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BOOK REVIEW

Hydrogen Energy Progress-XI, *Proceedings of the 11th World Hydrogen Energy Conference*, Stuttgart, Germany, 23–28 June 1996. Editors: T. N. Veziroğlu, C. J. Winter, J. P. Baselt and G. Kreysa, Published by DECHEMA eV, Frankfurt-am-Main, Germany, on behalf of the International Association for Hydrogen Energy, Coral Gables, FL 33124, U.S.A., June 1996. 3 volumes, 2766 text pages + Contents and Authors Index 56 pages. Hard cover. Price: US $425.00/set.

The 3 volumes of HEP-XI contain a total of 320 articles out of which as many as 186 are poster presentations of brief technical notes. The articles are grouped under six topic-heads, four of which concern the technologies of hydrogen production, storage, transport and utilization, materials and safety concerns of hydrogen use as energy medium. Of the remaining two, one reviews the various compulsions and strategies for an early transition to hydrogen fuel use and the on-going international and national programs and projects aimed at achieving this goal. Themes which are still in the basic research stage and have not matured even to bench-scale demonstrations are presented in the last part of the proceedings under the title "Fundamentals".

A welcome feature of WHEC-XI proceedings is that most of the contributions are from industrial and commercial organizations and from governmental project undertakings. Most of them relate to the technological implications of hydrogen energy expansion on an industrial scale. This is a welcome development as it reflects the growing confidence of industrial organisations around the world in the future of hydrogen as a viable and affordable replacement for hydrocarbon fuels in all sectors of energy needs.

The proceedings open with a forceful plea by the Conference Chairman, Professor Winter, to initiate steps here and now for the introduction of hydrogen as a public transportation fuel to begin with. He has put together, in a masterly fashion, the technological implications and has proposed a prescription for a smooth change-over to hydrogen fuel. The most promising prospect for hydrogen in the immediate future is as a vector for renewable energy sources such as solar- and wind-energy. Apart from status reports of several solar–hydrogen projects (the most advanced of which is the HYSOLAR joint project of Germany and Saudi Arabia), there is a detailed account (technical features and economics) of a 1 MWe Wind–Hydrogen demonstration plant set up in Argentina.

Hydrogen production: continuing the trend followed in the previous WHECs, electrolysis of water, particularly with proton exchanging Polymer Electrolyte Membranes (PEM), has received further emphasis in WHEC-XI as a preferred technology for hydrogen production on an industrial scale as well as for linking with solar–photovoltaic and wind power plants. Besides an excellent review article by a team of authors who are in the electrolyzer industry, there are contributions on the operational characteristics and fabrication of components such as membranes and electrodes which are crucial for the efficiency and endurance of the electrolyzer plants.

Another interesting process advanced by quite a few authors is the direct pyrolysis of methane or natural gas ($CH_4 = C + 2H_2$) which, besides avoiding carbon dioxide formation, yields high quality carbon black as a valuable byproduct. Steam-gasification of biomass as a cheap renewable resource has been proposed by some authors as a viable and economical process for hydrogen production. Concentrated solar energy as a high temperature heat-source for hydrocarbon processing and thermal water-splitting processes is proposed in an interesting paper from Israel.

Hydrogen storage and transport: the importance of hydrogen storage is appreciated not only in the use of hydrogen as a combustion fuel for stationary and mobile power-generation but equally as a capacious and practical means of "storing" other forms of energy, especially electrical and thermal. This has inspired proposals for the storage of solar–PV electricity by conversion to hydrogen through electrolysis. The "stored" hydrogen can be reconverted to electricity very elegantly and efficiently by means of fuel cells.

Of the three known options for hydrogen storage, namely compressed gas, metal hydrides (MH) and liquid hydrogen (LH), the latter has been rated as the most practical and economical for on-board storage on surface transport vehicles. There is a detailed coverage on all aspects of bulk LH storage, transport over land, sea and air, distribution and delivery, including the mechanics of automobile tank-filling operations. All the papers on metal hydrides are brief poster presentations. Worth mentioning among them are those describing a computer-automated apparatus for absorption–desorption measurements, a metal hydride-based thermal hydrogen compressor designed for use in solar thermal power plants and some new rare-earth metal compositions for hydrogen storage.

Hydrogen utilization: the most exciting part of WHEC-XI proceedings is the one pertaining to the energy-related applications of hydrogen, namely energy production, transformation and transmission. These comprise both consumptive uses as combustion fuel and non-consumptive uses as circulatory working fluid in heat pumps and heat transformers.

The main thrusts of the papers appearing in this section relate to the use of hydrogen as fuel for automobile engines of all types (Otto, Diesel and Wankel), aircraft jet engines, space rockets, high temperature steam-raising and catalytic heaters and stoves for domestic applications. The industrial development of hydrogen fuel cells, particularly for electromobiles (buses, trucks and cars) is reviewed in a number of papers. A notable, credibility-boosting feature of these articles is that most of them are from big industrial houses like Daimler–Benz, BMW, MAN, Ludwig–Bolkow and Ballard Power, and from government-sponsored programs like DLR, NREL, and WE-NET. Many of them have reported extensive field trials with hydrogen fluid vehicles.

Materials and safety: these two seemingly different aspects of hydrogen energy technology have been combined as the mechanical failure of ferro-alloys in hydrogen environment and at low temperature impinges on the safety of their usage for hydrogen storage and transport. Besides this aspect, there are articles (including a detailed bibliographical review) on new component materials for water electrolysers, PEC cells, nickel–hydrogen and nickel–metal batteries and hydrogen storage. Purely on the safety aspects of hydrogen utilization as fuel, there are papers on combustion, detonation and autoignition, safety considerations in the design of H-powered vehicles and LH storage tanks, and a novel safety device for use with hydrogen appliances.

The last part of the proceedings, titled *"Fundamentals"* contains presentations of innovative techniques for hydrogen generation and storage which are still in the basic research stage. These include photoelectrochemical (PEC) and photobiological (PB) processes and new alloy formulations for hydrogen-storage. Specially noteworthy are Grätzel's state-of-the-art review of PEC research under IEA program, Ti Tien's paper on semiconductor septum solar cells for hydrogen generation from sea water, and reports of utilization of agricultural and municipal wastes in photobiological hydrogen production and innovations in PEC and PB reactors. New technologies for the manufacture of membranes for PEM fuel cells and water electrolysis, zeolite powders for hydrogen storage and a chemical surface-cleaning procedure for Fe Ti alloys are among the other interesting items presented in this part. The logic of separating these contributions from the earlier parts dealing with hydrogen production and storage is not clear. The segregation of basic research from technological developments seems unnecessary and was not the practice in previous WHEC proceedings.

In conclusion, *Hydrogen Energy Progress-XI* is a welcome addition to the previous ten biennial editions of this series, with its accent on industrial developments and public awareness. Scientists, engineers, planners and energy policy makers will find the three-volume set very useful in formulating an integrated multidisciplinary approach to finding an environmentally acceptable long-term solution for the world's, growing energy needs.

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