T.E.M. analysis of the Pt catalyst developed.

Complete Direct Methanol Fuel Cell System – DREaMCAR

DREaMCAR

Objectives

The primary objective of the proposed project is to develop and demonstrate on a laboratory scale a complete Direct Methanol Fuel Cell (DMFC) System, and the necessary system components.
The use of fuel cells to power vehicles has been the subject of intense development efforts in recent years because of the significant advantages of zero emissions of pollutants and higher efficiency which these systems offer. These characteristics are of particular importance in large metropolitan areas, which suffer from intense atmospheric pollution caused by the use of automobiles.
The duration of this project is 42 months and is divided into two phases: Phase I focuses on the design, build and testing of a 1.25 kW module and Phase II concerns the design, build and testing of a 5 kW stack with optimisation of the operating parameters.

Challenges

The goal of the DREaMCAR project is to develop highly efficient, low emission automotive fuel cell propulsion systems that meet customer requirements in terms of cost and performance (better range, safety, and reliability than conventional vehicles).
The power density is the most important property of the DMFC to be improved. Indeed, the necessary active area, number of cells and stack dimensions is directly related to this property.
In order to maximise the power density, three approaches were selected:

- a higher operating temperature enhances the electrochemical reaction and so the objective is to operate at 140°C, or even higher if the innovative membranes can stand higher temperature;
- innovative membranes must be developed in order to reach a good compromise between conductivity, methanol cross-over and mechanical and thermal stability;
- new carbon supported Pt-alloy catalysts will be developed in order to increase the efficiency of the electrodes.

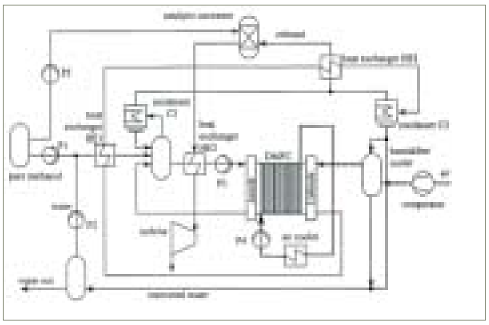
The target power density is at least 300 mW/cm^2 at 0.5 V for a stack operating at 140°C.
The power density could appear low compared to state of art Hydrogen Fuel Cells, but it is near double that of current state of the art DMFCs. Whilst it has a lower power density compared to a hydrogen fuel cell, the overall system is simpler, lighter, more efficient and quick starting.

Project structure

In order to reach successfully all the targets of the project, the partnership includes one car manufacturer (Fiat, Italy) for the specification transfer, life cycle analysis and final testing; one engineering company (Thales Engineering & Consulting, France) specialised in the field of electrochemistry and project management; one chemical company (SOLVAY, Belgium) experienced in the manufacturing of polymer membranes; two research institutes (TAU RAMOT, Israel and CNR-ITAE, Italy), skilled respectively in electrocatalysts and membrane development including scaling-up of material production *and* Membrane Electrode Assembly (MEA) large-scale preparation.

Expected impact and exploitation

The interest in fuel cells is based on their potential for energy saving and cleaner energy production. It is well known that the fuel cell can reach higher efficiencies (up to 60%) than thermal engines (around 20%). Fuel cells consume between 15% and 50% less fuel than conventional generators. Fuel cells will reduce the costs associated with greenhouse gas emission. These costs, which include public health funding, are very hard to assess because all secondary effects have to be included. It could however be said that fuel cells will reduce all these costs since they lower NO_x, VOC and particulate matter emissions.
The fuel used for fuel cells could be chosen from hydrogen, natural gas, gasoline or methanol. Hydrogen fuel is the cleanest but it needs a complete change of the fuel distribution network. The other fuels, including methanol, do not necessarily need substantial changes to the distribution network.



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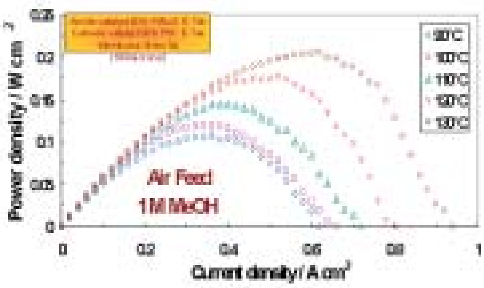

Membrane assessment.

Thus a transportation system on the basis of DMFC should be comparable to conventional systems with respect to effectiveness and user friendliness but more effective in term of energy saving and environmental aspects.

Progress to date

SOLVAY and TAU/RAMOT have been following several research routes in order to fulfil the objective of developing a membrane able to deliver a power of 250 mW/cm^2 at 130°C with air feed. The work has been split into two research areas: improve radio-chemically a grafted membrane obtained previously as well as modification of polymers by sulphonation; characterization of NP-PCM (nanoporous proton-conducting membrane) and SASA (Silica Anchored Sulphonic Acid membrane) in DMFCs and study of the performance of DMFC at high temperatures.

The recent acquisition of the Ausimont Company has given SOLVAY access to a new fluorinated polymer, which has been evaluated in the DMFC application with promising results.

The development of catalysts has concerned mainly the preparation and physico-chemical characterisation of a Pt catalyst with a lower concentration of active species on carbon supports, for the electrochemical reduction of oxygen and the electro-oxidation of methanol, respectively. Initially electrochemical characterisation was carried out on these catalysts in a DMFC, using Nafion 117 membrane as electrolyte. In a further step, the MEA was prepared using the membrane selected in the membrane development work.

Different technical protocols have been developed such as catalyst scale-up procedure, MEA preparation procedure and MEA characterisation procedure.

The cell design phase has been completed with reference to the single cell (100 cm^2 active area) and the 1.25kW module (300 cm^2 active area).

A model was developed for real-time control applications. Real-time models require a compromise between model complexity and execution speed. The DMFC model achieves a good compromise by balancing the use of physically based subsystems with look-up tables to minimise execution time.

The system model has allowed a deeper knowledge of the system, in terms of operating variables (pressure, flow, temperature etc.), and the optimum selection of components to be acquired and installed on the test bench. For each of these components a detailed technical specification file is being prepared, in order to acquire the components and assemble them on the test bench.

INFORMATION

References: ENK6-CT-2000-00315

Programme:
FP5 - Energy, Environment, Sustainable Development

Title:
Direct Methanol Fuel Cell System for Car Applications (DREaMCAR)

Duration: 42 months

Partners:
- Thales Engineering and Consulting (F)
- Centro Ricerche Fiat (I)
- Consiglio Nazionale delle Ricerche (I)
- Solvay (B)
- Ramot University for Applied Research and Industrial Development (IL)

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