

Realising the Potential of Fuel Cells

THE NEW REQUIREMENT FOR LOWER EMISSION VEHICLES STIMULATES GROWTH IN FUEL CELL DEVELOPMENT PROGRAMMES

The thirteenth Fuel Cell Seminar, held in Tucson, Arizona, U.S.A. from 29th November to 2nd December 1992, was attended by over 500 delegates from 18 countries. The theme "Fuel Cells – Realising the Potential" was chosen to focus attention on the opportunities and challenges involving fuel cells at this critical stage in their development. The conference heard that early commercial fuel cell plants, based on the platinum-containing phosphoric acid fuel cell (PAFC), which are being supplied from purpose built pre-production facilities located in Japan and the United States of America are now providing a considerable wealth of end-user experience and feedback to the manufacturers. Dominating the conference, however, was the world-wide growth in the number of development programmes addressing fuel cell applications in transportation, pushed forward by the move to have zero emission vehicles operating in the U.S.A. by the end of the century.

Phosphoric Acid Fuel Cells for Stationary Applications

During the next three years the number of PAFC demonstration units operating world-wide is expected to increase to about 200, and more than half of these will be in Japan. The largest capacity fuel cell power plant in the world is the 11 MW International Fuel Cells (I.F.C.) plant located at the Tokyo Electric Power Company's generating station in Goi. Since start-up in April 1991 the plant has been operating at 43.6 per cent gross AC power efficiency at the rated power output, and with less than 3 ppm nitrogen oxides in the exhaust. By August 1992 the plant had established a record for fuel cell power generation of 23,435 MWh. One of the key technical objectives of this demonstration concerns the durability of the fuel cell stacks, and at present they are surpassing their design specification.

Fuji Electric are currently producing 50 and

100 kW cogeneration units in a pre-commercial demonstration programme with full commercialisation targeted for the mid-1990s. Fuji are now designing a 5 MW plant for delivery to Kansai Electric in 1995.

Mitsubishi Electric stated that the 200 kW unit installed at the Hotel Plaza had completed its demonstration after achieving 13,000 hours of power generation. This was believed to be the longest PAFC operation to date. They reported that they were now planning to enter commercial production of 200–1000 kW cogeneration units in the mid-1990s.

Fuel Cells for Transportation

An overview of 12 major government-sponsored demonstration programmes world-wide was provided by P. Patil of the U.S. Department of Energy. Nearly all are focusing on the use of the proton exchange membrane fuel cell (PEMFC). This fuel cell is further from commercialisation than the PAFC, but it possesses many important characteristics which make it the most likely fuel cell to find application in transportation. In particular it can provide higher power densities, it starts up rapidly from room temperature and is more rugged than other types of fuel cell. For the PEMFC to become a practical system, however, there are several crucial technical issues that have still to be resolved.

One of the biggest PEMFC vehicle programmes is the General Motors/Los Alamos project, sponsored by the U.S. Department of Energy, which was announced at the 1990 Fuel Cell Seminar. Phase 1, scheduled for completion in mid-1993, targets the production of a 10 kW "Electrochemical Engine" combining reformer, fuel cell, ancillaries and control equipment to demonstrate systems feasibility. Emphasis to date has been on component technology development around two state-of-the-art 5 kW Ballard stacks. The development of high efficiency, fast

response, methanol reformer technology, which is compatible with the low operating temperature (< 100°C) of the PEMFC is central to this project. The team at Los Alamos has developed a new, compact methanol steam reformer, based on a three-bed monolith system (primary reformer, water-gas shift reactor, and a preferential oxidation reactor). The last reactor is designed to reduce to below 10 ppm the level of carbon monoxide, which can otherwise poison the platinum anode catalyst reaction.

Ballard Power Systems, of Canada, are widely acknowledged as world leaders in the development of PEMFC stacks. They are managing a Canadian government funded programme to produce a zero emission transit bus powered by fuel cells. The 120 kW (all fuel cell) compressed gaseous hydrogen-fuelled bus is on target to commence driver acceptance trials in March 1993. The primary aim of this programme is to demonstrate that the fuel cell can provide all the motive power required for vehicles without the need for an auxiliary power back-up unit. Ballard also reported on their own methanol steam reformer programme, which again comprises the three catalyst reactors, but all integrated into a single reformer unit. This reformer has already operated with a Ballard stack in load-following mode for 50 hours, in what is believed to be the first demonstration of a methanol fuelled PEMFC operating in load-following mode.

Current PEMFC stacks are still too costly for any widespread applications. In addition to cost savings through improving manufacturing processes, there is also a requirement for a reduction in component materials costs. One of the most expensive components is the solid perfluorosulphonic acid based proton conducting polymer electrolyte and an intrinsically cheaper material is now being developed by Ballard. Single cell results indicate similar performance to currently used Dow materials.

Other PEMFC development programmes were described, including those of Energy Partners, I.F.C. and Analytic Power Corporation in the U.S.A., Ansaldo/Sere-De Nora in Italy, and Vickers/CJB Developments in the United Kingdom. All the fuel cell stacks currently employ

high loadings of platinum-based electrocatalysts, typically around 8.0 mg/cm² platinum per cell. This equates to over 20 g Pt/kW which is far too high for vehicular applications, however, work is underway to reduce this loading. Further progress on catalyst and electrode development at Texas A.& M. University and at the Los Alamos National Laboratory was described. Advanced catalysts and new methods for producing electrodes with platinum loadings as low as 0.13 mg/cm² per electrode are showing great promise in single cell evaluations.

Platinum Availability

The issue of platinum supply, should fuel cells capture a large share of the future power generation market, was addressed by E. Becker of Environex Inc. For stationary applications, a platinum market of 20 metric tons per annum was projected by 2010 for fuel cells. If substantial vehicle penetration occurs, however, the demand for new platinum could increase to about 125 tons annually by the year 2030. With current world reserves of platinum amounting to 65,440 metric tons and projected to last for 380 years at the present rate of demand, it was concluded that fuel cells would not seriously affect platinum availability.

Conclusions

This is probably the most critical period in the long history of fuel cells, with significant numbers of pre-commercial 50–200 kW phosphoric acid fuel cell cogeneration units now being evaluated by end-users throughout the world. A successful outcome to these trials is likely to lead to the start of a full commercialisation programme commencing in the mid-1990s. Led by the impending regulations for zero emission vehicles in California from 1998, opportunities for the exploitation of fuel cells in transportation have opened up. The key technological developments required for the proton exchange membrane fuel cell are now being addressed and progress is being made on all fronts. By the time of the next Fuel Cell Seminar in two years time, we should know whether the potential of these systems will at last be turned into reality. G.A.H.