stability and, ultimately, fuel consumption. Data from several engines run in the dedicated EGR mode will be presented that will show the improvement in fuel economy and emissions. The results indicate that efficiencies in the region of 41-42% BTE are possible from a 2.0 L engine while also maintaining stoichiometric exhaust and the potential for LEV III emissions. Terrence Alger, Southwest Research Institute

Monday, April 15

Advanced Combustion Concepts - Longer Term - Part 1

Session Code: ***HEE2***

Room Venetian Ballroom ***Session Time:*** ***8:00 a.m.***

Organizers - *Zoran S. Filipi, Clemson-ICAR; Robert M. Wagner, Oak Ridge National Laboratory*

Moderators - *Gurpreet Singh, Department Of Energy*

Presenters - *Gurpreet Singh, Department Of Energy*

Time	***Paper No.***	***Title***
7:45 a.m.	***ORAL ONLY***	***An Investigation of Non-catalytic In-cylinder Fuel Reforming***

In-cylinder processes under fuel-rich conditions are not well understood but have important implications for a number of high efficiency engine concepts. Examples include direct fuel injection into the negative valve overlap (NVO) event for homogeneous charge compression ignition (HCCI) combustion, and for stoichiometric spark-assisted HCCI (SA-HCCI). Fuel-rich chemistry is also important for the dedicated exhaust gas recirculation (D-EGR) concept pioneered by Southwest Research Institute. The products of the fuel-rich in-cylinder reforming processes, namely hydrogen, carbon monoxide, and methane, are desirable because they have altered fuel properties and kinetics. The reformate products effectively provide a high octane number, and the high flame speed of hydrogen can extend the dilution limit for conventional spark ignited combustion. Despite the increasing importance of the fuel-rich processes, non-catalytic reforming chemistry on engine timescales is not well understood. Further, fuel-specific behavior cannot be accurately characterized by existing kinetic mechanisms which were not validated under the relevant fuel-rich conditions. In this talk, an experimental investigation is presented that characterizes fuel-specific fuel-rich chemistry under low oxygen conditions. A 6-stroke engine cycle has been developed to setup a NVO event where fuel is injected, the products of which are subsequently exhausted for detailed chemical analysis using a Fourier transform infrared (FTIR) analyzer and a capillary inlet magnetic sector mass spectrometer. Chemistry trends are presented as a function of fuel injection timing, NVO duration, and oxygen concentration for methanol, ethanol, iso-butanol, and iso-octane. Results show significant concentrations of hydrogen (>8 mol%) under some conditions, but that hydrogen production for iso-octane and iso-butanol is lower, partially due to fewer operable engine conditions due to their tendency to produce soot at fuel-rich conditions.

James P. Szybist, Oak Ridge National Laboratory

8:30 a.m.	***ORAL ONLY***	***GDCI Multicylinder Engine for High Efficiency, Low NOx, and Low PM Emissions***

Recent single-cylinder engine tests of gasoline direct-injection compression-ignition (GDCI) showed good potential for very high efficiency, low NOx, and low PM over the full speed-load range. Low-temperature combustion was achieved using multiple-late injection (MLI), intake boost, and cooled EGR. Advanced injection and valvetrain were key enablers. A new piston design was developed and matched with injector and spray characteristics. Efficiency loss analysis indicated a very efficient thermodynamic process with greatly reduced heat losses. A two-stage boost system was developed for down-sizing, down-speeding, and uploading for the most efficient operation.

<p>Towards a practical production engine, a new 1.8L, four-cylinder engine was designed and fabricated for the GDCI combustion system. Preliminary dynamometer tests were conducted and compared to single-cylinder engine tests at similar operating conditions. The new engine exhibited very low fuel consumption from idle to maximum torque, with low NOx and near zero PM emissions. Combustion noise and combustion stability were also well within limits. More work is needed to calibrate the engine over the full operating map, conduct transient tests, and demonstrate the concept on a development vehicle.

Mark C. Sellnau, Delphi Corp.

Monday, April 15

Advanced Combustion Concepts - Longer Term - Part 2

Session Code: ***HEE2***

Room Venetian Ballroom ***Session Time:*** ***10:15 a.m.***

Organizers - *Zoran S. Filipi, Clemson-ICAR; Robert M. Wagner, Oak Ridge National Laboratory*

Moderators - *Gurpreet Singh, Department Of Energy*

Time	Paper No.	Title
9:45 a.m.	ORAL ONLY	***The Outlook on Transport Fuels and Gasoline Compression Ignition (GCI) Engines***

Different projections suggest that in the coming decades, a) the worldwide demand for transport fuels will increase significantly, b) transport energy will still come substantially (around 90% share) from petroleum and c) the demand increase will be significantly skewed towards commercial vehicles. If engine technology remains as it is, there will be a massive shift in demand towards diesel and jet fuels. Hence there is likely to be a surplus of straight run gasoline from the initial distillation of crude and this is ideally suited for use in GCI (Gasoline Compression Ignition) engines.

Gautam Kalghatgi, Saudi Aramco

Time	Paper No.	Title
10:30 a.m.	ORAL ONLY	***Reactivity Controlled Compression Ignition (RCCI) for Ultra-high Efficiency IC Engine Operation with Low NOx and PM Emissions plus Transient Control***

Experiments aimed at identifying the maximum practical cycle efficiency in reciprocating internal combustion engines are described. The combustion strategy used is based on Reactivity Controlled Compression Ignition (RCCI) with in-cylinder blending of port-injected low reactivity fuel plus optimized direct-injections of a higher reactivity fuel. The experiments were conducted using a single-cylinder heavy-duty research diesel engine with and without piston oil gallery cooling. RCCI combustion demonstrated gross indicated thermal efficiencies near 60% and comparisons with cycle simulations show that ~94% of the maximum theoretical cycle efficiency was achieved with near-zero levels of NOx and PM emissions in-cylinder. Additional studies are described using single and multi-cylinder light-duty engines to demonstrate the controllability of the RCCI strategy for transient engine operation.

Rolf D. Reitz, Univ. of Wisconsin

Time	Paper No.	Title
11:15 a.m.	ORAL ONLY	***Low Cooling Heat Loss and High Efficiency Diesel Combustion using Restricted In-Cylinder Flow***

A new diesel combustion concept achieves high thermal efficiency without deteriorating emissions. This concept is characterized by the reduction of the heat transfer coefficient through restriction of in-cylinder gas flow using a zero swirl intake port and a lip-less shallow dish combustion chamber. Since restricting the gas flow generally causes an inadequate mixture of fuel and air, a micro multi-hole injector was adopted to create highly dispersed fuel spray that improves the air-fuel mixture. These improvements reduced the heat flux from the in-cylinder gas to the surface of the combustion chamber wall. As a result, a 5% reduction in fuel consumption was achieved compared to conventional combustion, without an emissions penalty.

Noriyuki Takada, Toyota Motor Corp.

Monday, April 15

Advanced Combustion Concepts - Enabling Technologies - Part 1

Session Code: ***HEE3***

Room Venetian Ballroom ***Session Time:*** ***1:30 p.m.***

Organizers - *Zoran S. Filipi, Clemson-ICAR; Robert M. Wagner, Oak Ridge National Laboratory*

Moderators - *Robert M. Wagner, Oak Ridge National Laboratory*

Time	Paper No.	Title
1:00 p.m.	ORAL ONLY	**Turbo Charged Boosting Systems: Yesterday, Today, Tomorrow, and Beyond** *Downsizing and turbocharging has become one of the major enablers to meeting future fuel economy and CO2 standards. Turbocharing has been around since the late 1930¿s, but it wasn¿t until around 2000 that viable turbocharged SI engine systems actually demonstrated better fuel economy than the larger engines that they replaced with comparable performance. The presentation starts with a historical perspective of turbocharged engines and their drawbacks, then shows what changed, and why downsizing and boosting is sweeping across the industry. A brief discussion on complementary technologies that have enabled the second generation of boosting systems for fuel economy will be followed by a discussion of the next generation of boosting systems. Several third generation subsystems and technology evolutions will be discussed, followed by a fourth generation system that will be entering production around the end of the decade. Lastly, a brief mention of fifth generation turbo systems for 2025 and beyond.* *Christopher P. Thomas, BorgWarner Inc.*
1:45 p.m.	ORAL ONLY	**Emissions Control Challenges and Opportunities for Advanced High-Efficiency Engines** *Criteria emissions from high-efficiency engines can be different from today¿s engines, whether they are new engine designs or extensions of today¿s technologies. For example, in general advanced LTC engines (low-temperature combustion) may have greatly reduced low load NOx emissions, but hydrocarbons and CO can be greatly increased. On the other hand, lean burn GDI engines could have a low- and medium load lean NOx emissions. Diesel engines can have both low-load and high-load NOx emission challenges.* *This presentation will cover the state-of-the-art on controlling these different emissions challenges. For example, low-load hydrocarbon control is being addressed with better thermal management, catalysts that light-off at lower temperatures, and hydrocarbon traps. Low-load NOx is being addressed with better thermal management, better lean NOx traps, better SCR catalysts, systems, and control, and with passive NOx adsorbers. High-load NOx remediation involves better catalysts and control, and new system designs.* *Timothy Johnson, Corning Incorporated*

Monday, April 15

Advanced Combustion Concepts - Enabling Technologies - Part 2

Session Code: ***HEE3***

Room Venetian Ballroom ***Session Time:*** ***4:15 p.m.***

Organizers - *Zoran S. Filipi, Clemson-ICAR; Robert M. Wagner, Oak Ridge National Laboratory*

Moderators - *James P. Szybist, Oak Ridge National Laboratory*

Time	Paper No.	Title

3:00 p.m. ***ORAL ONLY*** ***Future Powertrain and Required Engine Technology***

Driven by legislation and market demands, unprecedented opportunities in architecture and approach to powertrain concepts for passenger vehicles arise to satisfy fuel economy and emission goals. The combustion engine, as the most cost-efficient and widely-accepted propulsion concept today, will maintain its leading role in the powertrain while the trend of downsizing with gasoline direct injection further solidifies its momentum and advanced combustion concepts get ready to complement the technology packages, to meet the 2021 fuel economy goals for the US and EU markets. However, challenged by emerging hybrid concepts, the conventional powertrain starts to adopt the best out of both worlds and adapts hybrid approaches to shift or avoid unattractive operation points of the combustion engine, thus enabling further gains in fuel economy and emission improvements.

Oliver Miersch-Wiemers, Robert Bosch LLC

3:45 p.m. ***ORAL ONLY*** ***Next Generation Engine Control, Calibration and Optimization using Model-Based Methods***

Engine control is becoming significantly more sophisticated and difficult to optimize as engines become more complex with ever-increasing numbers of highly interdependent subsystems. Rising development costs, increased calibration burdens, and the difficulty of optimization require the development of entirely new methods of controlling engines and vehicles for maximum fuel efficiency and lowest regulated emissions.
Next generation vehicles will have multiple power sources that will need to be blended and optimized on a continuous basis. Advanced combustion regimes, hybridization, waste energy recovery and sophisticated aftertreatment will combine to require extremely complex control systems. Engine control is currently undergoing a transformation from primarily cycle-integrated emissions minimization to real-time power management along with instantaneous fuel and energy consumption optimization. This significant increase in complexity requires much greater control system sophistication than the engineering- and calibration-intensive methods used today.
Model-based methods have been developed for engine control and calibration that incorporate high-fidelity data-driven predictions of engine system performance, fuel consumption, emissions production and dynamics. These model-based methods have been used for off-line calibration optimization on existing, legacy-based, table-intensive engine controllers as well as for developing entirely new, on-line real-time engine controllers for advanced engines.
Model-based methods transfer a significant proportion of the engine control strategy development, refinement and calibration optimization tasks from the high-cost engine and vehicle test cell to the much lower cost computational environment. The reduction in development cost and effort, together with their improved emissions and fuel efficiency outcomes, makes these enabling techniques very worthwhile for further investigation.

Christopher Atkinson, Atkinson LLC

4:30 p.m. ***ORAL ONLY*** ***Opposed-Piston Engines for Light-duty Applications***

As vehicle customers, along with environmental and regulatory agencies, escalate demands for reduced CO2 emissions, automotive manufacturers around the world face the prospect of adding substantial cost and complexity to conventional four-stroke engines in order to respond. An alternative path forward, however, utilizes the inherent thermodynamic efficiency of the opposed-piston, two-stroke engine to reduce fuel consumption without the burden of added costs or complexity. In this presentation, Achates Power will detail an opposed-piston engine design for light-duty applications, providing a comprehensive description of the engine¿s performance, fuel consumption, emissions control strategy and package layout.

Fabien Redon, Achates Power Inc.