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Journal of Power Sources 71 (1998) 223–225

JOURNAL OF POWER SOURCES

The ‘advanced DIR–MCFC development’ project, an overview

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Accepted 29 October 1997

Abstract

An overview is given of the approach and mid-term status of the joint European ‘Advanced DIR–MCFC Development’ project, in which BCN, BG plc, GDF, ECN, Stork, Schelde and Sydkraft co-operate. Hospitals are identified as an attractive initial market for cogeneration direct internal reforming–molten carbonate fuel cell (DIR–MCFC) systems in the size of 400 kWe. Innovative system and stack design concepts are being developed for this application. The ‘SMARTER’ system, based on DIR stacks, combines high electric efficiency and a wide operational window with optimal system simplicity and low cost. © 1998 Elsevier Science S.A.

Keywords: MCFC; Direct internal reforming; Cogeneration; Cost reduction; System development; Stack technology

1. Introduction

Cost reduction by development of innovative concepts for both system and molten carbonate fuel cell (MCFC)-stack is the main objective of a joint European 3-year (1996–1998) ‘Advanced DIR–MCFC Development’ project in which Brandstofcel Nederland BV (BCN), the Netherlands Energy Research Foundation (ECN), Stork, Schelde Systems (The Netherlands), BG plc (UK), Gaz de France (France) and Sydkraft AB (Sweden) co-operate.

The ‘Advanced DIR–MCFC Development’ project is strongly ‘top-down’ driven (i.e. market led), ensuring that the resulting cogeneration plant meets all technical, economic, legislative and environmental requirements. Three fields are covered: (1) market analysis, (2) system development and (3) stack development.

The ‘Overall Development Plan’ of the project is shown in Fig. 1.

2. Market analysis

From the market analysis, which has been carried out in 1996 by BG plc, GDF, Stork and Sydkraft, the following conclusions were drawn.

- Opportunities for direct internal reforming–molten carbonate fuel cell (DIR–MCFC) cogeneration plants exist in many commercial and industrial market sectors.
- Hospitals are an attractive initial market.
- The targeted system size is 400 kWe.
- The cost per kWh, per BTU and the system reliability will determine the success in the market.
- A capital cost of 800–1200 US$/kWe is acceptable for most European markets.
- External regulations, in particular regarding electric grid connection and pressure vessels should be well regarded.
- Markets for larger system sizes can be reached by combining smaller modular units.

3. System development

The overall objectives for the system development are:

- lowest cost of energy (cost per kWh, BTU);
- high reliability and availability;
- wide operational window;

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PII S0378-7753(97)02755-9

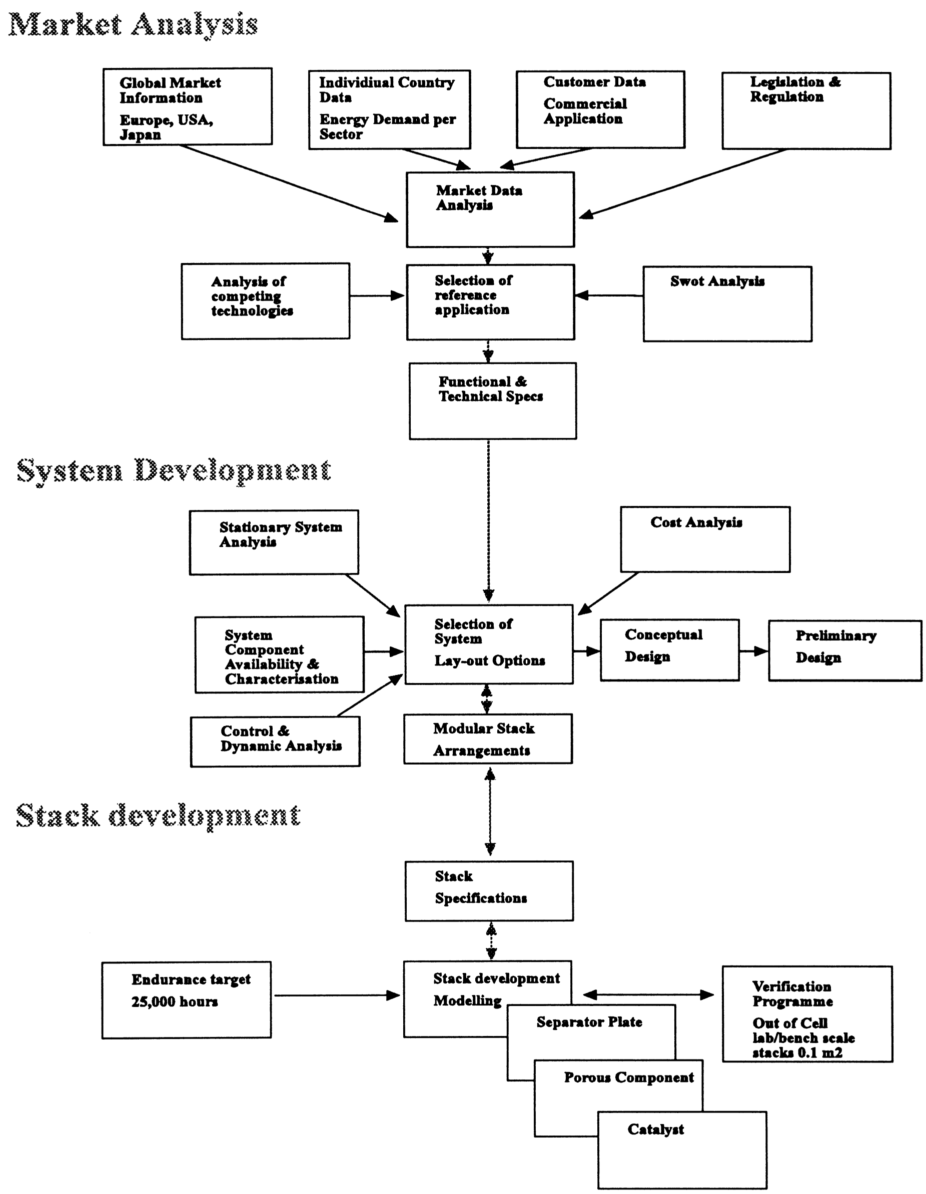

Fig. 1. Overall development plan.

- part load operation;
- stack ageing.

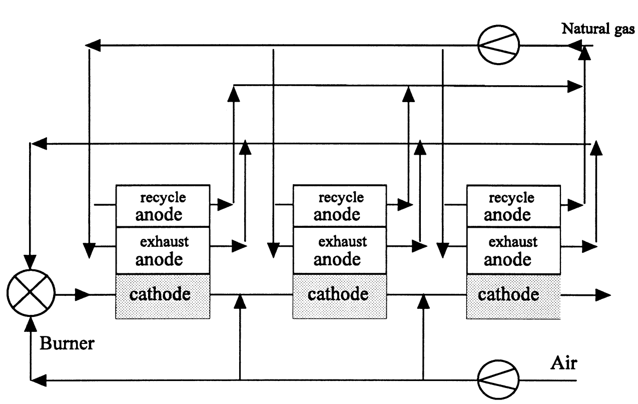

Fig. 2. The SMARTER system.

In order to fulfill these targets, the system is designed from the perspective of optimal simplification and by tailoring the stack design to the system requirements. Our approach is based on:

- direct internal reforming stacks;
- ambient pressure operation;
- recycle of anode gas (using high temperature blower);
- series connected stack cathode flows.

4. The SMARTER system

A process flow scheme of this system with the above features is shown in Fig. 2. The stacks in the SMARTER system are built up of two types of cells. All cells contain an anode, a matrix and a cathode. However, the anode off-gas is either fed to the anode recycle blower (recycle anode) or to the burner (exhaust anode). This system has an improved performance and controllability, whereas the temperature dip at the stack inlet side due to the endothermic reform reaction is eliminated.

More details on this system can be found elsewhere in this proceedings [1,2].

5. Stack development

The target in the stack development are:

- system dedicated DIR–MCFC stack;
- high overall utilisation;
- stack robustness;
- leak tightness under sustained differential pressures;
- service life >25 000 h (under system conditions).

A new DIR stack [3] has been designed based on:

- a validated 3-D electro-chemical/thermal/hydraulic integrated stack model;
- a new DIR separator plate;
- advanced active cell package;
- improved separator corrosion protection;
- BG catalyst.

The design will be verified in dedicated cell and stack tests up to 0.1 m^2 scale.

6. Next steps

The SMARTER concept will be worked out further to obtain an accurate insight in the characteristics. Special attention will be paid to the system controllability. A dynamic simulator will be built as a design tool [4].

After successful completion of this project the following steps are foreseen:

- 'proof of concept';
- prototyping;
- market entry.

7. Conclusions

Hospitals are identified as an attractive initial market for cogeneration DIR–MCFC systems in the size of 400 kWe.

The SMARTER system based on DIR stacks combines high electric efficiency and a wide operational window with system simplicity and low cost.

Acknowledgements

This project is funded by the project partners, the European Commission under contract JOE3-CT95-0033 and, for the Dutch part, by the Netherlands Agency for Energy and the Environment (NOVEM) and the Ministry of Economic Affairs.

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