



## **Fuel Cell Systems and Ancillary Equipment**

A fuel cell on its own is of very little use. It must be placed within a system that allows the required fuel to be produced or provided and the electricity created to be suitable for the required application. The typical configuration of a fuel cell system involves a fuel processor that converts fuel into a useable form, the fuel cell where the chemical reactions take place and the energy is produced, and a power conditioner to convert the output electricity into the power required by the specific applications.

A steam-methane reformer is often a component of a fuel processor. It converts Methanol into Hydrogen through a chemical reaction that requires a catalyst and temperatures exceeding 1000°C. The fuel processor must also remove all of the contaminants that reduce the output of the system.

Once the fuel processor has produced the fuel it is transported to the fuel cell itself where the chemical reactions take place and the Hydrogen and air are converted into water and a direct current is generated.

An power conditioner then converts the output power into the form of power required by the specific applications. Typically the fuel cell will provide a 4V DC current to an inverter. The inverter may then increase the voltage to 24V DC. Depending on the system there may be a battery store in this position of the system. This would store the electricity until it is required, allowing for the peaks and troughs in electricity demand to be met. Another inverter is then required to transform the 24V DC current into the 240V AC current required for domestic application.

A fuel cell produces three things of value. These are electricity, heat and pure water. Depending on the size and type of fuel cell in use the heat produced can be fairly substantial quantities. This heat can be captured as a method of heating or used to create steam to power turbines. This is known as heat recovery and increases the overall efficiency of the fuel cell.

A fuel cell system requires a range of ancillary equipment to be successful. Typically a stationary fuel cell system could comprise of a reformer to produce the hydrogen fuel, the fuel cell to convert the hydrogen into electricity and water, and an inverter to transform the alternating current into a direct current.

Furthermore the fuel cell system can require manifolds, blowers, heat exchangers, humidifiers, condensers, valves and filters. These components may all be required to ensure that a fuel cell system works correctly; alternatively a fuel cell system may require only certain parts to operate.

Typically a fuel cell system will require a compressor, heat exchangers, pumps and fans and blowers as well as a computer based control system. A compressor can play an important role in the fuel cell system. The function of the compressor is to increase the pressure and density of a gas. An increase in the pressure of the reactant gases could result in an increase in the efficiency of the fuel cell.

A manifold is often required within a fuel cell system. The purpose served by the manifold is to allow more than one fuel cell to be placed within a system. 'Stacking' the cells does this. Fuel cell stacks are necessary as they allow a greater energy volume to be reached. It also makes it possible for 'hot' swapping to occur. This is when one fuel cell is changed for another while the fuel cell system is still running. This allows a continuous power supply to be achieved.

Certain fuel cell systems require fluids to be preheated. Rather than using external heaters or coolers the desired temperatures are acquired through intelligently designed pipe work. This could be as simple as wrapping pipes with hot air blowing through them with pipes containing cold air. Through mainly the convection and conduction mechanisms of heat transfer the cold air cools down the hot air. The process is exactly the same when liquids are present. If a steam reformer is required to produce the Hydrogen fuel for the fuel cell then there is a high probability that heat exchangers are required to cool the reformer that may have been operating at temperature exceeding 1000°C.

Any gases that are present with the fuel cell system will need to be dispersed accordingly. Fans and blowers are often seen as an ideal solution to this problem as they are a simple way of controlling the flow of any gases. They are also considered as a useful device in cooling down fuel cell systems. In a system where air-cooling is sufficient fans and blowers are often utilized, as they are reliable and effective for this function.

Any fluids that are present within the system are moved through the use of pumps. There are a number of requirements that the pumps must meet in order to meet the necessary criteria of components of fuel cell systems. As they are being fitted in a system that's quiet operation is considered one of its strengths it seems inevitable that the pumps fitted must be quiet. The pumps must also be light, reliable and cheap as any high expense will serve only to increase the price of fuel cell systems at a time when manufacturers are determined to reduce the price whilst not compromising on quality.

The complete fuel cell system is often controlled by a computer based control system.

### **Types of Fuel Cell Systems**

A stationary fuel cell system typically consists of a steam-methane reformer producing hydrogen, a solid oxide fuel cell and an inverter converting the direct current into an alternating current.

The steam-methane reformer is required to convert methanol into Hydrogen through a process requiring a catalyst and temperatures exceeding 1000°C. The Hydrogen produced is then channeled into the solid-oxide fuel cell that in turn creates electricity and heated water. The heated water can then be utilized to provide heating. The electricity produced by the fuel cell is in the form of a direct current. For the electricity to be of any use it must be converted into an alternating current. This is accomplished through the use of an inverter.

The advantage with the typical stationary fuel cell system is that currently it is considered as one of the most inexpensive fuel cell systems available. The Hydrogen is produced relatively cheaply and efficiently, even more efficient if cogeneration occurs. The solid oxide fuel cell is an efficient cell and can also exploit cogeneration to increase its efficiency. The inverter then simply converts the direct current electricity into a more useful alternating current.

The main disadvantage with the system is that high operating temperatures are required within both the Hydrogen production process and the fuel cell itself. This indicates that reliability could become a problem and that systems must be in place to ensure that the temperature of the system does not cause a problem.

Portable power requires a slightly different fuel cell system. Because of the large-scale nature of the SOFC it is unsuitable for application in devices such as mobile phones and laptop computers. The Proton Exchange Membrane fuel cell is normally considered as the major technology relating to the production of portable power and power for motor vehicles. The size of the PEM is smaller than the SOFC, partly due to the higher level of funding and research being carried out into the cell. It is due to this, and the low operating temperature of the cell that makes it one of the most promising forms of portable power being developed.

The PEM normally requires heavy auxiliary equipment and a supply of pure Hydrogen. The inverter is then required to transform the direct current into an alternating current that is then

used to power the vehicle or portable application. The low operating temperature of the system allows the system to be used in portable and mobile power applications, as there is no requirement for an expensive containment structure. It also allows the cell to be placed in close proximity to other materials. This is useful as the cell can be placed within the structure of a motor vehicle or next to the workings of portable applications such as a laptop computer.

### **Benefits of a Fuel Cell System**

The volume of power needed to be produced by a fuel cell system can differ depending on the application. The modular structure of fuel cell systems allows it to be possible to provide a greater amount of power. The range of power a fuel cell can supply can vary greatly from a few watts to a number of megawatts. It also allows stacks to be added as and when they are required.

Different applications can require different volumes of power. The modular configuration of a fuel cell system makes it possible to stack a number of fuel cells together in order to provide the required power demand. For example if a company's energy demand increases dramatically they can add more fuel cells in order to provide the increased demand. As well as adding new fuel cells it is possible to replace failed stacks 'hot'. Providing there is more than one cell in the system the failed fuel cell can be swapped without the system being turned off. This allows a fuel cell system to guarantee a continuous power supply.

The nature of fuel cell systems implies that there will be very little noise created by the system. The fuel cell itself contains no moving parts and is therefore very quiet. The ancillary equipment required by the system is also fairly quiet when you compare it to an internal combustion engine or traditional power plant.