Extended Abstract

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Session: Tutorial on Fuel Cells

ALKALINE FUEL CELLS (AN OVERVIEW)

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Introduction:

Large R&D efforts have been going into **A**lkaline **F**uel **C**ells (AFCs) with liquid or immobilized KOH Ref. [1]. Much progress has been made, but many people may not be aware of it because other fuel cell types have publicly prevailed. Recently AFCs have received attention because they are very efficient and basically of low-cost. [2, 3]

Historical / Technical Developments:

Francis Bacon: Mid 50's, 5 kW, H_2/O_2, 200 °C, 5 MPa. He started the technology of dual porosity Ni-electrodes. His system was further developed by NASA in the USA.

NASA-Pratt & Whitney, 2.3 kW AFCs were used in nine Apollo Moon Flights, 3 Sky-Labs, total: 54 missions. [4]

Space Shuttle-United Technologies, 1975, First flight in 1981, 3 x 12 kW, 27.5 V, 92 °C, 0.4 MPa, bipolar design, KOH asbestos immobilized, 8 x the power of the previous NASA-Apollo units. Anodes: 10 mg/cm^2 Pt/Pd on carbon.

Allis Chalmers Mf.: 1962-67, new water removal design. First "civilian" usage: H_2/O_2 15 kW-Tractor, 65 °C. [5]

Union Carbide Corp. (UCC) in 1958: 3 mm thick baked porous carbon plate system for the US Navy and carbon tube systems (Brussel's World Exhibition). 1961: starting thin PTFE-bonded electrodes in 35 % KOH, 70 °C. [6] The General Motor's Electrovan, H_2/O_2, 400 V, 125 kW, was built 1967 [7] .The Kordesch-Austin-A40 City Car with a 6 kW, H_2-Air-Lead Battery Hybrid was built 1970 and operated 3 years in city traffic. The 96 V system was shut down in no-driving periods and started instantly.[8]

Occidental Chem. Corp. tried to develop the concept of **Alsthom Cie.** , France, to a high commercial level 1978. Basic material: Polypropylenes extruded in a conductive and in a non-conductive form. Goal: low-cost ($ 100/kW) production of bipolar units. Life expected: 8000 hrs. [9]

Varta, Germany, developed and demonstrated several AFC systems for years, started the Eloflux System in 1965. It used diaphragms between its double-porous Ni-electrodes and circulating KOH, entering centrally. [10]

Elenco NV. started in Belgium in 1970. They built PTFE bonded multi-layer electrodes with Ni-carriers, like UCC. Edge-collected 17 x 17 cm electrodes, 0.4 mm thick. Only 0.15 mg/cm^2 of Pt-metal catalyst loading!. A 220 V 52 kW system was built for the Belgian Geological Service. In 1994, a 20 module (10 kW each) H_2-Air-Bus system (EUREKA) operated as AFC-Lead Battery Hybrid. [11]. Elenco worked with the European Space Agency (ESA). In 1995 Elenco NV. was closed, continued as Zevco and ZeTek. A new Hybrid-Taxi was demonstrated in London in 1999, another one at the Fuel Cell Symposium in 2001. Both companies closed. New companies formed in 2003. The AFC plant in Cologne, Germany is now being sold.

Siemens AG, Germany has been developing H_2/O_2-AFCs in the 1970s and 80s for submarine applications. Special Ag-catalyst was used for cathodes. 20 kW systems were built [12]. Siemens cooperated with ESA in mid 1990s. Since 1990 Siemens also added the PEMFC Technology.

ASEA: O. Lindstrom at the Royal Techn. University of Stockholm [13] headed a large AFC program (ASEA), based on dual porosity Ni-electrodes for the Swedish submarine fleet. The program was abandoned after a serious accident. The Techn. Univ. switched to PTFE-Carbon electrodes for AFC applications in the civilian sector (also for farming).

The Russians built the "Photon" AFC for their manned space flights with very high Pt-metal catalyst-loadings. It was operating in one (the final) unmanned flight. [14]

The European Space Agency (ESA) had a very large AFC program with its center in Toulouse. The Space Shuttle "Hermes" program competing with NASA was abandoned 1993 and with it the ESA-AFC-program. [15].

In USA the AFC programs were stopped after the NASA units had been finished. The PAFC and PEM-FCs for vehicles and the high temp. FCs for plants went ahead.

In Canada the University of Toronto investigated AFCs and the Hydrogen Institute in Mississauga, Ontario, was formed. The "Astris" Co. followed, after the Hydrogen Institute closed. "Astris" is still developing AFCs today. Electric Auto Corp. in Ft. Lauderdale, FL, is now active in AFCs [2, 3], the H_2 from an NH_3-cracker is used.

References:

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[4] Pratt & Whitney, Design and Dev. of Apollo Fuel Cell Power Plants, Final Report, NASA/Houston, 6/16/1962

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Literature:

1. Handbook of Fuel Cells, 4 Volumes, W. Vielstich, ed., Publ. by J. Wiley & Sons, 2003. Chapters: **13**: AFCs, **11**: Ammonia, **63**: Stacks, Materials, **65**: AFC versus PEM-FC, **93**: Direct Methanol AFCs, **102**: Automotive-ZeTek.

2. Fuel Cells and their Applications, Karl Kordesch and Gunter Simader, VCH Verlag (also Wiley & Sons), 1999

3. Brennstoffbatterien, K.Kordesch, Springer Verlag 1984

4. Fuel Cells, Ullmann's Encyclopedia of Industrial Chemistry, 5th Ed., VCH, Weinheim, Vol. A12, pp. 55-83

5. Fuel Cells**,** Their Electrochemistry, J.O'M.Bockris**,** S. Srinivasan, McGraw-Hill Book Co. NY, 1969

6. Modern Aspects of Electrochemistry, J.O'M. Bockris, B.E. Conway, No. 10, pp. 376, Plenum Press, NY, (1975)

7. From Electrocatalysis to Fuel Cells, G. Sandstede, ed., Publisher: Battelle Seattle Research Center, 1972

Notes:

PowerPoint Presentation:
The author will show ca. 30 slides, with the various AFCs, circuits, designs, vehicles, etc.

2nd Paper at this meeting:
Alkaline Fuel Cell Operation with Ammonia and Methanol as Fuel Sources. Authors:
K. Kordesch, M. Cifrain, G. Faleschini, G. Koscher.