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PERFORMANCE AND FABRICATION OF PROTON EXCHANGE MEMBRANE (PEM) FUEL CELL WITH HUMIDIFIER

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Abstract- ***In this project a Bubble-Type humidification method is used in a PEM fuel cell experiment to improve the efficiency of the system and the life time of the membrane is improved. It also increases the moisture content in the membrane and makes the reactant gas flow continuous. Due to humidification, the humidity ratio can be adjusted easily and also the fuel cell setup becomes small and less weight. Proton Exchange Membrane (PEM) fuel cell are increasingly being cited by governments as a possible pathway to the reduction of greenhouse gas emission. It is one of the prospective power sources for automotive applications, train appliances, stationary cogeneration systems, and mobile electronic devices. But the dryness of the membrane of a PEM fuel cell decreases the ionic conductivity, resulting in performance reduction. The applications where fuel cell technology is used can be divided into three main categories: portable power generation (for mobile devices and portable auxiliary power), stationary power generation (distributed power generation, back-up power sources, and grid-connected power stations), and transportation (cars, public transportation, and heavy machinery). Train appliances like Fans, lighting may also run on PEM fuel cell.This new hydrogen train is thus perfect for shorter, quieter stretches of the network that electrification hasn't yet reached.***

Keywords- ***Bubble-Type humidification method, Proton Exchange Membrane (PEM) fuel cell, Portable auxiliary power.***

1. INTRODUCTION

The performance of a Proton Exchange Membrane fuel cell (PEMFC) is influenced by its operating conditions, including temperature, pressure, and moisture content of the inlet gases. These factors all directly affect membrane water content, which in turn impacts fuel cell performance. Hydration of the membrane is a very important determinant of the performance and durability of a PEMFC. If not properly hydrated, the membrane exhibits higher ionic resistance and in extreme cases can be physically damaged. Membrane hydration is affected by the water transport phenomena in the membrane itself, which in turn are affected by the condition of the inlet gases and the operating parameters of the fuel cell.

Water is transported through the membrane in three ways: Electro-osmotic drag by protons from the anode to the cathode, back diffusion due to concentration gradients from the cathode to the anode (or vice versa in limited cases), and convective transfer due to pressure gradients within the stack. At high current densities, where electro-osmotic drag of water from the anode to the cathode often exceeds the rate of back diffusion of water, the anode side can dry out if the inlet gases are not sufficiently humidified. Without reactant gas humidification, the fuel cell membrane will become dehydrated leading to high ohmic losses and potential damage to the membrane.

Conceptually, relative humidity is an indication of how close a gas is to being saturated; a gas with 100% RH is saturated in water vapor. Note that specific humidity is unaffected by temperature whereas relative humidity can be changed by changing thetemperature of the gas and/or quantity of water vapor present in the gas. Relative humidity is empirically useful because most materials respond, absorb or adsorb in proportion to relative humidity rather than specific humidity. Specific humidity is useful when considering chemical equilibrium because it is related to the absolute amount of water vapor in a gaseous mixture. Dewpoint is the temperature at which the gas will become saturated. Dew point is a direct measure of vapor pressure expressed as a temperature. The dewpoint temperature is always less than or equal to the temperature of the gas. The closer the dewpoint is to the temperature of the gas, the closer the gas is to saturation and the higher the relative humidity. If the gas cools to the dewpoint temperature it is saturated in water vapor and the RH is 100 %. Condensation will occur on any surface cooled to or below the dew point of the surrounding gas. In fuel cell operation and fuel cell test equipment, one generally controls the moisture content of the inlet gas stream. Water is a product of the fuel cell reaction. The rate at which it is produced in the cell is a function of the reaction rate which relates to the electrical current through Faraday's Law. Water is also transported from one electrode to the other through the membrane. The direction and rate of net water transport through the membrane is a complex function of the cell conditions including anode and cathode RH, current density, and membrane water permeability, among others. For these reasons, the water content of gases within anode and cathode compartments and exit streams can differ from the water content of the respective inlet gas.

II. COMPANY PROFILE

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Integral coach factory, Chennai, is a premier production unit of Indian railways manufacturing railway passenger and other special coaches. ICF is the first of its kind to be established after independence for manufacture of light weight, all shell and all welded “integral” railway passenger coaches. The factory was set up in Swiss collaboration.

ICF’s initial plan was to produce 350 Broad Gauge Third Class shells (unfurnished body of railway coaches) only which were to be furnished by the zonal railways workshops. Later, in view of the severe limitation of capacity of the railway workshops & also to take advantage of mass production, a separate Furnishing division was added on 2nd Oct, 1962.The capacity was progressively expanded from initial 350 shell to 750 fully furnished coaches per annum by 1973-1974 with additional inputs. This was enhanced progressively from 850 coaches during 1986-87 to1000 coaches in 1990-91. The modernization project is under last stage of execution to augment capacity to 1250 coaches & will over by 2011-12.

Capacity has further enhanced to achieve 1600 coaches per annum through infrastructure additions and modernization of machines. The current target set for 2012013 has been 1601 coaches.

Total area: 19,22,500Sq.m

Workshop covered area: 1,89,229Sq.m

Production capacity/year: 1,600 coaches.

Cumulative production: 47,836 coaches.

Capital: 132 crores.

Track length: 47 kms.

A. DESIGN FEATURE

The design concept of the coach stimulates that the separately manufactured roof, side wall, end wall and the under frame are joint together by welding, to form a fully ‘Integral’ coach shell. Further, crash worthy features are provided CBC design to minimize impact on passengers during accidents/derailments. From the basic design handed down by the collaborators, ICF has diversified having established its expertise and skill in this field, to design and manufacture more than 350 different types of coaches for Indian Railways and export market. Every time a new type of coach is launched, emphasis is laid on improving passenger comfort, passenger safety and higher speeds. ICF follows standard inspection procedures to ensure quality from raw material stage to the finished coach. ICF has laid down necessary action plan in manufacturing high speed coaches of LHB (Linke Hoffman Bausch) model and entire future coaches will manufacture under this category. Already under 37 coaches of this type has been rolled out of this factory.

ICF’s production can be classified into following divisions-

- Furnishing Division
- Shell Division

B. FURNISHING DIVISION

Aesthetic look, comfort and safety are very much essential forpleasant journey. Furnishing Division takes care of the above byfurnishing the interior of the coaches.

C. ACTIVITIES OF FURNISHING DIVISION

Furnishing of coaches is done in stages, viz. Grit Blasting, Painting in Automatic Paint Booths, Drying in Ovens, Lettering, Flooring, Wiring, Paneling on Side Walls, Window fixing, Partition Paneling, Plumbing, Floor Moulding, Lights & Fans fixing, Seats, Berths and Racks fixing, Air-conditioning where required, Brake fitment and Buffer height adjustment The Furnishing Division also does assembly of Self Propelled Coaches where Engine/Electrics for DEMUs and Transformers/Motors for EMUs are fitted, commissioned and tested before dispatch. [5] discussed about a system, GSM based AMR has low infrastructure cost and it reduces man power. The system is fully automatic, hence the probability of error is reduced. The data is highly secured and it not only solve the problem of traditional meter reading system but also provides additional features such as power disconnection, reconnection and the concept of power management.

III. PROPOSED SYSTEM

The basic idea is to power both light and heavy trains with hydrogen instead of diesel and overhead line electric.The relevant hydrogen manufacture and distribution infrastructure must be in place and people need to be made aware that it is a safe technology, while it must be shown to be economically viable.With the rapid development of battery technology and the existence of grids to deliver electricity, it is likely that light vehicles will mostly use electricity there will be little incentive to provide a new, universal fuel distribution grid for hydrogen.Local rail networks are particularly suited - hence the Hydrail concept, which could use hydrogen fuel cells or, in the short-term, converted diesel.

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A. HUMIDIFIER PART

Fig.1. Bottle-Type Bubbling Humidifier

Bottle-type humidifiers provide humidification from a fixed volume of water in a chamber. This water is consumed over time and needs to be replaced. Although a manual fill valve allows the water level to be restored, an automatic filling system reduces the number of tasks required by the test operator and also can provide less disruption to the test conditions when the filling is performed. Automatic water filling also allows long-term unattended operation of the fuel cell test system. Regardless of the humidification system used, the water from the humid gas will condense on the walls of the tubing exiting the humidifiers unless the lines are heated to a temperature above the dewpoint of the gas. If the water condenses on the tubing, the dewpoint is reduced and droplets or "slugs" of liquid water may enter the fuel cell and potentially disturb the cell's operating condition and performance. [6] discussed about a project, in this project an automatic meter reading system is designed using GSM Technology. The embedded micro controller is interfaced with the GSM Module. This setup is fitted in home. The energy meter is attached to the micro controller. This controller reads the data from the meter output and transfers that data to GSM Module through the serial port. The embedded micro controller has the knowledge of sending message to the system through the GSM module. Another system is placed in EB office, which is the authority office. When they send "unit request" to the microcontroller which is placed in home. Then the unit value is sent to the EB office PC through GSM module. According to the readings, the authority officer will send the information about the bill to the customer. If the customer doesn't pay bill on-time, the power supply to the corresponding home power unit is cut, by sending the command through to the microcontroller. Once the payment of bill is done the power supply is given to the customer. Power management concept is introduced, in which during the restriction mode only limited amount of power supply can be used by the customer.

B. TEMPERATURE CONTROLLER

Temperature control is a process in which change of temperature of a space (and objects collectively there within) is measured or otherwisedetected, and the passage of heat energy into or out of the space isadjusted to achieve a desired average temperature. Using three temperature controller we can control flow of heat. Two is to control heat and another one is fixed in a temperature upto 60^{o}c.

Fig.2. Temperature Controller

In the case of the optimal design of the fuel cell, the onset of species transport control regime is delayed.Consequently, as the current density increases, the optimal design yields increasingly higher cell voltage values, in comparison to the ones obtained in the reference-case design, at the same current density.

The results of the optimization analysis show that the optimum design point falls onto the upper bounds of the air inlet pressure and the fraction of the cathode length associated with shoulders of the interdigitated gas distributor, and onto the lower bounds of the cathode thickness and the cathode length per one shoulder of the interdigitated air distributor.

IV. CONCLUSION

In this project a Bubble-Type humidification method is used in a PEM fuel cell experiment to improve the efficiency of the system and the life time of the membrane is improved. It also increases the moisture content in the membrane and makes the reactant gas flow continuous. Due to humidification, the humidity ratio can be adjusted easily and also the fuel cell setup becomes small and less weight. Proton Exchange Membrane (PEM) fuel cell are increasingly being cited by governments as a possible pathway to the reduction of greenhouse gas emission. It is one of the prospective power sources for automotive applications, train appliances, stationary cogeneration systems, and mobile electronic devices. But the dryness of the membrane of a PEM fuel cell decreases the ionic conductivity, resulting in performance reduction. The applications where fuel cell technology is used can be divided into three main categories: portable power generation (for mobile devices and portable auxiliary power), stationary power generation (distributed power generation, back-up power sources, and grid-connected power stations), and transportation (cars, public transportation, and heavy machinery). Train appliances like Fans, lighting may also run on PEM fuel cell.This new hydrogen train is thus perfect for shorter, quieter stretches of the network that electrification hasn't yet reached.

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