THE INDUSTRIAL PHYSICIST

Publisher
Randolph A. Nanna
Tel: 301-209-3102
rnanna@aip.org

Associate Publisher/Editor
Kenneth J. McNaughton
Tel: 301-209-3051
kmcnaugh@aip.org

Art Director
Steven R. Black

Senior Contributing Editors
Jennifer Ouellette
Patrick Young

Contributing Editors
Jay C. Cherniak
Eric J. Lerner

Web Designer/Administrator
Tom Connell

Circulation Director
Jeff Bebee
jbebee@aip.org

Publishing Assistant
Cynthia B. Cummings

Advisory Committee
Joseph B. Reagan (chair),
Charles E. Bryson, Paul Grant,
G. Groot Gregory,
Anthony M. Johnson,
Patrick P. McCurdy,
Harold Reitsema,
Beth A. Rosner,
Jennifer J. Zinck,
Kenneth J. McNaughton (staff liaison)

Senior Production Specialist
Kenneth J. Pagliuca

Advertising Production
Eric A. Duke, Elliot Plotkin
Rita C. Wehrenberg

Application Tips Editor
Jennifer L. Huergo

Editorial Offices
One Physics Ellipse
College Park, MD 20740-3842
Tel: 301-209-3051
Fax: 301-209-0842
e-mail: tip@aip.org

Advertising Offices
Tel: 800-247-2242

World Wide Web
www.tipmagazine.com

AMERICAN INSTITUTE OF PHYSICS

Executive Director
Marc H. Brodsky

Member Societies
The American Physical Society
Optical Society of America
Acoustical Society of America
The Society of Rheology
American Association of Physics Teachers
American Crystallographic Association
American Astronomical Society
American Association of Physicists in Medicine
American Vacuum Society
American Geophysical Union

Other Member Organizations
Corporate Associates
Sigma Pi Sigma Physics Honor Society
Society of Physics Students

LETTERS

Scramjets

Thanks for the article on hypersonic craft by Dean Andreadis, "Scramjets integrate air and space" (August/September, pp. 24–27). I had an idea for increasing the efficiency of aircraft at hypersonic speeds that your readers might enjoy: use the boundary layer air around the entire aircraft (thus reducing the ram drag) by ingesting it in the inlets. The boundary layer air would be used to feed a turbojet, and the inlet air would feed a scramjet, with both modes operating at the same time. Here is a Web post to the sci.astro newsgroup that describes the idea: http://groups.google.com/groups?th=21073f81b29c025c.

Robert Clark
Widener University
Philadelphia, Pennsylvania
rgc0300@mail.widener.edu

Energy machines

In "Big green energy machines" by Jesse Ausubel (October/November, pp. 20–24), the author laments that while computers have grown smaller and more powerful over the last 25+ years, thus enabling the Internet, power stations are still about the same size, if not bigger. As a result, power stations have not achieved much of an increase in "power density," and there is the same sort of centralization of power production that we had in mainframe computer days. The reason power stations are big is that the input fuels supply only a limited amount of energy per unit weight; and to generate 3,000–5,000 MW per station, you have to input or process a large amount of "stuff" on a continuous basis, all of which requires big plant and machinery to move it around and large-bore pipes to carry the fuel to the burners. To get 10,000 MW of power from the proposed big zero-emission power plant (ZEPP) at 70% efficiency, you need to push about 300 kg of methane and a similar amount of oxygen into the burner every second—a process that takes a big burner. Pressurizing, pumping, and monitoring that sort of mass flow also take a lot of equipment, as does removing the waste gases.

Moreover, to bring up a counterargument to the author's preamble, 50 years ago cars were about 20 ft long, 8 ft wide, and 5 ft high, so to keep pace with computers, shouldn't they now be 2 ft long, about a foot wide, and 6 in. high?

The author states that we put methane and oxygen in and get only CO_2 out. Methane is CH_4, so we actually get CO_2 and H_2O out, and the output product is fizzy water under extreme pressure. I'm not sure what this does to existing materials, but early power-station experience usually included nasty surprises, for example, stress corrosion cracking that led to a turbine burst at the Hinkley Point B station in 1969 (http://www.npl.co.uk/npl/cmmt/ncs/docs/stress.pdf). So the predictions that the ZEPP would be easy or cheap, or even necessary, seem overly optimistic.

The diagram of the ZEPP seems to show that the CO_2/H_2O is recirculating. Will methane and oxygen even burn in a CO_2/H_2O working fluid?

Won't the cost of separating O_2 from the normal atmosphere make the whole thing uneconomic? Couldn't we get similar energy

BPA INTERNATIONAL *THE INDUSTRIAL PHYSICIST* (ISSN 1082-1848; CODEN INPHFA), volume 10, number 6, Copyright © 2004 American Institute of Physics. **Subscriptions:** *The Industrial Physicist* is available free to qualified parties in the USA. New subscriptions, renewals, address changes, and other subscription needs can be facilitated at www.ezsub.net/ipy, or complete and return the qualification card in each issue to The Industrial Physicist, Starrcorp, 201 Commerce Drive, #6–7, Moorestown, NJ 08057, or fax to 856-380-4101. Questions? E-mail jbebee@aip.org. **Non-qualified readers** can receive the magazine for $45/year in the USA or $75/year outside the USA. **Libraries and institutions** pay $169/year in the USA or $199/year outside the USA (airfreight only). **To order a paid subscription**, please send your request with name, address and payment—a check for $U.S. drawn on a U.S. bank, or credit card information (indicating VISA/MC/AMEX, credit card #, expiration date, name as it appears on the card, and billing address)—to AIP, Attn: TIP Payments, P.O. Box 503284, St. Louis, MO 63150-3284. **Back copies** are available for $20 each postage paid from the AIP office listed under "paid subscriptions," using the same prepayment instructions. **Republication** or systematic or multiple reproduction of any material in this publication is permitted only under license from AIP. Please send requests for permission to AIP Office of Rights and Permissions, Two Huntington Quadrangle, Suite 1N01, Melville, NY 11747-4502; fax (516-576-2450); phone (516-576-2268); e-mail (rights@aip.org). Copies of articles may be made upon payment of a fee of $22/copy through the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923.

density and reduced pollution by using pure O_2 in a conventional gas turbine, which is what the ZEPP basically is? If you push air into the burner, reaction with nitrogen and other trace elements would totally negate the zero-emission part of the plan.

Do power electronics exist that can rectify a 10-GW power flow from 30 to 60 Hz? The author proposes a 10,000-MW generator with a 30,000-rpm shaft speed.

The second proposal, for a combined hydrogen–electricity pipeline, seems fatally flawed in today's uncertain times too, given that a small explosive device or a carefully placed series of devices could sever both forms of power transmission across the continent in short order. That is, one bomb, and we're left with no electricity and no hydrogen.

Roger Cowles
Marblehead, Massachusetts
rojcowles@comcast.com

[*Author replies*: Roger Cowles asks many excellent questions. Limited by space, I will comment on two, ZEPP design and footprint. The TIP cartoon of the ZEPP was not an engineering drawing, and several readers noted its incomplete design. TIP reader Don Jenkins, former head of propulsion for General Dynamics, has already offered excellent suggestions for starting the concourse of designs for which my paper called. I look forward to working with Don and other TIP readers. We can certainly deal with fizzy water, but other nasty problems, such as by-products of the very high temperatures, will arise and keep industrial physicists employed.

As for power plant mass and equipment, pipes will come and go, but high pressures can narrow them, and siting the plants as adjuncts to existing natural gas pipelines minimizes the need for more acreage. The acreage of a coal plant, including its rail yards and carbon heap, would easily accommodate a ZEPP producing 5–10 times the kilowatts, including associated oxygen or other facilities. As for shrinking cars, one can think of the Intelligent Transportation Systems and many other auto developments, even seatbelts, as a strategy to increase the flux of vehicles through an infrastructure of the same size by denser packing at higher speeds. Magnetically levitated trains could finally offer us much lighter, more-compact bubbles in which to move around.]

As a science writer who deals with ways to present data to the public, I have a suggestion. Figure 4, showing how the efficiency of power generation increases, should include data points on the Space Shuttle main engine, which operates in similar temperature and pressure regimes, namely ~490 atm and ~3,000 K at 37,000 rpm. The high-pressure pumps are smaller than what is envisioned for a ZEPP, but the data points would help show people that the numbers are achievable. For information on the Space Shuttle main engine, visit http://www.boeing.com/defense-space/space/propul/SSMEamaz.html and http://www.boeing.com/defense-space/space/propul/SSME.html.

Dave Dooling
Sunspot, NM
deesqrd@earthlink.net

[*Author replies*: Mr. Dooling is right to point to rockets, and I expect many of the technical ideas for ZEPPs to come from rocket engines. A cruise missile engine and the furnace in your basement may compare in size, but they differ a bit in power. The challenge is to make an engine that lasts, say, 300,000 hours.]

Jesse Ausubel's article was disappointing to this advocate of novel but scientific approaches to practical, clean, sustainable energy. The article presents no thermodynamic-cycle efficiency analysis. It also displays poor appreciation of realistic potential advances in materials science (both ceramics and metals); no appreciation of recent progress in advanced biofuels, wind, or solar; short-sightedness with respect to natural gas and nuclear resources; and no appreciation of the many serious challenges associated with a hydrogen economy.

At the United Nations-sponsored Expert Workshop on Abrupt Climate Change (Sept. 30–Oct. 1, 2004; http://www.accstrategy.org/), it was shown that recent progress is beginning to allow advanced biofuels to compete economically while dramatically reducing greenhouse gas emissions. A number of recent analyses show the highly hyped "hydrogen economy" to have little chance of living up to any of its promises in the foreseeable future.

Advanced concepts were shown to have the potential to produce economically competitive biofuels (even at oil prices 30% below today's prices) with high energy balance; achieve negative carbon emissions (via sequestration), along with highly effective soil-fertility enhancement; substantially enhance quality of life, especially in developing countries with limited oil resources; provide a higher degree of energy security in oil-importing nations than any other known option; and contribute to improved health through the diverse benefits that come from clean, sustainable, economical energy (such as improved quality of water and air, a reduction in international conflicts, and increased overall economic growth).

I suspect that within a decade at the most (and probably sooner), the "hydrogen economy" will be seen to fit in the same category as oceanic thermal gradients. Readers may find my recently updated paper interesting and informative: "Fuels for tomorrow's vehicles" (http://www.dotynmr.com/PDF/Doty_FutureFuels.pdf).

Physicists do themselves and their profession a disservice by presenting starry-eyed visions with poor appreciation of engineering, economic, and societal realities.

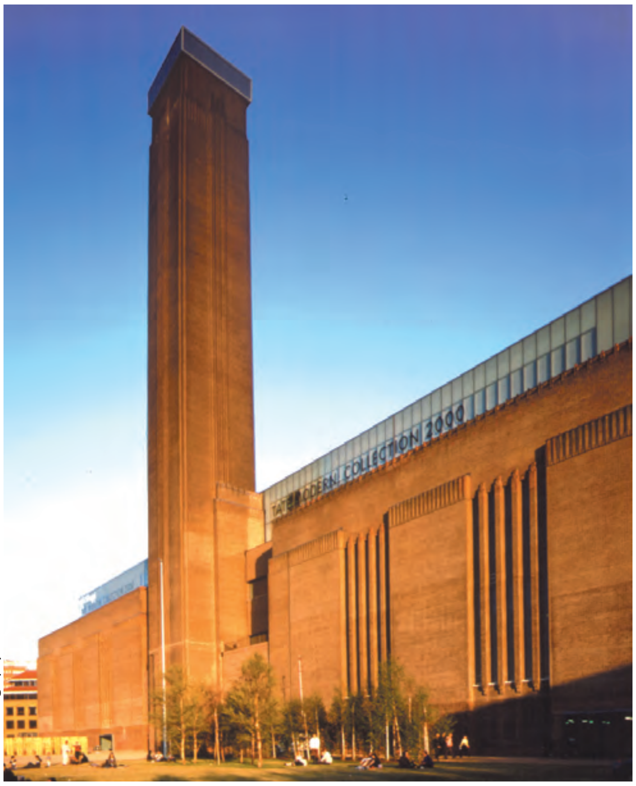
F. David Doty
Doty Scientific, Inc.
Columbia, South Carolina
david@dotynmr.com

[*Author replies*: Having spent much of my career working on biodiversity and habitat for nature, I conclude that biofuels are a catastrophic use of land on scales that matter for the United States or world energy. A huge environmental challenge is to reduce the human footprint in green nature, to shrink farming and logging. Many papers at http://phe.rockefeller.edu address sparing land. For more on the sad facts of wind, solar, and biomass, see http://phe.rockefeller.edu/PDF_FILES/NEIrevision11june04.pdf and http://phe.rockefeller.edu/

PDF_FILES/neigraphics11junerevision.ppt.

Chronic fears about exhaustion of natural resources abound, and so do the resources. The famous King Hubbert charts project human fears, not geology. Dr. Doty's paper does offer welcome realism about using retail hydrogen for transport. Yet, globally, the hydrogen industry is growing nicely, although it is not driven by the start-ups of the 1990s. Visit the Dow facility in Freeport, Texas, to see hydrogen operations at the scale of hundreds of megawatts.

From the Doty Scientific Web site, it sounds like your company does terrific things and that you have a strong appreciation of technical change. Put your mind back to 1904, and then think forward to 1950 or 2000 (the time scale for our big green energy machines) and the changes in scale and character of the electric power enterprise. Compare today's nuclear magnetic resonance machines with their ancestors that came out of General Electric's Milwaukee plant. I will wager that the thinking behind Doty microturbines will matter more for energy systems than algal ponds in the Sonoran desert. You should take heart from your own achievements.]



Tate Photography

Although I am not qualified to fully judge the article's details, your ideas appear to be reasonable and workable, and I was able to understand the basics. Your article enables one to better imagine future possibilities. I also appreciated the inclusion of the Bankside power station in the U.K. as a historical note.

However, at this geopolitical time, centralized energy generation and distribution components would be a terrorist's dream. To me, it seems better to have an arrangement that follows the Internet more closely, that is, one using smaller generating components interconnected in a survivable grid arrangement. Our defense industries have followed the principle of geographic dispersion to achieve some measure of survivability in the event of a national catastrophe.

Bob Downs
Development Associates
Tustin, California
devassoc@yahoo.com

[*Author replies*: The United States has about 8,000 large generators. Suppose the fleet dropped in half because of the success of ZEPPs and other larger machines, even as demand rose. If the generators were networked in a smart mesh that moves electric power around at a continental scale, saboteurs (or earthquakes) would probably need to remove 400 or more plants (10% of the supply) to make a big problem. Not so easy. Think of the Supergrid concept as an "eBay" for power, in which everyone can buy and sell, no matter where you are, with transaction costs very low. Idaho could be the Saudi Arabia of hydrogen, shipping to all corners of North America. Creating this mesh with very low cost for transport, and putting it underground, should lift security.]

Regarding the big green energy machines, I have two problems. The first is that the input is natural gas and oxygen. The oxygen problem, which is a huge one, is noted, but not noted is the fact that natural gas is a scarce raw material, and too valuable (as a chemical feedstock) to burn. Somehow, nobody in developing energy scenarios wants to look at the supply of fuels.

A table from the Department of Energy's Energy Information Administration of best-guess worldwide fossil-fuel resources shows that coal far outweighs gas and oil. I say, "We had better use coal or we'll be out in the col'." Coal can substitute for natural gas in the ZEPP, and the CO_2 can be sequestered from the gas cleanup system. (By the way, natural gas must be "sweetened"—have the sulfur compounds removed—before it can be used.) No matter how we wiggle, we aren't going to be able to avoid reliance on coal. In addition, the nuclear option must be considered, but only if it is possible to "breed" (produce more fissionable material with surplus neutrons).

My second problem is that there is no economic analysis, and when an analysis is complete with capital, operating, maintenance, and variable costs and realistic values for the product-plus-sensitivity analysis, I believe the results will not be "bankable." The problem with energy systems is that they permeate the entire economic framework. For example, $50/bbl of oil does a whole lot more to the economy than raising the price of gasoline 50 cents.

E. Gerald Meyer
University of Wyoming and Coal Technology Corp.
Laramie, Wyoming
EGMeyer@uwyo.edu

[*Author replies*: We can and should avoid reliance on coal. The question of the amounts (and origins) of hydrocarbons remains open. A team led by Henry Scott reported in a recent paper entitled "Generation of methane in the Earth's mantle" (*Proc. Natl. Acad. Sci. U.S.A.*, Sept 20, 2004) that the hydrocarbon budget of the bulk Earth might be much larger than conventionally assumed, for better and worse.]

Correction

In the October/November issue, p. 23, Figs. 4 and 5 incorrectly included a credit to Ian Worpole.