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## Book Review

### *Fuel Cell Systems*

Edited by L.J.M.J. Blomen and M.N. Mugerwa, published by Plenum, New York, USA, 1st edn., 1993, 588 pp., US\$ 125, ISBN 0-306-44158-6

Fuel cells are now becoming available for demonstration as quiet, clean and efficient power plants after sporadic R&D for more than 150 years. Low-temperature AFC and PAFC types are essentially fully developed, whilst the SPFC and high temperature types MCFC and SOFC are approaching commercialization.

This compilation is a welcome addition to the literature. Following the comprehensive *Handbook of Fuel Cells* by Appleby and Foulkes, these contributed chapters are well-written by established exponents of the art, including Appleby himself. Topics are oriented towards practitioners and include engineering and marketing aspects: many of the live issues are reviewed, the editors themselves also being contributors. The volume illustrates well the interdisciplinary aspects of the field.

The opening chapters by Ketelaar, by Srinivasan et al. and by Barendrecht relate the history, background technology and electrochemistry of fuel cells, respectively. This provides a good setting for newcomers, but the treatment of some important topics like porous electrode theory, the concept of the real, the electrochemical and the geometrical electrode areas, hence current densities, is somewhat cursory, as is the reference to vital laboratory studies of electrode kinetics at planar electrodes. Pietrogrande and Bezzeccheri give a concise outline of fuel processing with a strong engineering flavour; the introductory remarks on fuel sources and infrastructure might have repayed expansion, but most aspects are mentioned. Appleby reviews the main features determining fuel cell systems design; he lays to rest misapprehensions surrounding fuel cell thermodynamic efficiency and concludes with brief considerations of emission, siting, reliability, waste disposal at shut-down, safety and power conditioning. A separate chapter on electrical engineering aspects would have been appropriate at this juncture, as this is not well-understood by all in the field. Mugerwa and Blomen, the editors, outline systems design and optimization, including flow diagrams, design points,

and operational modes, inter alia; all that difficult but essential mathematics of heat and mass transfer is strangely absent? So, too, is mention of systems control and oscillating systems – the nub of viable plant design.

The text then turns to the main fuel cell types presently under development. Alkaline fuel cells (van den Broeck), phosphoric acid fuel cells (Anahara), molten carbonate fuel cells (Selman), solid oxide fuel cells (Murugesamoorthi, Srinivasan and Appleby) and solid polymer fuel cells (Watkins) are separately considered. The first type is comprehensively discussed and an assessment of future development needs given, but the tone seemed unnecessarily pessimistic? The citation list is rather short in Anahara's chapter due, no doubt, to the proprietary nature of much of the information, but lacks nothing for that, especially as the author has, himself, been responsible for much development. Selman's chapter is extremely comprehensive and makes excellent reading; he indicates the key role that MCFCs are likely to play in the next generation of multi-fuel cells. The solid oxide fuel cell chapter was a little thin and disappointing, unlike the other chapters from Texas A&M. It did not include the recent developments of multi-planar cells, new sealing technologies, 'metal' bipolar plates, gadolinia-doped ceria electrolytes and duplex structures for lower temperature operation in direct methanol mode; additionally, Figs. 2.13 and 10.12 are duplicates. Watkins provides an extensive review of SPFC development, design, construction and performance. Since this chapter was written, even greater efforts have been initiated to develop these units for the transport sector. Commendably, Watkins uses the correct acronym SPFC for these cells, (SPE is NOT allowed as it is registered by GE/ Hamilton Standard and, since protons tunnel rather than exchange, PEM is misleading or incorrect – editors please note!)

The last few chapters consider fuel cell economics (the editors), fuel cell markets (Hooie), and there is a helpful epilogue, again by the editors. The first two are most apposite, but since politics has more influence on fuel cell development in particular and power generation, in general, why was there no chapter on this? The first of these chapters includes useful material from commercial market studies. The second is cursory,

and does not adequately address the competing technologies which could provide enough material for an entire volume. The cost and availability of precious metals is left to a few sentences and a long footnote by the editors in their epilogue.

The book is well printed and substantially bound by Plenum, has a helpful index, with plenty of clear illustrations and diagrams. The price would attract personal copies in the USA, (but not Europe). Typographical errors are not infrequent but do not unduly detract or distract. Although the editors have

accomplished a splendid task, there is some overlap in many chapters. The dated accounts in some chapters, are explained by the editors in terms of the long preparation time – update will need to be accessed from the literature and abstracts of fuel cell meetings. In spite of some shortcomings, this book will be essential reading both for the cognoscenti and newcomer alike.

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