BATTERY AND HYDROGEN FUEL CELL

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ABSTRACT

Batteries are necessary and prime component of any DC power system, providing a source of on-demand stored energy with proven reliability. The integration of batteries and basic fuel cells poses a new challenge in portable and stationary utility applications. For high value applications, the specification and operating requirements for this hybrid module differ from conventional requirements as the module must withstand extreme weather conditions and provide extreme reliability. Although the battery charging system remains trivial, battery life is prolonged and the charging system is more dynamic. However, given the new characteristics of this module, existing battery maintenance standards must be updated. Increased flexibility in packaging allows for variation in physical environments ranging from the compact to more conventional rack mounting. As a utility company, BCHydro has embarked in the development and application of a battery and fuel cell combination for field use. With the expected reduction in battery degradation due to the new charging source, battery reliability is increased and life expectancy is prolonged. In addition, the requirements of a battery monitoring system will need to be reviewed because of the integration of the new DC component. One of the many challenges of this application includes battery selection. This paper describes the battery requirements, installation, operation, maintenance, and battery life expectance issues for this new application as viewed by an electric utility.

KEYWORDS

battery, fuel cell, charging source, maintenance standard, monitoring, electric utility, and battery life.

INTRODUCTION

The reliability of a customer's power supply is always the primary concern in the utility business and with generating stations, substations, telecommunications systems, and computers depending on a utility's DC power supply, the selection of a DC power source poses a challenge. Also, as a corporate citizen, a utility is responsible to the environment, making the large volume of electrolyte in batteries a cause for concern. Environmentally sensitive applications such as a mountain top communication site are a potential for disaster if the electrolyte is not properly managed.

A typical utility mountain top telecommunication site will require many lines of defense to ensure all equipment have the power supply to provide the required level of reliability. Commercial distribution power, diesel generator(s), and batteries work in unison to deliver nominal AC power for long periods of time at these sites where climate and terrain may hinder people from immediately reaching the site. Rising to the challenge of both customer and environmental responsibility, a combination of the battery and fuel cell may meet these requirements. This arrangement provides clean, long term DC power as long as hydrogen is provided. An investigation and work in progress to test a battery and hydrogen fuel cell system for this high value application is underway at BCHydro and its partners. Minimizing the potential of an acid spill, experience with spill clean up, and early detection of battery casing cracks are all taken into consideration in this project.

CASE BACKGROUND

A utility company's mountain top telecommunication site faces harsh weather conditions and encounters environmentally fragile situations. A typical site is shown in figure 1.

Figure 1. A typical mountain top microwave tower

Located on-site, diesel generators serve as the first line of defense in the event of a commercial distribution power failure. When this system is in operation, many days of AC power are provided to the battery charger for continuous site operation until power line problems are fixed. If the diesel power system fails to operate, the site will solely rely on the remaining battery bank capacity for equipment operation. The duration that this battery bank can provide adequate power is very dependent on the weather and temperature conditions. For example, during the winter season, a substantial amount of battery capacity can be lost, making the sizing of these batteries especially critical. Most of these sites use 1900 Ah cells to provide the required reserved capacity creating a large quantity of acid that poses an environmental threat.

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The flooded lead acid battery has been proven to be reliable and to provide a long service life. For high-value utility telecommunication applications, this is the choice unless other requirements are to be met, such as weight or limited space. Maintaining a flooded lead acid battery consists of an established routine of regular physical and cell resistance tests. A hydrogen fuel cell can be a self-contained unit that supplies DC power and charges the battery. Also, because the fuel cell is inherently a DC source, there is no AC ripple to be concerned with. Current knowledge on battery charging indicates that this method will improve the battery life in addition to increasing system reliability. The block diagram of the basic Battery and Hydrogen Fuel Cell DC System is shown in figure 2.

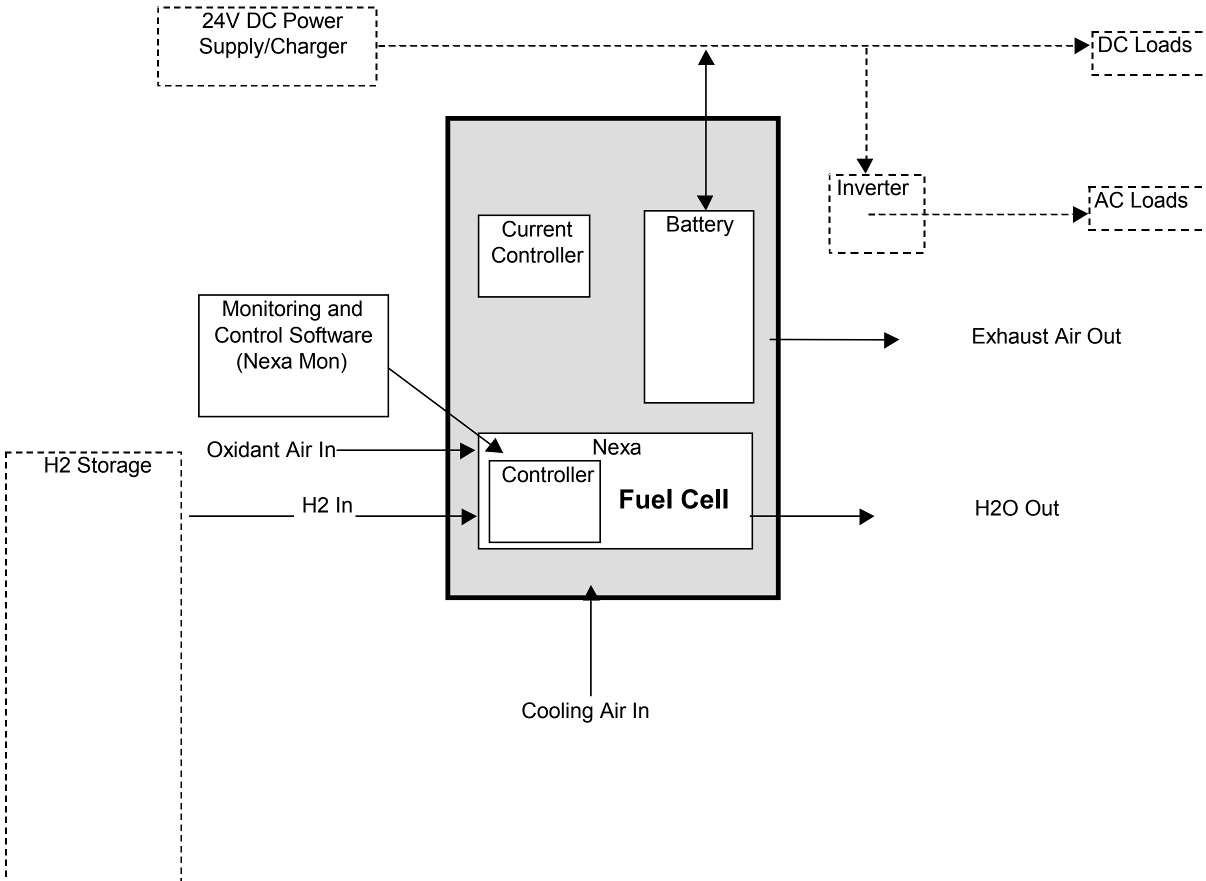

Figure 2. Block Diagram of Battery and Hydrogen Fuel Cell System

This self contained system uses hydrogen as a continuous fuel source and is considerably more environmentally friendly than diesel generation that requires diesel fuel and discharges pollutants.

BATTERY SELECTION AND CHARGING SYSTEM

Because the fuel cell alone is not capable of behaving like an ordinary battery that can provide stored energy for transient load demand, the addition of a battery makes up for this performance deficiency. A properly selected battery can ride over the surge period by responding to a load with ample amounts of energy and a reasonable voltage dip. This need for transition energy is extremely critical to the performance of the overall DC system in utility applications such as motor start modules, electronic module start up, and circuit breaker open and close operations.

The charging component of the system is essentially a pure DC voltage regulator with its power source coming from the hydrogen fuel cell module. Factors in reducing battery life like the AC ripple and battery cycling should be eliminated enabling the battery to enjoy a good DC environment and longer lifespan.

The climate of high mountains vary drastically between the summer and winter seasons and therefore the operating environment of the batteries have to be considered very seriously in order to meet the minus 40 to plus 40 degrees Celsius requirement. Selection of a battery to meet this condition needs to be investigated because while the fuel cell generates heat, it does not produce the cooling required in the summer. To this respect, the complete battery and hydrogen fuel cell system will be subjected to environmental chamber tests prior to a field trial and on site performance evaluation. In addition, current battery performance specifications may require revision if the batteries will be used in this specific application. Some other issues include the storage of hydrogen under high pressure: this will be resolved by using a pressure vessel that withstands up to 10,000 psig.

ENVIRONMENTAL AND MAINTENANCE ISSUES

The potential impact of a flooded battery in environmentally sensitive areas where mountain top microwave towers are often located needs to be considered. These sites are not frequently visited due to limited accessibility caused by location and a high winter snow pack. In the summer, there is a high cost of travelling to the site by helicopter to perform routine maintenance and system tests. With flight time in a helicopter valued at up to $1,000 CDN per hour depending on the number of seats available, the relative overall maintenance cost is very high. Minimizing the electrolyte volume will be an asset to the environment, since it strikes a balance between the high ampere-hour capacity requirement and the risk of battery casing failure. There has been an effort made in assessing battery-casing condition: it involves the simple measurement of casing walls for flatness using a ruler. This simple procedure places a ruler against each wall of the battery. A good battery casing will have a flat surface on all sides, while any deviation is considered to be a potential problem. From experience, this process can lead to a good feel of the casing condition, as a recent test of several 15-year old battery banks revealed some potential casing problems. The cells in question were promptly replaced and the cell removal is documented in figure 3.

Figure 3. Mountain top battery removal

The clean-up of an acid spill is very expensive and the cost is only exacerbated on high and remote sites. A typical clean up on a public city road for five gallons of battery acid electrolyte by the emergency response team will cost $20,000 CDN, in addition to any fines levied by the government. Preventive measures are therefore the most cost effective and environmentally responsible method to avoid this scenario.

CONCLUSION

The application of DC systems in environmentally sensitive and high value locations needs careful consideration during the selection of both the battery and the complete system. The combination of a high quality battery and a hydrogen fuel cell is one of many means to lower the environmental risk posed by DC power supply systems when compared to the traditional large flooded lead-acid battery and diesel fuel generation systems. Diesel generation requires a quantity of on-site diesel fuel that the fuel cell does not. The application of the fuel cell provides a superior DC charging source for the battery as compared to the conventional AC powered battery charger. Useful battery life is expected to increase through the reduction of AC ripple voltage and battery cycling. A simple method to assess the battery casing condition by using a ruler to measure surface flatness is a workable and effective solution. In addition, a coordinated battery user group for information exchange is needed to specify and develop an environmental friendly DC supply system for long duration and high value applications. Utilizing a hydrogen fuel cell and a carefully selected conventional battery, a hybrid DC power supply system can have vastly improved reliability and environmental friendliness.

AUTHOR

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Alex Lam has more than 20 years experience in electrical engineering and is responsible for B.C. Hydro's battery replacement program, maintenance standards, and enterprise monitoring program. He manages the centralized battery data base, analysis and diagnostics. He is also a past technical paper contributor and panelist for BATTCON.