Readout
HORIBA Technical Reports

English Edition November 1997 ■ No.1

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Scott Samuelsen, Kozo Ishida

(Pages *11*－*16*)

株式会社 堀場製作所

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Scott Samuelsen
and
Kozo Ishida

roceeding from the premise that many environmental problems are energy-related, and further technological developments are required to solve these problems, Professor Scott Samuelsen, Director of the UCI Combustion Laboratory and the National Fuel Cell Research Center, at the University of California, Irvine and Dr. Kozo Ishida, Senior Managing Director of Horiba, Ltd. discuss the present and future developments in technology that will be required to protect the environment. Professor Samuelsen describes some of the new technologies being developed to generate electricity, control combustion, and create new fuels. Dr. Ishida discusses the important role of university and industry teamwork in solving the environmental problems of the future. Measurement and monitoring instrumentation will be required by researchers working on technology to protect the environment. Both speakers agree that a paradigm shift calls for significant changes in energy generation scenarios and in industry's approach to research and development.

Historical Perspective: Economic Growth and Energy Demand

K.I.: I'd like to start our discussion from the consensus that many of today's environmental problems are due to energy-related issues, and further technological developments are needed to solve these problems. I have personally observed many examples of how the environment is changing. In Kyoto, when I was a student, we could see beautiful snow every year. Now, however, we seldom have snow—only on very rare occasions. For me, that is very clear evidence of the greenhouse effect. To raise awareness of these kinds of changes is very important for people living on the earth, and we are responsible for raising this awareness because we, in the developed countries, use most of the energy.

S.S: For the first time in history, signs of stress between the provision of energy and the ability of the environment to absorb the impacts of energy generation are now appearing. In the future, a new way of looking at technology, a new way of looking at energy generation, a new way of looking at environmental monitoring, and a new way of looking at business will be required. The first report of urban haze (later attributed to photochemical oxidant) appeared in a 1943 "Los Angeles Times" newspaper article. In the 1980s, evidence of global warming became apparent to the public and, in the last ten years, the public has begun to accept the threat of stratospheric ozone depletion. During the next century, the engineering community will be especially challenged to address this conflict. New strategies will be required, new technologies will be born, and business must change in ways that we neither understand nor recognize at the moment.

Energy-Related Political and Technological Change

K.I.: With the COP3 meeting to be held in Kyoto in December, people in Japan are now discussing how to reduce carbon dixide (CO_2) levels. Recently, the United States announced that it will reduce total CO_2 emissions to 1990 levels by the year 2010. I was pleased to hear this because it will have an impact on industry and governments that will lead to solutions and compromise.

S.S: The Kyoto meeting in December is, historically, a pivotal meeting relative to the conflict between the generation of energy and the ability of the earth to absorb the environmental impact of the energy generated. The world's leaders will determine whether the developed countries, particularly at a time when developing countries are ready to explode in their need for energy, can effectively mobilize CO_2 reduction strategies. It is encouraging that the U.S. administration has gone on record as supporting a commitment to reduce CO_2 emissions.

The strategy has to immediately encompass conservation, much higher system efficiency, and much lower pollution in the production of electricity and other energy forms. The dependence on combustion must be reduced and replaced with sources that are renewable. This will take time. Meanwhile, higher efficiency systems are needed with lower pollutant emissions. Examples include fuel cells for the generation of electricity and for hybrid automobiles. In the area of renewables, we will witness an initial emphasis on biomass as a strategy for allowing our combustion economy to be maintained. Hydrogen will play a pivotal role. In time, solar energy must rise as a favored technology.

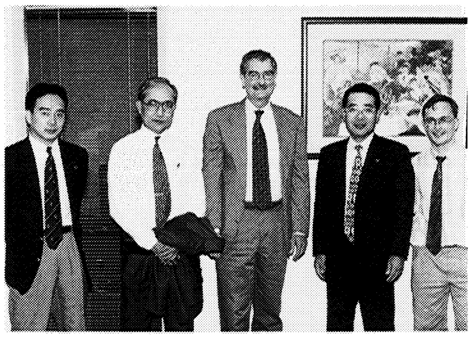
K.I.: In Japan, we are carefully looking at the future of energy development plans. We know that two basic approaches are necessary: improving the existing technologies and developing new energy systems. Horiba is participating in a joint project organized by the Research Institute of Innovative Technology for the Earth (RITE). One of their goals is to find new sources of energy. In this project, we are searching for a measurement technology that contributes to the conservation of the global environment.

We need to greatly improve our current technologies. In the past, we have mainly focused on very small activities, but now we must look at the broader objectives in order to solve today's environmental problems. This enlarged viewpoint is the most important factor needed to achieve our current development goals.

The Paradigm Shift in Existing Technology

S.S.: There are many opportunities for a paradigm shift to improve existing technology. More natural gas can be used as a fuel to take advantage of its higher hydrogen-to-carbon ratio and its lower overall pollution, particularly in urban areas. There is an opportunity to design improved combustion systems by using advanced diagnostic and experimental technologies to reveal a mechanistic understanding of combustion in practical systems, and thereby identify refinements. A particularly promising target, for example, is tailored mixing of the fuel and air in commercially deployed combustion systems.

Another example is active control. Optimum operation of commercial systems will, in the future, benefit by active control with sensors to sense the performance, such as system efficiency and pollutant emissions, and provide feedback to the system controller. For example, in practical combustion systems today, when one reduces nitric oxide (NO), carbon monoxide (CO) increases. However, by using laser diagnostics, fuel-air mixing regimes have been discovered where both NO and CO are simultaneously reduced. To locate these regimes in practical systems, sensors and active control strategies are required. The net result is optimal performance over the duty cycle of the system with an associated quantum jump in efficiency and quantum drop in CO_2 and pollutant emissions.



The discussion was held on September 30th at Horiba Instuments Inc., in Irvine, California, with attendants of;Mr. M. Adachi(Horiba, Ltd.), Mr. Y. Hayashi(Horiba Instruments Inc.), Prof. S. Samuelsen, Dr. K. Ishida, and Mr. Demayo(UCI)

Active control is, at this moment, being introduced to furnace burners and boiler burners. The advanced active-control technology has been tested for stationary gas turbines and will be commercially launched in the next few years. In the future, active combustion control will be considered for gas turbine propulsion units as well.

K.I.: You mentioned that UCI is now working on new combustion control systems for low-nitorogen oxide (NOx) burners. We would like to contribute to such an interesting project and continue the nine year relationship between UCI and Horiba. We have been collaborating to educate our young engineers and to promote environmental sciences. beginning with our president, Mr. Atsushi Horiba.

UCI -Horiba Co-authored Papers (Selected)

Authors	Title	Journal
M. Adachi, V.G. McDonell, and S.Samuelsen	Non-Intrusive Measurement of Gaseous Species in Reacting and Non-Reacting Sprays	Combustion Science and Technology, Vol. 75, p. 179, 1991
T.Igushi, V. G. McDonell, and S. Samuelsen	An Imaging System for Characterization of Liquid Volume Distributions in Spray	Presented at ILASS, 1993
V. G. McDonell, S. W. Lee, Y. Iuchi, and S. Samuelsen	Fuel /Air Mixing Diagnostics Development (A programconducted for GE Aircraft Engines.)	UCICL ARTR-94-03, Oct. 1994
L. Arellano, A. Ateshkadi, H. Fukushima, V. G. McDonell, and S. Samuelsen	Multivariate Experiments to Assess the Effect of Combustor Dome Geometry on Fuel Distribution and Stability	American Society of Mechanical Engineering: International Turbine Institute, Orland, June 1997

S.S.: Indeed, in the future, cooperation between universities and industry will grow in order to develop the technologies needed and to educate the students who will use their expertise to meet these challenges in industry. We will also witness an increasing collaboration and cooperation among technologists from various countries and regions of the world. Energy and the environment are universal and not bound by country borders.

The Paradigm Shift in International Collaboration

K.I.: The Pacific Rim Consortium on Energy, Combustion, and the Environment (PARCON) was founded as a worldwide collaboration project to promote environmental protection in various fields. Could you explain PARCON's goal?

S.S.: If one plots gross national product against energy, a direct correlation is revealed. A country must have energy to develop economically. The earth has now demonstrated that the generation of energy impacts the environment, particularly the earth's air resource. This conflict between energy generation and environmental impact is, as a result, understandably political. As a result, it is difficult for countries to meet together and discuss energy and environmental impact in a reasonable and rational way. In 1992, PARCON's first meeting brought together key technologists from countries in the Pacific Rim—representatives with

Professor Scott Samuelsen

Scott Samuelsen is the Director of the National Fuel Cell Research Center and the UCI Combustion Laboratory, both based at the University of California Irvine. Professor Samuelsen is actively engaged in the area of advanced power generation, and in addressing the conflict between energy conservation and preserving the environment.

"systems look" advanced power operation. We will emphasize the use of solar energy to the greatest extent possible, not only for the provision of hydrogen, but for the provision of direct current electricity.

K.I.: From an energy-saving point of view, we have to think about other technological developments or improvements. For example, if you can reduce the weight of the car by one-half, this would be a radical improvement. We usually just look at energy issues, but the surrounding situation must also change. For example, we may need more micro-technologies or new materials to make stronger and lighter components, and we need to coordinate all of these technologies.

Another issue is of automotive fuels of the future. Alternative fuels such as natural gas or hydrogen will require fundamental changes in the automotive industry. Electric cars that run on batteries will require energy to make batteries and to charge them. I believe that we must also study how to make high energy-density liquid fuels that work with high-efficiency combustion techniques. Perhaps there are ways to create new fuels from CO_2, hydrogen, and natural gas by using biotechnology. If industry can supply these liquid fuels, then the automotive industry can continue to make cars that buyers will find acceptable.

S.S.: A rational strategy would be to introduce an 80-mile-per-gallon automobile to the American public. That is the target for the Department of Energy's Partnership for a New Generation Vehicle (PNGV) program. A second rational strategy would be a policy that reduces the use of the automobile to one-half to one-third of what it is today. Right now, the energy use per capita in the United States. is a factor of three to five times higher than in Japan. Yet, the quality of life in Japan is still at a very high level. In the United States, a substantial portion of the energy consumption is directed to nonessential needs. It is allowed and promoted by scheduling and maintaining the cost of energy at remarkably low price. This is a paradox for the United States, and remarkable political leadership will be required to change the tide.

Education too is a key. In kindergarten through 12th grade, energy and environment should become as common as language and math. In all university engineering curricula, courses in energy and the environment should be as common as breadth requirements. The earth is a finite resource. The governing laws of physics (conservation of mass, momentum, and energy) are now expanding to include a fourth law: the conservation of the finite environmental resources of the earth. In fact, a transition is occurring. Subtle as it is, the environment is indeed becoming a governing equation in the engineering design of societal systems. Education founded on a "Stewardship of the Earth" would be a paradigm shift that would be responsive to this reality.

The Paradigm Shift in New Measurement Technologies

K.I.: I think that measurement technologies are a key in developing the next step. The direct injection gasoline engine is a very effective means for achieving high fuel economy and clean exhaust gas. Our motor exhaust gas analyzers played a key role in the development of this engine. I think that this is a typical example that shows the role of measurement technologies.

Kozo Ishida

Kozo Ishida is Senior Managing Director of Horiba, Ltd., and Vice Chairman of the Japan Environmental Technology Association. Since joining the company in 1970, Dr. Ishida has worked on various energy-related issues, from R&D of measurement technology and instruments to internal combustion engines and new energy technologies.

S.S.: Horiba, being the world's leader in environmental monitoring, has indeed provided substantial leadership and technology to produce the instrumentation required to monitor the quality of the earth's environment and sources of environmental pollutants. For the future, your company stands in a strong position to provide measurement and sensor technology as we move into an era that demands increasingly stringent requirements for sensors for active control, transient measurements with ultra-fast response, robust measurement systems with ultra-high reliability, ultra-sensitive systems with the ability to detect decreasing levels of pollutant species, and advanced hydrocarbon speciation techniques with ultra-high detectability.

K.I.: Mankind must continue to research and develop new technologies to solve environmental problems. We are at a time when we must change our approach to R&D. At Horiba, we are working on developing a new environmental unit, a quantitative value to indicate the environmental impact of technologies, whether detrimental or beneficial. Our business perspective is based on the idea that measurement instrumentation is very important and will grow in the future. Although we are not a big company, we are very proud to contribute to that future.