

Internal Combustion Engine



ASME International

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CALL FOR PAPERS

Internal Combustion Engine Division of ASME and the CIMAC World Congress

Invite Papers for the 2004 CIMAC Congress

June 4th – 11th, 2004 • Kyoto, Japan

www.cimac.com



The 2004 ASME-ICED Spring Technical Conference will be held as a track of sessions at the 2004 CIMAC World Congress on Combustion Engine Technology. This conference will be held in Kyoto, Japan from June 4th – 11th, 2004. Papers are invited for publication and presentation on topics related to all types of automotive, marine, locomotive, off-highway, and industrial engines. Papers may address any aspect of the design, development or application of compression-ignition (diesel), spark ignition, rotary or reciprocating engines. Light-duty and heavy-duty engines, as well as large-bore I.C. engine systems for power generation and transportation propulsion are welcome.

Anticipated technical sessions span the range from fundamental research to practical in-use applications. Examples of topics include, but are not limited to, combustion, noise and vibration, engine-fuel interactions, in-cylinder emission control and flow processes, exhaust after-treatment, alternative fuels, engine cooling, lubrication, fuel injection and ignition systems, engine design, control and monitoring, engine simulation and diagnostics, advanced engine concepts, component dynamics, wear, and materials.

All accepted papers will be published in the Conference Proceedings, which will be published on a searchable CD and available at the conference. Papers will be considered for the Journal of Engineering for Gas Turbines and Power. Exceptional written papers and presentations will be considered for ASME IC Engine Division Conference awards. ASME review and publication policies will apply.

Please submit an abstract of the paper to the Technical Program Chair.

Kirby S. Chapman, Ph.D.

Kansas State University, National Gas Machinery Laboratory, 245 Levee Drive, Manhattan, Kansas 66502

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Important Dates

September 1, 2003	Offer of Paper, One Page Abstract	February 1, 2004	Draft Paper Reviews Complete
October 1, 2003	Abstracts Accepted	March 1, 2004	Camera Ready Paper Due
December 15, 2003	Draft Manuscript Due for Review		



Internal Combustion Engine



Newsletter of the Internal Combustion Engine Division of ASME • Summer 2003

www.asme.org/divisions/ice/

Chair's Message

Victor W. Wong



The internal combustion engine covers a wide range of applications from transportation such as marine, railroad, aircraft, and highway vehicles to stationary applications that include many kinds of machinery where power is required or delivered. Therefore, the members of ASME International who have selected the Internal Combustion Engine Division (ICED) as one of their areas of interest, numbering over 4000, span a wide cross-section of different industries and professions. We share common interests in similar issues related to the internal combustion engine. The ICED serves the needs of a diverse group of members.

As your new chair, I plan to enhance, with your support, ICED's excellent programs and future activities. Many individuals participate in the success of the division. The Executive Committee, consisting of five voting members and four non-voting standing and advisory members, coordinates the overall operation of the division. Besides the Executive Committee, various other committees are organized along *technical disciplines* - such as advanced technology, friction and lubrication, etc., and along *administrative functions* - such as membership development, and newsletter (responsible for what you are now reading). A special Board of Associates, consisting of about 140 nominated and elected members, participate in developing and implementing ideas and activities of the Division. The

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Erie PA to be Site of ASME-ICED & RTD Joint 2003 Fall Technical Conference

Gong Chen

The ASME-Internal Combustion Engine Division & Rail Transportation Division Joint 2003 Fall Technical Conference will be held at the Courtyard Marriott Conference Center in Erie, PA on September 7-10, 2003. The conference will be co-hosted by GE Transportation Systems and Gannon University. The hotel/conference center is located at 7792 Peach Street and close to I-90.

The conference will include a strong technical program addressing key issues related to all types of automotive, marine, locomotive, off-highway, and industrial engines. During the conference technical program to take place on Monday and Tuesday, September 8th and 9th, numerous technical papers, spanning the range from engine fundamental research, technologies development, to practical in-use applications, will be presented in more than ten technical sessions.

The technical program will begin on Monday morning, September 8th, with a special keynote presentation of the 2003 Honda Lecture, "Near Zero Emission Internal Combustion Engines," by Wallace R. Wade, a Ford Technical Fellow and Chief Engineer at Ford Motor Company.

In addition to the technical program, a variety of tours and social events are planned. On Sunday evening, the conference will kick off at the hotel with a reception featuring complimentary hors d'oeuvres and a cash bar.

On Monday evening, conference attendees and spouse/guests will be given a guided tour of GE Transportation Systems and its locomotive assembly and test buildings in Erie, PA. Dinner will be provided at the GETS Learning Center.

As is customary, the annual ASME-ICE Honors and Awards Banquet will be held on Tuesday evening at the historic Union Station. A sit down dinner will be

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Editor Suri Rajan

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Improved Large Engines Using Automotive Techniques

Stephen G. Dexter

Keynote Speech given by Helmut List, CEO of AVL at the Spring Conference in Salzburg on 12 May 2003

Helmut List did a brave thing and he did it well. In his keynote speech he described some techniques used to develop automotive engines and showed how they are now being used by AVL and others to improve large engines. He then went on to predict what fuels and power sources will be used by future generations.

Mr. List explained that numerical analysis to support engine design is as old as the engine industry. The drive behind this is the ever increasing cost of engine testing and the steady reduction in cost of computing power. Large engines, which consume more than two tons of fuel an hour, soon eat into a development budget. Since those early days the automotive industry has put huge resources into developing techniques. The large engine industry can now benefit from these efforts.

Finite element analysis (FEA) is now universally used at the design stage to calculate

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Outgoing Chair's Message

Steven G. Fritz, P.E.



The Internal Combustion Engine Division of the American Society of Mechanical Engineers has been promoting the art and science of mechanical engineer-

ing of internal combustion engines since 1921. As we reflect on the 82nd year of the Division, I think you will agree that the Division continues to be a viable and active resource for technical information for mobile, marine, rail, generation and stationary applications.

In keeping with the conference format that has served us well for the last ten years, we held two successful conferences. The Fall 2002 Conference in New Orleans was co-hosted by the University of New Orleans and Avondale Industries. The Spring 2003 Conference was held in Salzburg, Austria, and was hosted by the Austrian Marine Equipment Manufacturers. The Salzburg conference was notable in that it was the first overseas conference for the ICE Division. The general consensus was that although it took an extra amount of effort from the organizing committee, the conference was very successful, with 84 technical papers presented and 180 people attending.

The Division also has implemented several changes in the way we organize and administer the conference technical programs. The ASME "Web Tool" is now routinely used for managing the technical paper process. The Salzburg Conference proceedings were distributed on a CD for the first time with a Final Program that contained paper abstracts. E-mail has replaced most paper correspondence, although there are legitimate concerns as to the effectiveness of e-mail as we are all overwhelmed by the sheer volume of e-mails we receive daily.

Exciting times are ahead for the Division. Fall 2003 will offer a joint conference with the ASME Rail Transportation Division in Erie, PA, hosted by GE Transportation Systems and Gannon University. In the Spring of 2004, the ICED will sponsor a tract of sessions at the CIMAC conference in Kyoto, Japan.

I look forward to continuing to work with the Executive Committee and the Board of Associates to serve the Division and the Society. Thank you for the opportunity to work with this great group of people. ▶

CIMAC News Greg Gutoski – Chairman of CIMAC U.S. National Committee

CIMAC (International Council on Combustion Engines) is an international organization involving companies, organizations, and individuals interested in marine, locomotive, power generation and gas compression reciprocating engines and gas turbines. Members include engine manufacturers, engine users, component suppliers, oil companies, classification societies, research organizations, universities and others.

The ASME is the National Member Association (NMA) for the CIMAC organization in the U.S. All dues paying ASME members have automatic CIMAC membership and can enjoy the benefits they offer. The ICE division, along with the ASME Gas Turbine division, pays the annual \$4500 dues. As an ASME/CIMAC member, attendance at most CIMAC Circles around the world are free and the registration fee at the CIMAC Congresses is significantly discounted.

In recent years, a closer partnership between ICED and CIMAC has solidified and has boosted mutual participation/communication at each other's events and functions.

Some recent and future CIMAC news highlights follow:

- The CIMAC webpage was redesigned and is now more user-friendly with more information. The CIMAC website is www.cimac.com
- The Technical Paper Database project was initiated and now provides electronic access to more than 70% of all CIMAC papers – free of charge to CIMAC members on a password-protected basis.
- In September 2002, another successful

CIMAC Circle was held at SMM in Hamburg with the title, "Interaction between engine design, cylinder lube oil design, and cylinder condition."

- A CIMAC session was held at the ASME-ICE FTC in New Orleans on September 8-12, 2002 (See separate article)
- A new CIMAC recommendation (No. 20), "Guidelines for diesel engines lubrication – Lubrication of large high speed diesel engines" was published.
- A new CIMAC NMA was founded in India.
- The CIMAC statutes were modified to allow more flexibility in membership.
- A CIMAC session was held at the ASME-ICED STC in Salzburg, Austria on May 11-15, 2003 (See separate article).
- A CIMAC Circle was held in India May 23, 2003 covering Heavy Fuel Oil quality.
- A CIMAC circle was held at NORSHIP-PING June 5, 2003
- A CIMAC international symposium on I.C. Engines will be held on October 13, 2003 in Shanghai, China.
- The 2004 CIMAC Congress will be held in Kyoto, Japan on June 7-11, 2004 and will include 6 sessions organized by ASME-ICED.

Please take advantage of CIMAC opportunities and enjoy the value-added benefits that the ASME/CIMAC partnership is yielding in mutual conference participation. ▶



The Hellbrunn Palace in Salzburg was the site of the 2003 Spring conference.



Wallace R. Wade

The title of Wallace R. Wade's lecture is "Near Zero Emission Internal Combustion Engines."

Wallace R. Wade is another in the Internal

Combustion Engine Division's series of outstanding Soichiro Honda Lecturers. He is a Ford Technical Fellow and Chief Engineer, Powertrain Systems Technology and Processes, North America Engineering, Ford Motor Company. He is currently responsible for the application, development and certification of emission and control system technologies for Ford Motor Company's powertrains in North America.

Mr. Wade joined Ford Motor Company in 1972 and has been involved in every phase of powertrain engineering, including Research, Advanced Powertrain, and Forward Model Engineering. Previous responsibilities have included Assistant Chief Engineer, Powertrain Systems Development; Executive Engineer, Powertrain Electronics Development; Manager, Advanced Control Systems

Engineering; Manager, Engine Research; and Supervisor, Engine Development.

Mr. Wade has received 26 patents related to improvements in powertrains and written 24 published technical papers on powertrain research and development. He received the prestigious Henry Ford Technology Award in 1986. He is a Fellow Member of the Society of Automotive Engineers and a Member of the American Society of Mechanical Engineers.

Mr. Wade's inventions range from control systems for traction control, as used on many Ford vehicles, to diagnostics for monitoring the operation of emission control systems, new designs for emission control systems and new designs for engines with reduced friction and heat loss.

Mr. Wade has a BME from Rensselaer Polytechnic Institute and an MSME from the University of Michigan. I have known and respected Mr. Wade since his diesel engine emissions evaluations and automotive

gas turbine research at Ford Scientific Labs. His paper will prove to be a landmark in IC engine emissions; one you will want to refer to in the future. His lecture promises to be one you can't afford to miss.

In 1986, ASME established the Soichiro Honda Lecture to recognize achievement and significant contribution in the field of Personal Transportation. Wade joins a distinguished group of eminent past lecturers including: Helmut List, AVL; Prof. Phillip Myers, U. of Wisconsin; Dr. Horst Hardenburg, Daimler Benz; Prof. John B. Heywood, MIT; Karl J. Springer, SWRI; Charles E Amann, KAB Engrg; Dr. Roberta Nichols, Ford; Dr. Henry Newhall, Chevron Chemical Co.; Franz Pischinger, FEV; Dr. Gary Borman, U. of Wisconsin; Prof. Hiroyousi Hiroyasu, U. of Hiroshima; Dr. Thomas Asmus, Daimler Chrysler; Prof. Ghazi A. Karim, U. of Calgary; Dr. Patrick Flynn, Cummins Engine Co.; and David F. Merriam, Detroit Diesel Corp. ▶

Merrion Honda Lecture a Huge Success!

Dave Merrion's Soichiro Honda Lecture at the 2002 Fall Technical Conference was timely, professionally delivered, and well received. The lecture titled Heavy Duty Diesel Engine Emissions: Fifty Years-1960 to 2010, was based on personal experience and reflected Merrion's long association with Detroit Diesel Division of General Motors. Merrion recently retired as Executive Vice-President of the Detroit Diesel Corp. The printed version of his lecture is contained in the Proceedings of the Fall Technical Conference of ICED held September 9-11, 2002 in New Orleans and is available from ASME. For those involved with engine emissions, the lecture is a most useful reference and is highly recommended. ▶

Survey of Gas Engine Performance and Future Trends

Timothy J. Callahan

Introduction

Worldwide, reciprocating engines play a major role in power generation. Many of the reciprocating engines are diesel engines used as standby generators, but increasingly, natural gas engines are providing distributed base load generation and finding service in combined heat and power applications. The economics of power generation continues to place a premium on engine efficiency while environmental regulators continue to legislate lower and lower exhaust emission levels, specifically NOx emissions. NOx emissions and efficiency tend to be proportional, so while not mutually exclusive, low NOx and high efficiency are difficult to obtain simultaneously. In spite of the NOx-efficiency relationship, natural gas engines are more efficient, with lower emissions today than in the past. The trend toward higher efficiency will continue in the future. This article reviews current natural gas engine performance and emissions and discusses future engine performance.

Approach

As those familiar with the engine industry know, reciprocating engines are very flexible. A single engine can be tailored to meet the requirements for a variety of applications. Engines are rated according to application in

the power generation market with variations in ratings for various types of service: 50 or 60 Hz, base load, standby, or peak shaving. The ratings also depend on the quality of the gas, whether the application involves combined heat and power (CHP), and the emission regulations that pertain to the installation site. Sites that require low emissions generally are serviced by engines with lower efficiencies than sites that can tolerate higher NOx levels. Changes in engine coolant temperature required for some applications also may produce variations in engine power, efficiency, and NOx. Without belaboring this point, application requirements lead to variations in engine power ratings, performance, and emissions. These variations can make comparisons difficult.

Compounding the problems imposed by a variety of data specific to various applications is the fact that there is a certain "fuzziness" regarding engine thermal efficiency numbers and associated NOx levels. First, as with any measurement, thermal efficiency or fuel consumption has an associated uncertainty stemming from uncertainties in the measurements used to compute the efficiency number. Kubesh [1] has recently discussed these errors and concluded that the uncertainty in the thermal efficiency ranges from

Survey – continued from page three

+/- 0.34 to 0.97 efficiency points based on measurement techniques and practices. Second, while recognizing this uncertainty, various manufacturers and standards treat this uncertainty differently. ISO 3046 provides some standardization; however, not all manufacturers follow these guidelines. Third, reciprocating engines require certain accessories (alternator, oil and water pumps, etc) for operation. In some cases, these accessories are engine-mounted contributing to the engine parasitic losses; in others they are electrically driven off-engine and do not detract from the engine efficiency. And finally, because efficiency is dependent on the NO_x level, variations in efficiency can occur for engines meeting a certain NO_x specification due to variations in the size of the NO_x margin used by various manufacturers.

This study focused on continuous power applications, both 50 and 60 Hz. Data was assembled from the literature and from technical data sheets. The data presented are for the engine, not the generator set.

Engine Manufacturer	Engine
Caterpillar, Inc	G3500 G3600 G-CM34
Cummins Engine Company, Inc	QSK QSV
Deutz	TBG 616 TBG 620 TBG 632
Fairbanks Morse Engine	FM-MAN 32/40DF
Guascor	SFGLD
Jenbacher	Series 3 Series 4 Series 6
MAN B&W	28/32 SI 32/40 DF
Mitsubishi Heavy Industries	KU 30G Mach 30G
MTU	4000
Niigata Engineering Company	26HX 33HX
Perkins Engine Company	4000 Series
Rolls-Royce	KVG
Wärtsilä [38-41]	220SG 28SG 34SG 32DF 50DF
Waukesha Engine	VGF VHP AT27GL

In cases where the generator package efficiency was given without the engine efficiency, a generator efficiency was assumed to compute the engine efficiency. The efficiency comparisons were performed at an equivalent NO_x level. In some cases this necessitated interpolation between a higher and lower NO_x level.

Engine Manufacturers and Engines

The efficiency and NO_x data included in this study were obtained from the literature, technical brochures, and contact with the manufacturers. The table below lists the engine manufacturers and engines surveyed.

Performance of current engines

While the engines given in the table are not a totally inclusive list, they cover a wide range of engine sizes, powers, and speeds. The bore diameter ranged from 130 to 500 mm, with the majority of the engine models having bore diameters less than 200 mm. All of the engines are offered in multiple cylinder arrangements, with some models coming in a 20-cylinder V arrangement so the range of power represented by the combination of size, number of cylinders, and engine speed is quite large, as shown in Figure 1. It's interesting to note that there is a broad range of engine bore sizes that provide 1 MW of power. The smaller bore engines with up to 20 cylinders operating at higher speeds provide power equivalent to much larger engines. In terms of power density, Figure 2, the 1500 to 1800 rpm engines achieve 25 kW/liter, while the slower (larger) engines are typically below 15 kW/liter. In terms of BMEP, the state of the art for engines of all sizes is 20 bar, as shown in Figure 3. A BMEP of 20 bar is quite impressive for a gas engine that must operate free of both knock and misfire. The higher BMEP levels have resulted in higher engine efficiency with improved mechanical efficiency because parasitic losses are a smaller portion of the engine power.

The efficiency data are shown in Figure 4 as a function of BMEP. As indicated, efficiency increases with BMEP. It should be noted that with such a diverse data set in terms of engine size and engine speed some scatter in the data should be anticipated, as other parameters also impact efficiency. Figure 5 illustrates the correlation of BTE with both BMEP and engine speed. Since engine speed is inversely related to the size of the engine, this data could also have been plotted against any number of parameters that scale with engine size, including bore, stroke, cylinder displacement, and combustion chamber surface-to-volume ratio. The highest efficiency is obtained at the highest

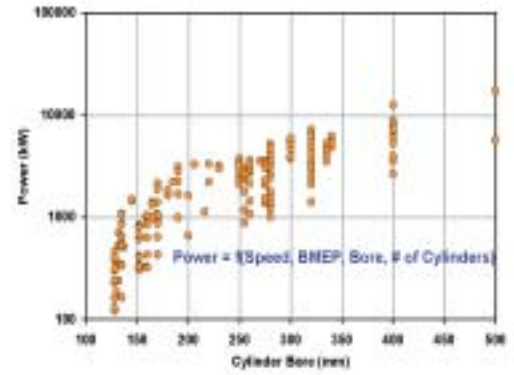


Figure 1. Gas Engine Power Range

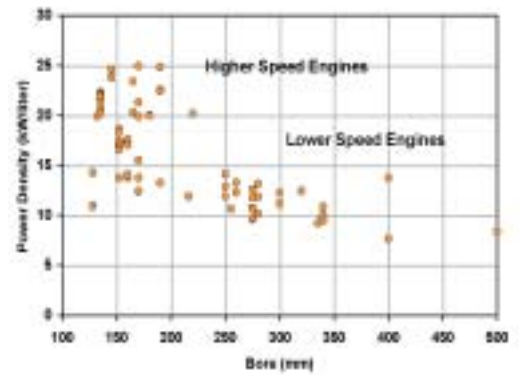


Figure 2. Gas Engine Power Density

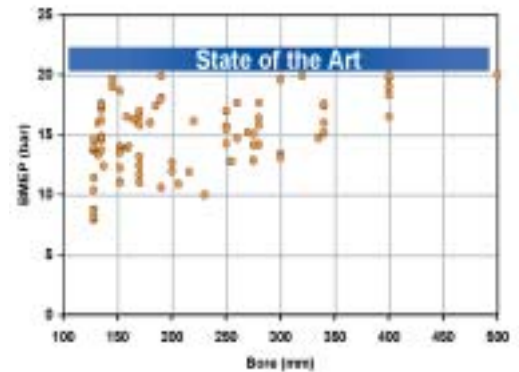


Figure 3. Gas Engine BMEP Levels

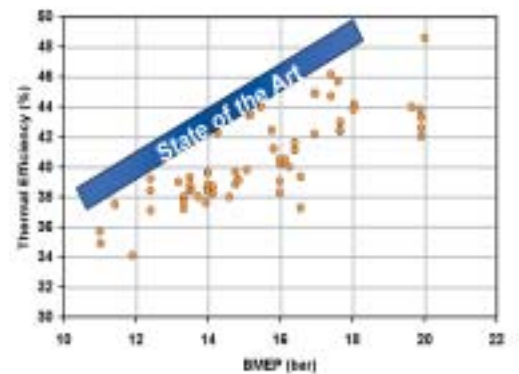


Figure 4. Impact of BMEP on Gas Engine Efficiency (NO_x<1.5 g/kW-hr)

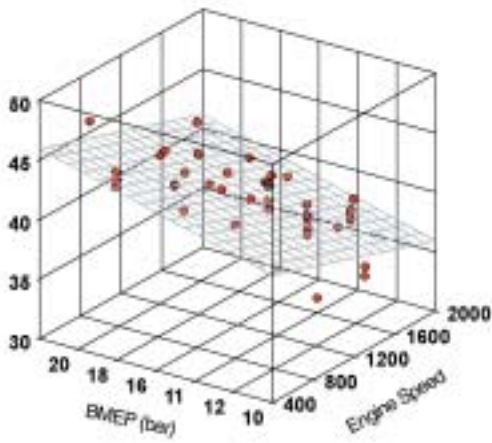


Figure 5. Efficiency as Functions of BMEP and Engine Speed

BMEP levels for the largest bore engines (lowest speed). One of the main benefits of a larger bore size is a reduction in the surface-to-volume ratio and a corresponding reduction in heat loss through the cylinder wall. The slower speed engines also benefit from a reduction in rotating speed of components and lower friction. At slower engine speeds, the effects of finite combustion times become less and combustion is closer to the ideal constant volume case.

Future Engine Performance

Historically, gas engine BMEP and efficiency have increased over the last 17 years. There are two main driving forces for product development: regulation and competition. The U.S. heavy-duty engine is a prime example of product development driven by regulation, as ever more stringent emission regulations for diesel particulate and NOx have forced the development of technology to meet those regulations.

In the large gas engine industry, although emissions have been a driver to some extent, competition would appear to be the driving force behind product development trends. Competition has many elements—all of them cost related—including cost of power, cost of operation, cost of maintenance, cost of down time, etc. Cost of an engine or genset is a main competitive element. Engines with higher specific output either through higher BMEP or higher engine speed have a competitive advantage with regard to cost per kW, thus the trend toward higher BMEP. Higher BMEP, as shown, also results in improved efficiency, which reduces the cost of operation. Higher BMEP levels, however, can have an adverse effect on the cost of maintenance because higher BMEP puts more stress on various engine components, especially spark ignition systems. Pilot ignition alleviates this concern to some extent.

Although competition itself will lead to improvements in engine performance, there are efforts in the United States to more rapidly advance the technology to achieve higher efficiency and lower emissions than would be achieved under typical competitive pressures. These efforts are known as the Advanced Reciprocating Engine Systems (ARES) and the Advanced Reciprocating Internal Combustion Engine (ARICE) programs.

The ARES program began as a cooperative research program involving Southwest Research Institute, the U.S. Department of Energy, engine manufacturers, industry suppliers, and an energy supplier. This program continues with competitive programs with three major engine manufacturers (Caterpillar, Waukesha, and Cummins), DOE, U.S. national laboratories, universities, and other research organizations.

The ARICE program is funded in part by the California Energy Commission. The ARICE program is a technology development and demonstration program targeting 0.02 g/kW-hr NOx levels at high efficiency levels.

With regard to exhaust emissions for large gas engines, there are regions in the world that have very stringent emission regulations, notably in the United States. In Southern California, for example, the standard is 0.2 g/kW-hr NOx. Other regions of the United States with ambient air pollution problems are adopting similar regulations. Additionally, in the distributed generation market, reciprocating engines must compete with gas turbines, which can have very low NOx levels. Worldwide concern over climate change and efforts to reduce CO₂ emissions will continue to encourage improvements to efficiency.

The bottom line is that gas engine efficiency will continue to improve as exhaust emissions continue to be reduced. The question of what the future targets will be is pertinent to this article. These targets depend heavily on the size of the engine being considered. According to the latest market survey [2], 75 percent of gas engines ordered were in the range of 1 to 2.0 MW, with 16 percent in the range of 2 to 3.5 MW. Thus it would be appropriate to qualify the future target discussion to engines less than 3.5 MW. Second, even though historical trends are available, extrapolation of these data would not be the best approach when various engine models exist for estimating performance.

On the emissions side, regions of the U.S., as mention earlier, have regulations of 0.2 g/kW-hr. Other regions will adopt this regulatory level in the future.

On the efficiency side, there are development efforts under way to achieve emissions

and efficiency targets, as shown in Figure 6. The ARES program has an intermediate efficiency goal in the neighborhood of 46 percent, with a long-term goal approaching 50 percent. While there are engines approaching these efficiency targets (Figures 4 and 5), the combination of low NOx with high efficiency makes these targets challenging.

As part of the ARES program, a technical path evaluation was undertaken to evaluate efficiency limits. This evaluation used modeling and simulation in conjunction with experimental engine data to identify barriers to high efficiency and technologies that may overcome the barriers. The barriers identified were:

- Knock (uncontrolled combustion)
- NOx emissions
- Structural limitations
- Combustion efficiency (unburned fuel)
- Combustion rate (slow reactions at low temperature)
- In-cylinder heat loss
- Frictional losses
- Pumping losses
- Exhaust port and manifold heat loss
- Inefficient exhaust energy recovery

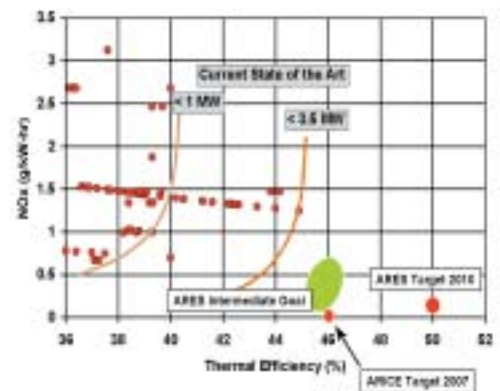


Figure 6. Gas Engine Efficiency and NOx Current and Future

A comprehensive list of technologies required to overcome these barriers was identified. These included combustion chamber designs for knock tolerance and complete combustion of mixtures diluted with either excess air or exhaust gases. To achieve the anticipated NOx levels, aftertreatment will likely be required. Aftertreatment is a technology that can provide emission reductions greater than 85 percent with limited efficiency penalty. For lean burn applications, aftertreatment options involve lean NOx catalysts (LNC), NOx traps, or selective catalytic reduction (SCR). SCR systems impose an operational cost due to the requirement for a reductant, usually urea, for NOx reduction.

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2002 Fall Technical Conference in New Orleans – A Success

The 2002 Fall Technical Conference was held in New Orleans, LA from September 8 – 12, 2002, and was co-hosted by NGSS, Avondale Shipyards and the University of New Orleans (UNO). The conference opened with the Soichiro Honda Lecture by David Merrion, Retired Executive Vice President of Detroit Diesel. The title of his lecture was, “Heavy Duty Diesel Emissions: Fifty Years 1960 – 2010” and was enjoyed by all.

The conference consisted of 3 concurrent technical sessions over 2 days and comprised 60 technical papers and a panel session on the topic of marine engine exhaust emissions featuring renowned panelists from vessel owners, engine manufacturers, classification societies, technology developers and pollution control organizations. A CIMAC session titled, “Common Rail Fuel Injection for Marine Applications”, was also featured at the conference.

Attendance at the conference exceeded 140 and all enjoyed the quality technical content as well as the social and culinary experience

typical of the New Orleans environment.

A works visit tour was conducted at NGSS, Avondale Shipyards, known for its manufacturing of large ocean-going ships propelled by large bore reciprocating diesel engines. Ships observed on the tour included the 951 foot long T-AKR Sealift Ro-Ro vessel and the LPD-17 Class Amphibious Landing Ship Dock vessel, both propelled by diesel engines manufactured by Fairbanks Morse Engine in Beloit, Wisconsin. The University of New Orleans also displayed and described their in-depth involvement in Marine Engineering, Naval Architecture, and first-hand involvement with the LPD-17 Program with NGSS-Avondale.

The annual ASME-ICED awards banquet was held on Tuesday evening with individual contributors to the Internal Combustion Engine Division being recognized.

The New Orleans 2002 Fall Technical Conference was a great success that was enjoyed by all attendees. ▶

New Members Join Growing Group of Associates

A growing organization demonstrates strength and vitality. The ICE Division is continually welcoming new members into its Board of Associates, who contribute their talents to assist the Executive Committee and serve their peers. Please congratulate and welcome the following five Associates, who were approved by the Executive Committee since the last edition of the Newsletter.

Dr. Wole Akinyemi
Cummins Engine Co., Columbus, IN

Dr. Gong Chen
Gannon University, Erie, PA

Dr. Allen Kirkpatrick
Colorado State University, CO

Mr. Mark McNeely
Diesel Progress, Waukesha, WI

Mr. Stuart Neill
National Research Council Canada,
Ottawa, Canada ▶



Timothy J. Callahan is a principal engineer at Southwest Research Institute specializing in the development of high efficiency, low emission, natural-gas engines, particularly those used in stationary applications. He has worked to improve the performance and emissions of large-bore natural-gas engines by applying various combustion system technologies. Past experience includes designing, developing, and evaluating engines for coal and coal-derived fuels, fuels from renewable resources (biofuels), and alternative fuels designed to reduce exhaust emissions. Callahan has been an associate member of the ICE Division of ASME since 1996. ▶

Survey of Gas Engine Performance – continued from page five

If the cost of urea is lumped with the fuel cost, an apparent efficiency penalty is incurred. Using exhaust gas recirculation for dilution in conjunction with a three-way catalyst (TWC) is a promising alternative since no reductant and subsequent efficiency penalty are incurred. Several researchers and work conducted on the ARES program have shown that stoichiometric-EGR engines with a TWC can obtain very low NO_x levels while achieving high BMEP and high efficiency.

One problem with dilute mixtures is misfire. Multiple site ignition can potentially aid in extending the misfire limit. Multiple site ignition options include multiple spark plugs, pilot ignition, and prechambers (both spark- and pilot-ignited). The multi-site ignition technologies are applicable to both lean-burn and stoichiometric combustion. Pilot ignition of stoichiometric-EGR mixtures was shown to be a promising approach on the ARES program. One key to achieving high power density will be obtaining high boost pressure levels through retaining and efficiently utilizing exhaust energy via high efficiency turbochargers and possibly turbo-compounding. Friction reduction through design modifications of piston ring packs, bearing, and valve trains offer immediate improvement in efficiency without a NO_x emission increase. Development of these

technologies and others are continuing through the ARES and ARICE programs.

For additional information, the reader is referred to ASME paper ICES2003-628, “Survey of Gas Engine Performance and Future Trends”, presented at the Spring Technical Conference of the ASME Internal Combustion Engine Division.

Timothy J. Callahan
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1. Kubesh, J.T., “Uncertainty in the Determination of Thermal Efficiency in Natural Gas Engines”, ICEF2002-522, Proceedings of the 2002 Fall Technical Conference of the ASME Internal Combustion Engine Division, V.W. Wong Editor, 2002.
2. McNeely, M., “Engine Order Survey – As Expected Engine Orders Stumble”, Diesel and Gas Turbine Worldwide, October 2002. ▶

2003 STC: First Off-Shore Conference

The 2003 Spring Technical Conference was held in beautiful Salzburg, Austria from May 11-15; the first ICED conference ever held outside the U.S. mainland. The conference was hosted by the Austrian Marine Equipment Manufacturer's Association (AMEM) with strong support from numerous Austrian companies. Over 180 delegates were in attendance.

Austrian company exhibitors included AVL, Bosch, Geislinger, Hoerbiger, Jenbacher, Kral, Miba, and Voestalpine. The conference site was at the Hellbrunn Castle known for its floral gardens, trick water fountains and water-powered mechanical equipment and figurines.

The conference was kicked off with a keynote speech by Dr. Helmut List, Chairman and CEO of AVL-List GmbH, titled "Improved Large Engines using Automotive Techniques". The conference featured 84 technical papers presented in 4 concurrent sessions over 2 days. The conference also contained 3 CIMAC sessions titled, "Engine Design – Components & Performance", "Gas Engines I", and "Gas Engines II".

Monday evening featured a classical music concert for all attendees/spouses with-

Attendees visited the Bosch Fuel Injection Manufacturing facility in Hallein.



Attendees enjoy a cruise on Lake Traunsee.

in the famous Fortress overlooking the city of Salzburg, and added some culture to the technical content of the conference.

The Austrian Gold sponsors hosted a dinner reception at the Hellbrunn castle on Tuesday evening for all delegates and their partners. Cocktails and warm dishes of Austrian cuisine were plentiful.

Works tour visits of Austrian companies were reserved for Wednesday, May 14th and Thursday, May 15th at Geislinger/Jenbacher and Bosch/Miba respectively. The tours, technical presentations and breakfasts/lunches provided by the 4 Austrian companies were appreciated by all.

In addition to the work's visits, delegates and their spouses were treated to a tour of the Crystal World of Swarovski in Wattens, Tyrol on Wednesday and a visit to the Gmundner Ceramics factory on Thursday. Thursday also included a boat ride aboard the historical Paddle Steamer GISELA on Lake Traunsee amid the picturesque Alps.

The ASME-ICE 2003 STC held in Salzburg, Austria was a most enjoyable experience for all and at a very reasonable cost. ▶



John Kuehmayer (AMEM) welcomes attendees.



Koudai Yoshizawa receives Most Valuable Technical Paper Award.



Visit to Geislinger.

Improved Large Engines – continued from page one

temperatures and stresses in all major components. It is now also used to calculate vibration velocity and laser scanning is used to validate the calculations. Prediction without validation is worth nothing. FEA also prevents fretting damage simulating the contact behaviour of joint faces and controlling the magnitude of relative movement between faces, contact pressure and surface stress condition.

Furthermore FEA calculations predict the stress-strain history under cyclic thermal load. Fatigue strength data is obtained from specimen tests on a special rig which cycles stress and temperature while the specimen is restrained. A very accurate assessment of fatigue life can now be made.

Mr. List emphasised the importance of validation saying we all know that CFD produces pretty pictures and animations but for an engine designer to rely on it we need validation. Laser Doppler and laser fluorescence are used to do this but he presented a new Visiolution technique developed to predict knock in gasoline engines and now applied to large gas engines. A fibre optic bundle in a small sensor allows a series of flame luminosity sensors to detect the knock location and motion of the flame fronts in both open and prechamber gas engines. The sensors are so small that they are sometimes built right into the spark plug itself.

He gave further examples of techniques used in the automotive industry which could be applied to large engines including:

- Real time simulation to develop ECUs,
- Special tests and FMEAs (Failure Mode and Effects Analysis) to improve reliability,
- Cost reduction programmes to reduce manufacturing cost,
- On Board Diagnostics to monitor emissions from engines in service.

Turning his attention to the future Mr. List considered fuel cells as an alternative to the reciprocating engine. He believes fuel cells will become a reality, but “when” or “if” for passenger cars or for marine or locomotive propulsion is not so clear.

Those who do research for a living know one cannot predict the outcome of research in the long-term. If long-term research were predictable, it wouldn't be research. In the near and mid-term, we have a fairly good idea of the evolutionary changes we can expect of reciprocating internal combustion engines but few people realise that the evolution of internal combustion technologies is accelerating right now,

more quickly than ever before.

Not so long ago many people were convinced that by the year 2000 we would be driving electric vehicles in great numbers. Today we know that the advanced batteries that looked so promising for personal transportation work better for cell phones and laptops. Going back a bit further it was claimed that gas turbines would soon revolutionise the auto industry but still, in 2003 Mr. List said he could not get from AVL in Graz to the conference in Salzburg on land using turbine power. But in both cases it was important that we tried, and tried hard, to develop these technologies.

Scientific prudence demands that we in the business of engine research must take into account different scenarios, especially in the long term. You don't put all your eggs in one basket. Moreover, we should have the vision to see the ways in which these different scenarios are inter-related.

Mr. List is concerned that we are focusing on only one long-term scenario: hydrogen-powered fuel cells. But we should be planning for more than one scenario by asking the following questions:

“What options do we have in terms of primary energy?”

“What options do we have in terms of fuels or energy carriers?”

“What options do we have with propulsion systems?”

In his view, we need to look carefully at all three, and understand how they are inter-related.

The first and most-discussed scenario is that we will have developed hydrogen-powered fuel cells as a cost-effective power source capable of eventually replacing fossil fuels. Mr. List's view is that commercially viable fuel cells for personal mobility are *at least* 15 years away and for marine propulsion at least 30 years.

Hydrogen-powered IC engines are much closer, but the availability of hydrogen and the technology to distribute hydrogen are both serious issues.

In the distributed hydrogen scenario, nuclear energy is without question the ideal source of energy to produce the necessary hydrogen but the political barriers may prove more daunting than the technical barriers. However the loss of energy during hydrogen distribution may be as high as 50 percent. In this respect, traditional fuels have a significant advantage over hydrogen.

We may be able to extract the hydrogen from other sources, like coal or natural gas. Carbon sequestration is something people are working on, and rightfully so. The idea is to extract the hydrogen and leave the carbon

behind without emitting it into the atmosphere. Nevertheless we should remember that if we, as a society, are interested in “wells-to-wheels” efficiency, hydrogen is not the best energy carrier found in nature.

He pointed out that everywhere in the natural world, carbon combines with hydrogen to act as an energy carrier, and not just in fossil fuels. The fuel our bodies need – food – is primarily composed of carbohydrates. It has been said that nature doesn't like straight lines. It seems that nature doesn't like hydrogen by itself as an energy carrier, either.

Another scenario is that biomass becomes a major source of energy for personal transportation. Today only a very small percentage of available sunlight per acre is used to grow plants. With advancements in the life sciences it is possible that we could develop plants that grow larger and much more quickly than today's crops. But if we were to re-deploy large tracts of land for biomass farming, we would have to look at the impact on the environment. Or, in the case of solar energy, if we were to cover very large areas of land with solar cells, perhaps the deserts, this too, might change the climate in ways we can't predict.

The third scenario is our current situation. In this scenario, fossil fuels continue to be the primary fuel for engines. Advancements in internal combustion technology continue to amaze us. Engine builders and the supplier community continue to develop the IC engine to levels of performance, emissions and fuel efficiency unimaginable just a decade ago. As an example Mr. List said AVL MTC has a prototype twin-cylinder diesel engine developed for a drone aircraft that weighs 53 pounds and produces 46 horsepower, giving it a world record for power density in its class.

AVL is researching concepts with greater thermal efficiency by raising combustion temperature as much as 100 degrees Centigrade. These would need new oils or possibly no oil at all. There are other technological opportunities to advance the IC engine. If we apply this kind of thorough research Mr. List believes that we have a good chance to achieve technological breakthroughs that would allow us by 2020 to increase the efficiency of the internal combustion engine to 60% and maybe more.

The development of advanced aftertreatment systems is progressing at great speed to allow the potential for lower exhaust emissions than even the most technologically advanced engines can achieve. In the future, we will be able to achieve what Mr. List

continued on page nine

called "zero impact emissions" from internal combustion engines. This means that, while there will still be emissions, they will have a minimal effect on air quality. He is very confident that we don't need fuel cells to eliminate regulated emissions in the long term.

Mark Twain once remarked that reports of his death were "greatly exaggerated." Mr. List thinks the case is the same for the internal combustion engine.

For each of the scenarios he described, there will be interesting relationships between them. He imagines a grid that compares several energy sources, several fuels, and several power systems. Because this paints a picture of complexity that is mostly absent from current popular discussions, he thinks we need to define critical enabling technologies for each, and examine our progress against each on a regular basis. This will help us decide where we should commit our research resources, and more importantly, help us to decide to re-direct funds if need be.

Lastly Mr. List added something about the way in which Europeans collectively go about the process of long term research planning in Brussels by building a joint vision first, and then identifying the various scenarios. For each scenario, they will define the critical enabling technologies, and then build their strategic research agendas. The advantage to this approach is that by securing commitments in the beginning of the process, the barriers between these groups can be overcome.

Research can be planned. But the long-term outcome of research cannot. Our pioneering vision for technological research must take this into account. We also need intelligent and inventive engineers to do the work. We must all persuade our next generation that mechanical engineering will continue to be an exciting and very relevant profession.

In thanking the delegates for their attention Mr. List said that if they didn't know, Graz - the location of his headquarters - has been designated the Cultural Capital of Europe for 2003. If they had time while in Austria he invited them to visit. If they did they should be sure to see the new Concert Hall, one of the world's most acoustically perfect. AVL's acoustic engineers helped design it.

After the Keynote Speech Mr. List capably handled many questions on the scenario he had predicted, though, understandably, he drew the line when asked by one delegate if he could predict the future price of energy. ▶

Erie PA – continued from page one

held, followed by the presentation of honors and awards with a special guest speaker.

While the technical program is underway on Monday, September 8th, the spouses and guests of conference attendees may enjoy a wonderful tour of the beautiful Buhl Mansion, built by Frank Buhl in 1890 as a present for his wife and now a guest house and art gallery. Next there will be an interesting and tasty tour of Daffin Chocolates. Lunch will be served at Tara, inspired by the movie "Gone with the Wind," a virtual museum of rare and priceless antiques, works of art and collectibles. Lunch will be followed by a guided tour of Tara's beautiful rooms and garden.

On Tuesday, September 9th, the spouses and guests will start with a historical visit to the Erie Maritime Museum and have a tour of the Brig Niagara. The tourists will relive

the Battle of Lake Erie during the War of 1812 that secured this part of the continent for the U.S. The restored Niagara is the oldest commissioned ship in the US Navy. Afterward, you will take a ride to the top of the Bayfront Tower for a beautiful look of Presque Isle Bay. Lunch will be served on a two-hour cruise around Presque Isle Bay on the Victorian Princess, an authentic paddle wheeler.

On Wednesday morning, September 10th, conference attendees and spouses/guests will tour the GE Diesel Engine Plant, located half way between Erie and Pittsburgh in Grove City, PA. A short presentation will be followed by a guided tour of the machining and engine assembly area.

The 2003 Fall Conference will be an exciting and enjoyable experience on all fronts including technical program, tours, social and entertainment. For more details, please visit the ASME-ICE website:

<http://www.asme.org/divisions/ice/>. ▶



Gannon University is a sponsor of the 2003 Fall Technical Conference.

Fall 2002 STC Award Winners

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ICE Division Speaker Awards

Koudai Yoshizawa
Nissan Motor Co., Ltd.

Lyle M. Picket and Dennis L. Siebers
Sandia National Laboratories

Most Valuable Technical Paper

Koudai Yoshizawa
Nissan Motor Co., Ltd.

ICE Division Meritorious Award

Alan C. Anderson
Cummins Engine

Romesh Poola
Electromotive Division GM

Martin J. Heimrich
Southwest Research Institute

ICE Division Citation

Gong Chen
Gannon University

Paul Flynn, Eric Dillen and
Shawn Gallagher
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Systems

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Chair's Message – continued from page 1

dedication and support of the various Committees, the Associates, and members at large are what make the division work so well. Mr. John Bendo, of ASME International staff, has been offering invaluable assistance to the Division. However, we are always looking for additional active volunteers.

The division has a lot to offer. Our two annual conferences, as well as other initiatives, provide opportunities for participants to present and discuss the latest technical issues and developments, interact with industry experts and customers, and join a dedicated group of distinguished colleagues in industry, academia, and government in organizing and shaping the future of ICED and the profession. The ASME and ICED Award programs recognize achievements of individuals that could also benefit their employers. I call for everyone, young engineers, seasoned professionals, established leaders and mentors to offer their support by actively participating in ASME and ICED.

First, I invite all those who have not done so to become a member of ICED by selecting ICED or *updating* your preference of ICED in your areas of interest in your membership profile. This can be done by calling ASME Membership or visiting the ASME website. This way, you will automatically receive this ICED Newsletter and periodically receive other valuable information from ICED regarding our activities. Second, please visit the ICED website: <http://www.asme.org/divisions/ice>, contact any member of the Executive Committee or other committee chairs listed therein, and participate in our activities, by attending our conferences, joining any of the many technical or adminis-

trative committees, submitting papers, organizing technical sessions or panel discussions on certain issues. Just contact any of the individuals listed in the website and volunteer. It will be very much appreciated.

Attendance at our conferences has gradually increased in recent years. In May 2003, we held our first-ever ICED Technical Conference overseas in Salzburg, Austria that was hosted by the Austrian Marine Equipment Manufacturers Association. It was attended by over 180 U.S. and international participants, with a record 84 papers published. We received very positive feedback on the conference and ICED received significant international exposure. We thank all those who contributed to the success of the conference. We are encouraged by the response and plan to include periodic conferences at similar international locations in the future.

The Fall 2003 Conference is a joint event with the Rail Transportation Division, hosted by General Electric Transportation Systems and Gannon University and held in Erie, PA. The joint effort highlights a strategic consideration for ICED of increased alliances with other Divisions/Institutes to maximize the diversity and depth of opportunity available to ICED members.

Current technological advancements and organizational changes within the Council of Engineering (COE) of ASME, of which the ICED is a part, provide new opportunities for improved operation of the division. In the Spring 2003 Salzburg Conference, we took advantage of the ASME “web tool” in organizing the conference paper submission and review processes through the internet. We also made the Conference Proceedings for that conference

available on CD for the first time. Better realignments of the technical division structure within COE would also provide more opportunities of collaborative efforts among the divisions. We are moving in that direction. Our strategic plan considers periodic joint conferences with other divisions or with even larger entities within COE (perhaps once every three years) that traditionally use larger conference venues. The first such attempt is slated for our Spring Technical Conference in 2005.

What happens before then? Our traditional conference arrangement in Spring 2004 will take the form of ASME-ICED participation in the CIMAC (International Council on Combustion Engines) 2004 Conference, to be held in June 2004 in Kyoto, Japan. ICED has organized a track of sessions at the CIMAC Conference. The technical program arrangements for the ICED track of sessions will be organized by ICED and the venue arrangements made by CIMAC. All are invited to participate in that exciting event. The Fall 2004 Technical Conference will be a traditional ICED conference to be held in September 2004 in Kansas City, MO and hosted by Kansas State University.

The ASME-ICED is poised to go through some exciting developments in the near future – developing more diverse conference arrangements and strengthened alliances with other organizations, supporting COE within ASME in organizational changes, operating more efficiently as appropriate with technical innovation, and meeting the technological challenges facing the internal combustion engine industry. I look forward to working with you to continue the growth of ICED. ▶

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