

Environmental Engineering

MESSAGE from the CHAIR

Public Policy and the Fiscal Year 2005 Research and Development Budget

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As the chair of the Environmental Engineering Division (EED), I have had an opportunity to work with ASME's Government Relations Department and participate in the annual budget appropriations process that unfolds in Washington, DC each year. Through ASME, I have discovered that I could provide meaningful input into the annual budget process, and that voices from stakeholders are valued opinions as priorities are set with limited resources.

As part of the process, I agreed to serve on the ASME Environmental Protection Agency (EPA) Task Force as a representative from the EED. As a member of the EPA Task Force, I joined other ASME volunteers in analyzing the President's budget request for EPA, the VA, HUD, and Related Agencies appropriations bill, within which the EPA budget is contained, and subsequent legislation and regulations for that agency.

Each Task Force is comprised of a number of ASME volunteers who assist in the annual budget analysis process. Last year, members who joined me on the EPA Task Force included Steven G. Buckley of the University of California, Evaristo J. Bonano of Beta Corporation International, and Kathryn Knowles and Mike Hightower

of Sandia National Laboratories.

As the first step in this year's budget process, the various task force representatives will meet in Washington, DC on March 8-9, 2004 for an Engineering Research and Development (R&D) Symposium. The Symposium is convened each year for representatives as a way for various engineering, scientific, and technical organizations to share information and collaborate on public policy issues that affect engineering research. Additional information about the Engineering R&D Symposium is available at <http://www.engineeringpolicy.org>.

During the Symposium, we will be briefed on the annual budget process by a series of speakers from the government (e.g., Office of Management and Budget), Capitol Hill, and the private sector (e.g., American Association for the Advancement of Science). ASME volunteers will have an opportunity to participate in meetings with officials from the various agencies to closely examine the President's Fiscal Year (FY) 2005 budget request to determine how it will affect the mechanical engineering community.

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As a result of the discussions in Washington, DC, other Task Force members will undertake an analysis of their respective agencies' FY 2005 budget requests. These analyses, when completed, will provide the basis for ASME position statements in support of, or opposition to, specific legislation or regulations affecting mechanical engineers throughout the calendar year. You can find such position statements at www.asme.org/gric.

Participating in the annual budget process has been an informative learning experience for me and for other members of the EPA Task Force. What happens in Washington, DC does have a day-to-day impact on the mechanical engineering community. I encourage you to become involved and to join the EPA Task Force today! For additional information, please contact Kathryn Holmes at the ASME Washington Center at holmesk@asme.org. ■

Developments in Laser-Based Continuous Emissions Monitors for Toxic Metals, Chemical Species and Particulate Matter

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The last ten years have witnessed an explosion in new laser sources, detectors, and optical instrumentation. These developments have translated into new technology for continuous emissions monitors (CEMs) designed to measure emissions from coal-fired power plants, incinerators, cement kilns, and other thermal processes. There are at least two basic drivers for the development of CEM technology. The regulatory driver often springs to mind first, and recently promulgated and incipient regulations often do play a big role in the advances in CEM technology. However, this mechanism for development of CEM technology requires substantial government “push,” in the form of investment dollars for technology development and maturation. Industry has little incentive to develop instrumentation to respond to regulatory drivers in advance of regulations, and regulators cannot require CEMs until the technology has been developed. Hence CEMs developed for regulatory applications typically must be funded by government research dollars. The implementation of CEMs improves knowledge of actual emissions, often allowing increased plant throughput through elimination of overly conservative “emission factor” calculations based on trial burns and worst-case scenarios.

The second, often overlooked, driver is the improved process knowledge and control that CEMs can provide. Real-time measurements of key parameters such as process temperatures, gas concentrations, and particulate loading can be used directly in feed-forward control or as input to sophisticated computer models to predict and improve process performance. This application of CEMs or in-process measurements, while not mandated by law, can often bring overall financial savings in the form of increased throughput or enhanced efficiency, as well as reduced emissions of harmful substances.

Optically-based CEMs lend themselves to real-time, in-process measurements suitable for control applications. For regulatory purposes, CEMs performance is typically evaluated using EPA performance criteria, most of which are still

in draft form, e.g. proposed performance standard (PPS) 10 for multi-metals CEMs, PPS 11 for particulate matter, and PPS 12 for total mercury CEMs. These PPS documents spell out the requirements for precision and accuracy of the CEMs compared with typical extractive reference methods. Currently optically based CEMs exist for opacity, and this path-integrated measurement can be correlated with total suspended particulate matter. In addition, several proposed CEMs for multi-metals (including mercury), trace gases, and particulate matter use either path-integrated or point optical measurements. A good example is the recently developed multi-metals monitor based on inductively coupled plasma spectroscopy developed at the Naval Surface Warfare Center, China Lake Division, and marketed by Thermal Jarrell Ash 1. One potential disadvantage of this system is that it requires extractive sampling of the exhaust stream prior to analysis. Several emerging laser-based technologies lend themselves to the possibility of in-process, or “in situ” analysis. Here, a few of the all-optical in situ technologies under development for next-generation CEMs are discussed in brief.

Laser-Induced Breakdown Spectroscopy (LIBS)

Laser-induced breakdown spectroscopy (LIBS), illustrated in Figure 1, is increasingly under consideration as a method for rapid elemental analysis applied to multiple media. Applications of LIBS typically employ a pulsed laser with a high peak power to form a spark (breakdown) in the medium to be examined. In gases, the temperature of the resulting plasma at short times (< 10 ms) is in the range of 10,000 – 25,000 K, hot enough to dissociate molecules into their constituent atoms, and to excite the electrons in the neutral atoms and ions formed in the plasma out of the ground state and into excited electronic states. As the plasma cools, excited electrons and ions relax back into their ground states, emitting light at characteristic atomic frequencies. Identification of the atoms present in the sample volume occurs using well-known atomic emission lines, and quantification of the elemental species concentration occurs via quantification of the intensity of the emission lines.

LIBS was extensively tested for CEM applications by the Department of Energy Characterization, Measurement, and

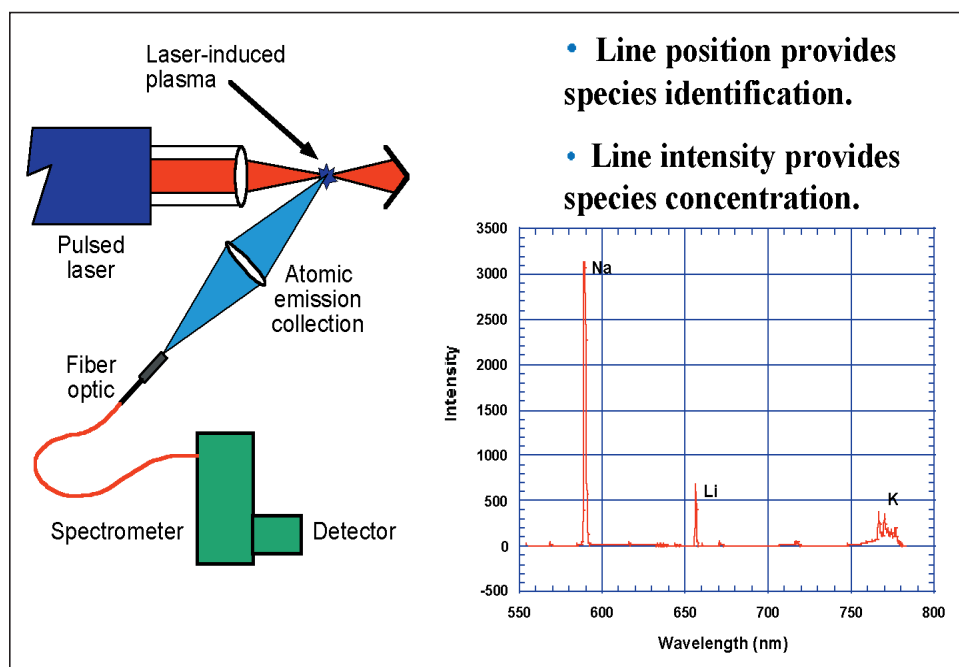


Figure 1: Typical LIBS setup and a sample (partial) spectrum of emissions from glass production facility.

Sensors Technology (CMST) program, which resulted in several favorable DOE reports, as well as publications by groups at Sandia National Laboratories 2,3 and Mississippi State 4. LIBS can be used for measurement of composition of many condensed-phase (e.g. most toxic and non-toxic metal species) and gas-phase elemental species, with sensitivities on the order of $\mu\text{g}/\text{m}^3$ for many species. The plasma erases knowledge of the molecular or particulate origin of the elements, so LIBS is strictly an elemental detection technique. Work continues at the University of Florida and University of California, San Diego, to improve quantification and calibration methods for LIBS.

Laser-Induced Incandescence (LII)

Accurate measurement of the size of soot aerosol particles may be achieved using Laser-Induced Incandescence (LII). LII relies on the heating of small particles following the absorption of an intense laser pulse, after which the particles incandesce. It has been shown that the LII signal is roughly proportional to the soot volume fraction,⁵ and the combination of LII and elastic scattering has been used for determination of a mean diameter of soot particles,⁶ even in complex flows such as engines.⁷ This technique has gained in attention in recent years, particularly with the development of time-resolved LII,⁸ which permits direct measurement of the soot primary particle sizes from measurements of the emission decay following the laser pulse, which is controlled by the rate of re-equilibration of the particles with the surrounding gas. Recent papers have worked to improve the quantification of LII measurements.⁹ LII has been under development for use primarily in engines, but recently has been under investigation as a CEM method for industrial process monitoring, for which it shows excellent promise.

Tunable Diode Laser Absorption Spectroscopy (TDLAS)

The development of single mode near-IR room-temperature diode lasers with optical powers of tens of mW, spurred by the telecommunications industry, has led to tunable diode lasers' extensive use for species measurements.^{10,11} The absorption of laser light is measured as it is swept over the energy range corresponding to a

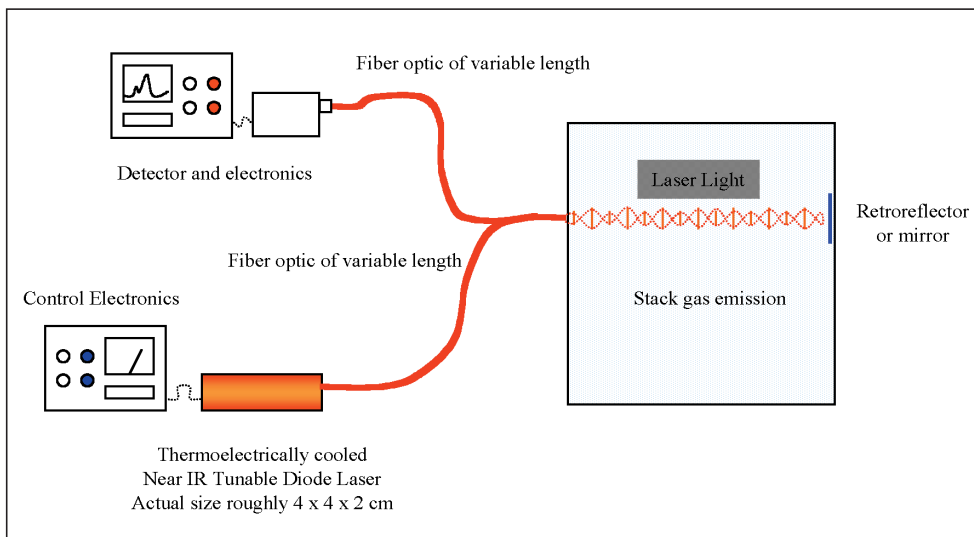


Figure 2: Typical setup for tunable diode laser absorption spectroscopy measurements in an industrial setting.

molecular transition; the concentration of the absorbing species can be determined using the Beer-Lambert law. These measurements are very species-specific and can be performed at kHz rates or even faster. The speed associated with TDLAS measurements gives them distinct advantages for capturing combustion process dynamics, which often occur on millisecond time scales or faster. TDLAS-based sensors are entering the commercial sensor marketplace, with vendors such as Southwest Sciences, Inc. and Physical Sciences, Inc. providing turnkey systems with sensitivities in the range of a few ppm for many species. Wavelength modulation (so-called "derivative spectroscopy") can be used to extend the detection limits of these sensors by several orders of magnitude. In addition to species measurement, tunable diode lasers can be used for temperature measurement using the variation in absorption line strengths as a function of temperature.¹² A relatively recent review covering many of the more challenging measurements in high-temperature processes has been contributed by Allen.¹³ Work on these types of measurements continues at many places in both industry and academia, including Stanford University and the University of California, San Diego.

Summary

Emerging optical technologies such as those highlighted above have significant promise for implementation as next-generation CEMs. The real-time, in-process characteristics of optical measurements is ideal for process monitoring and control applications, which may yield substantial

cost savings as well as emissions minimization. For further information about laser-based optical diagnostics applied to thermal systems, feel free to contact the author at buckley@ucsd.edu.

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ASME Membership

One of the benefits of ASME membership is the opportunity to join with your peers in a conversation with governmental agencies that set the guidelines for our professional and, in some cases, our personal lives. EED is offered this opportunity each year when the budgets for agencies are debated in Congress. Last year EED presented testimony that commented on EPA's R&D budget with recommendations in several areas. The entire testimony can be found in its entirety at <http://www.asme.org/gric/ps/2003/03-20.html> and also in this issue. This year we plan to expand our review to cover the environmental programs in the Department of Energy.

One of the issues discussed in the article cited above, the use of "risk" to inform decision making, will be the organizing theme of a joint summer meeting currently being organized by EED and SWPD. Plans are to meet on August 8 – August 10 in Central California. If you want to participate in this meeting (i.e., by attending, by pre-

senting a paper, by organizing a session, by helping to plan the agenda, etc.) please contact me at mce1@mac.com.

"Risk" has both a technical and a common definition. They are quite similar but the technical usage of "risk" has a computational dimension that is often absent from the common usage. Although we often hear, "The chances for rain tomorrow are 40%," we rarely hear that followed with, "The standard deviation associated with this estimate is 80%." So we carry our umbrella more often than we probably should.

Prioritizing government or industry decisions based on "risk" sounds like the right thing for people comfortable with mathematical analysis, like engineers, but the uncertainty in the computation is often so great that risk-based decisions may really be quite arbitrary. In any case, they are often quite contentious. I hope to explore some of these issues at the August meeting. Drop me a note to continue this discussion on a 1-1 basis if the topic interests you. ■

Task Force to Focus on Clear Skies Act

One of the overriding goals of ASME emphasizes the engineer's responsibility to the public interest. Engineers contribute to the policy making process by providing government decision makers with technical information needed to make the most informed decisions on technical and related issues.

ASME's government relations activities prepare and enable the Society's members to provide all levels of government with this essential guidance. Under the direction of the Board on Government Relations, ASME conducts programs to facilitate participation in the public policy process through presentation of non-partisan analysis, study, or research; informal briefings for government personnel; formal comments on proposed legislation and regulations; and testimony before government bodies.

The most prominent air quality issue in the 108th Congress has been what to do about emissions from coal-fired electric power plants. The Administration and several members of Congress have proposed legislation on the subject - a group of bills referred to

as "multi-pollutant" legislation. The Administration's version, called the "Clear Skies Act" proposes to replace numerous existing Clean Air Act requirements with a national cap-and-trade program for sulfur dioxide, nitrogen oxides, and mercury. Additional information about Clear Skies is available at <http://www.epa.gov/clearskies/>.

ASME's Environmental Engineering Division and Energy Committee will convene a task force in 2004 to review and issue a position statement on the Administration's Clear Skies Initiative. If you are interested in volunteering your time and expertise during the coming year to participate on this task force to develop this statement, please contact

Kathryn Holmes at the ASME Washington Center at holmesk@asme.org. ■

The Continuity and Change Reorganization

The Continuity and Change reorganization affects each member of ASME and yet it can appear as if there will be no impact. The goal is for each member to clearly know all the benefits that ASME can provide and how that member fits into the whole. More importantly the benefits should be readily available without barriers and obscure paths. Members, and other groups looking to ASME for support, have at times suffered from obscure entities within ASME putting constraints and added requirements to their initiatives. The reorganization should result in clearer areas of responsibility and empowerment that will allow for more agility to respond to member needs.

What this means for members of the Environmental Engineering Division is that the divisions themselves will stay as an entity but will be called upon to join with other divisions and local sections to create a product for a specific customer. The divisions need to outreach to other knowledge units and create opportunity. We are asking each member of the EED to respond to the questions, Who are my customers? What are their needs? Where do they need the support of ASME? If the answer lies with another technical division or local section, then EED will gladly propose a joint effort such as a conference, position statement, workshops and journal articles. EED is participating in many areas with other knowledge units, such as carbon sequestration, sustainable engineering, waste management, public outreach and education.

The important concept for each member to realize that the technical division and the local section are the fundamental units that make ASME what it is. They can be used for any problem that any member is willing to work on. We encourage you to bring your ideas and complaints to EED. ■

12th Annual North American Waste-to-Energy Conference (NAWTEC 12)

May 17–19, 2004
Savannah, Georgia

for program and registration
www.asme.org/divisions/swpd/events

Upcoming Events

On August 8 -10, the Environmental Engineering Division plans to meet jointly with the Solid Waste Processing Division and examine the way that “risk” is used to set regulatory standards, to discuss technical approaches used to estimate “risk” from industrial processes and ways that operators ensure that these processes are in regulatory compliance so that “risk” to the public is minimized. We intend to also discuss ancillary issues of some concern. For example, how the “risk message” is best communicated with the public and how public concerns are factored into the “risk equation.”

The venue for this meeting will be Northern California (e.g., Pleasanton, Livermore, etc., are being strongly considered) and we welcome your comments about this theme and, particularly, your interest in participating. Please contact either Steve Buckley (buckely@ucsd.edu), Kathryn Knowles (mkknowl@sandia.gov) or Martin Edelson (edelson@krellinst.org) to discuss how you can participate.

And please be certain to keep your eyes on the EED website (www.asme.org/division/eed/) for further information about this meeting.

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November 13-19, 2004
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www.asmeconferences.org/congress04/

Join thousands of colleagues in Anaheim, California, in November 2004 for a week of sharing information, testing new ideas, networking, and conducting business. At hundreds of technical sessions, special forums, product exhibits, tours, and social events, you receive updates on current trends, learn new techniques, trade tips, and explore the perspectives of engineers from different companies, industries, and countries around the globe.

The One Event for All Engineers

At Congress, you trade notes with colleagues in research, development, design, project management, testing, reliability, and quality control. You gain new insights on material mechanics, structural/system dynamics, heat transfer issues, fluid flow phenomena, vibration response, and much more. You learn about new methods, procedures, algorithms, approaches and techniques to apply in your workplace. You leave Congress with increased ability to...

- Gauge your progress in your technical specialization
- Identify new technologies and applications to improve your projects
- Formulate better testing and measurement methods
- Recognize potential technological alliances and partnering opportunities both within and outside your industry

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