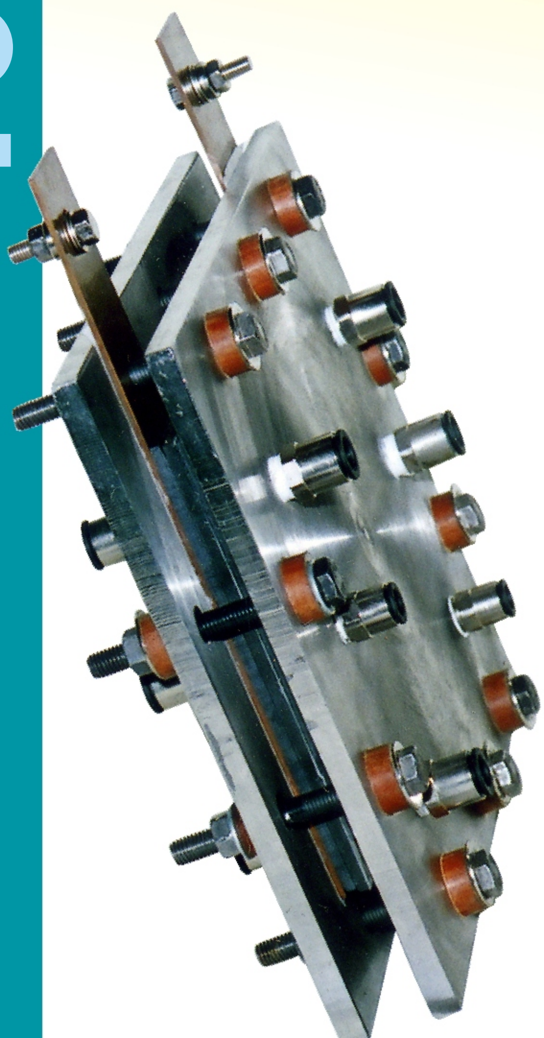
Fuel Cells

HYDROGEN-BASED FUEL CELLS



A fuel cell is an electrochemical power source with advantages of both the combustion engine and the battery. Like a combustion engine, a fuel cell runs as long as it is provided fuel; and like a battery, fuel cells convert chemical energy directly to electrical energy. As an electrochemical power source, fuel cells are not subject to the Carnot limitations of combustion (heat) engines.

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Fuel cells bear similarity to batteries with which they share the electrochemical nature of the power generation process and to the engines that, unlike batteries, work continuously consuming a fuel of some sort. A fuel cell operates quietly and efficiently and, when hydrogen is used as a fuel, it generates only power and water. Thus, a fuel cell is a 'zero-emission engine'.

In the past, several fuel cell concepts have been tested in the laboratory but the systems that are being potentially considered for commercial development are: i) alkaline fuel cells (AFCs), ii) phosphoric acid fuel cells (PAFCs), iii) polymer electrolyte fuel cells (PEFCs), iv) solid polymer electrolyte direct methanol fuel cells (SPE-DMFCs), v) molten carbonate fuel cells (MCFCs), and vi) solid oxide fuel cells (SOFCs). Among these, PEFCs are considered attractive power systems for quick start-up and ambient-temperature operations. CECRI has developed world-class PEFC stacks with power densities approaching about 0.5 W/cm2 at 0.6 V using hydrogen as fuel (specific energy = 33 kWh/kg) and air as the oxidant. Fig. 1 shows a 1kW (nominal power) stack developed at CECRI. CECRI has developed and transferred the know-how for a self-supported hydrogen-air PEFC system. Fig. 2 shows such a 300 W stack that operates at near 1 hydrogen stoichiometry using air as a coolant.

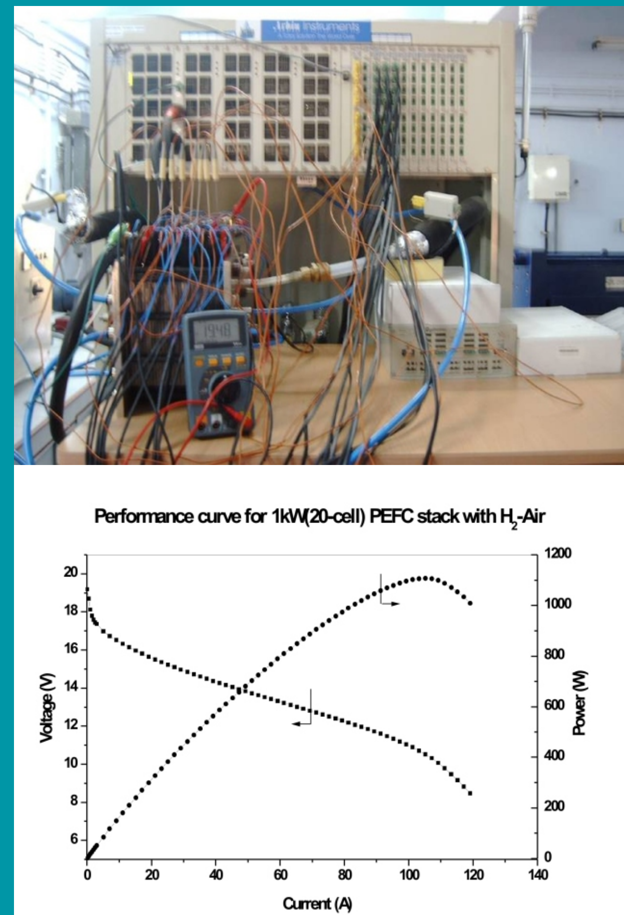


Fig. 1

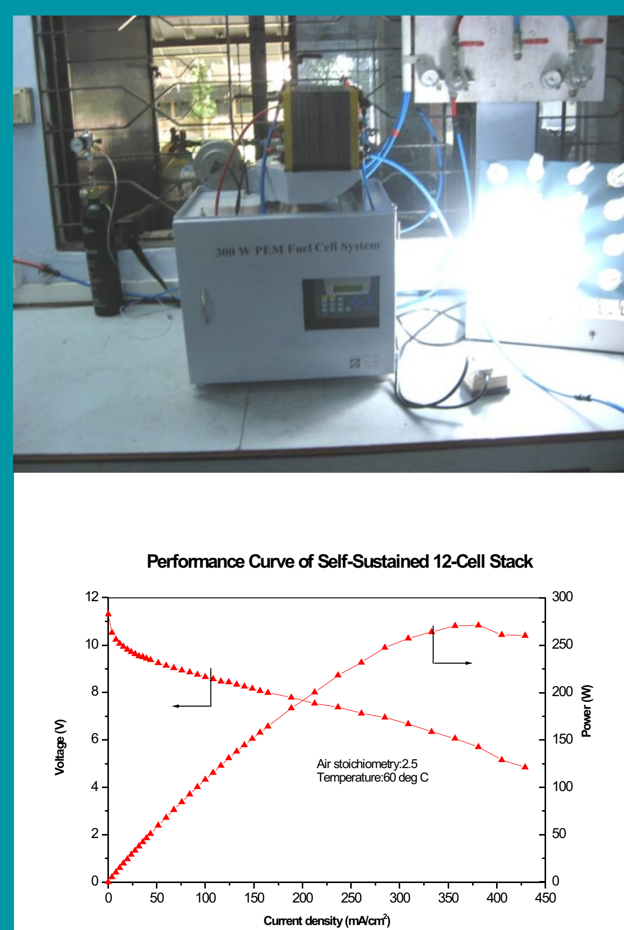


Fig. 2.

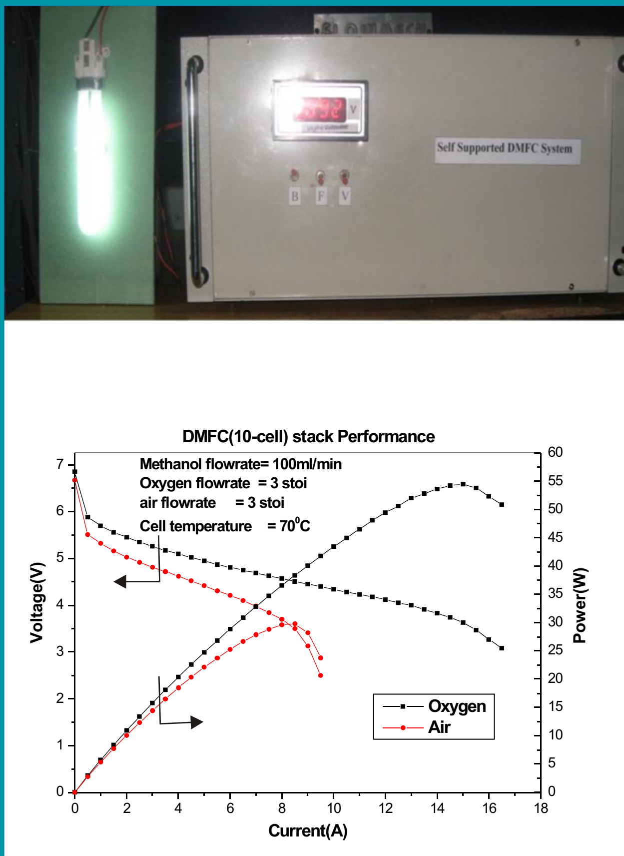


Fig. 3

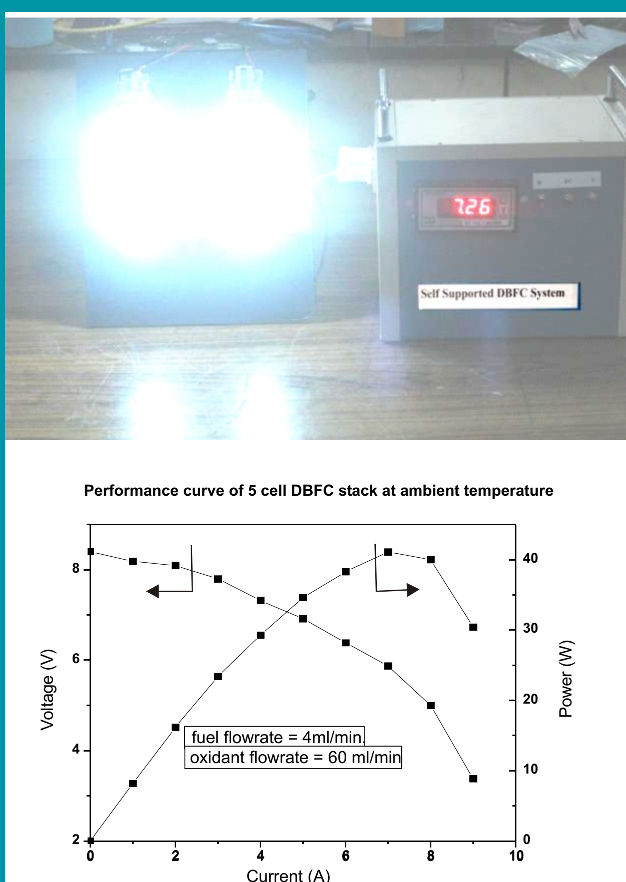
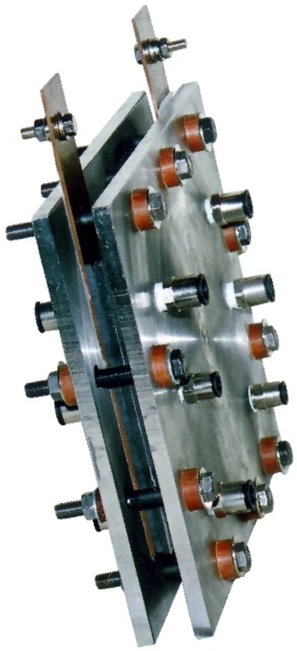


Fig. 4

Certain hydrogen-carrying organic fuels such as methanol, ethanol, propanol, ethylene glycol and diethyl ether are also considered for fuelling PEFCs directly. Among these, methanol (specific energy = 6.1 kWh/kg) is the most attractive organic liquid. CECRI has developed and demonstrated self-supported DMFC systems (Fig. 3). But SPE-DMFCs suffer from methanol cross-over across the polymer electrolyte membrane, which affects the cathode performance and hence the cell during its operation. SPE-DMFCs also have inherent limitations of low open-circuit potential and low electrochemical-activity.

An obvious solution to the aforesaid problems is to explore other promising hydrogen-carrying liquid fuels such as sodium borohydride (specific energy = 12 kWh/kg), which has a capacity of 5.67 Ah/g and a hydrogen content of about 11 wt.%. CECRI has recently developed and demonstrated a direct borohydride fuel cell (DBFC) system with hydrogen peroxide as oxidant (Fig. 4). A unique feature of this system is that it can be operated at locations where free convection of air is limited. Such a DBFC is attractive for submersible and space applications.

Polymer Electrolyte Fuel Cells



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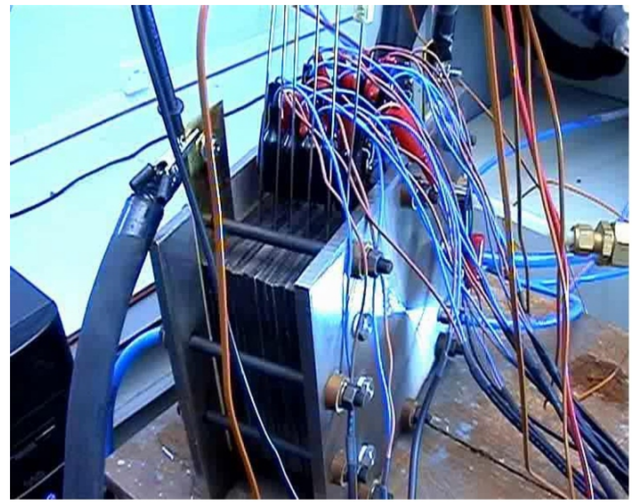

Stacks

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