Abstract #121, 223rd ECS Meeting, © 2013 The Electrochemical Society

THE APPLICATION OF INTERMEDIATE TEMPERATURE FUEL CELL FOR THE AUXILIARY POWER UNIT OF THE AIR CONDITIONING SYSTEM IN AN ELECTRIC VEHICLE

Sethu Sundar Pethaiah, Alison Subiantoro, Ulrich Stimming
TUM CREATE, 1 CREATE Way, #10-02 CREATE Tower, Singapore 138602

Electric Vehicles (EVs) are widely researched and proposed as the alternative to the conventional internal combustion vehicles. They offer a solution to the air pollution problem faced by many cities in the world. However, they face a major challenge when operated in hot regions like in the tropics due to the air conditioning demand.

Conventional automotive air conditioners draw up significant electrical energy (in the region of up 5 kW, depending on the thermal load demand). This obviously reduces the driving range of the battery. For illustration, a typical electrical vehicle would have a travel range of 150km, but this range may be reduced by about 50% when the air-conditioner is switched on. To address this issue, an auxiliary power unit (APU) is proposed. At the same time, the APU may also be used to extend the battery range when necessary.

Fuel cell technology has been widely proposed for APU applications. The main advantage of using fuel cell for power production is because the by-products are heat, carbon dioxide and water only. Moreover, the electrochemical process in the fuel cell is highly efficient, converting nearly 90% of the chemical energy of the fuel into electrical energy and heat, in contrast to the other power generation device.

In this project, an intermediate temperature proton exchange membrane fuel cell (IT-PEMFC) was proposed to be used for the APU. One advantage of this fuel cell system is its relatively good immunity to CO poisoning. Another advantage of using fuel cell as the source of APU is that the feedstock can be easily stored, similar to the conventional gasoline or diesel. A typical IT-PEMFC unit operates at 150-180°C using methanol or ethanol as the feedstock. The energy densities of these fuels are shown in the table below.

Fuel Type	Energy Density (MJ/kg)
Methanol	19.7
Ethanol	23.4

However, the integration of the IT-PEMFC APU and the air conditioning system is not so straight-forward and poses many challenges. The air conditioning system has its own specific demands that have to be met by the APU. On the other hand, the IT-PEMFC system also has a certain specific characteristics in its power production. Special design techniques have to be implemented in order to meet these two differing characteristics.

For illustration, the air conditioner needs power mostly to operate the compressor. In an electric vehicle, the compressor is operated by an electrical motor. Depending on the type, the motor can only operate in a certain voltage range (for example about 110 V and 220 V for AC, and 12 to 400 V for DC). In addition, this power demand fluctuates during operation due to many factors, such as the thermal load, operating conditions and compressor design characteristics.

On the other hand, a IT-PEMFC unit usually produces electrical power with a voltage of approximately 0.95 to 1 V per cell. Therefore, the APU has to be specially designed to match the compressor electrical motor demands. Needless to say, the air conditioner design must also be adjusted to better suit the APU characteristics.

In this paper, we are presenting our design proposal for such integration. Both the APU and the compressor designs are discussed. The space and size constraints related to electric vehicle are also considered. The waste heat from the APU is also utilized for dehumidification of the air intake to increase the air conditioning unit’s efficiency.