5 Key Considerations for Designing a Fuel Cell Thermal Management System in Commercial ON-Highway & OFF-Highway Applications

Fuel cell powered systems used in Commercial ON-highway/OFF-highway applications are becoming increasingly popular to meet net zero emissions. They perform duties by powering the powertrain in addition to generating electricity and charging the batteries.

Fuel cell systems take in diatomic hydrogen unlike diesel/gasoline in the traditional IC engines and use the chemical energy to produce electricity which in turn is used to power the traction motors/charge the batteries. Heat is generated as a by-product along with water in this process. The fuel stack needs to be maintained in the temperature range of 55C - 80C to avoid rapid degradation of the fuel cell stack.

- **Temperature Differential:** Ambient temperatures have risen to 50C during summer times across the country. Unlike IC engines, the radiators can see up to 110C on the coolant loop, so the entering differential is around 55C. The fuel cell systems have an entering temperature differential of about 20C to 30C which makes it more challenging to design a thermal management system. The lower the temperature differential, the larger the size of the heat exchanger. With 104 years of experience, AKG's heavy/premium duty fins provide advantages to space, cost, and performance.
- **Low Conductivity:** Using a low conductive coolant in the fuel cell system is an important part of the fuel cell system in addition to corrosion inhibitors. Fuel cell systems consist of specific metals and reach optimal working temperature ranges/limit thermal runaways in addition to maintaining the fuel cell efficiency, therefore a lower coolant conductivity range is vital. This can be achieved by using a filter to capture the ions and a vacuum braze (VAC) heat exchanger. AKG has a long history of manufacturing VAC type heat exchangers and capabilities to measure coolant conductivity to meet the industry standards of <5-25uS/cm depending on the application.

- **Direct Loop vs Indirect Loop:** AKG offers two types of solutions for fuel cell thermal management systems. Direct loop uses a liquid to air heat exchanger for heat rejection. The low conductive coolant is in direct contact between the heat exchanger and fuel cell stack in a closed loop. The indirect loop uses a liquid-to-liquid heat exchanger to reduce the size of the cooling loop between the heat exchanger and the fuel cell stack. This provides cost and space savings in the application to limit the amount of low conductive coolant leading to less ionic emissions in the system.
- **Duty Cycle:** Fuel cell systems have variable output based on the application requirements. Some systems only use one fuel cell system to drive the powertrain while others may have multiple fuel cell systems to drive the vehicle based on duty cycle. In cases where multiple fuel cell systems are used, it is important to review the application duty cycle with the fuel cell manufacturer and thermal management provider so it can be designed accordingly.
- **Fan Noise and airflow:** Due to low entering temperature differential as explained in the above section and the need to use 460VAC or 12/24/48/350/650Vdc fans for thermal management, the cooling fans are typically stacked in series to meet the heat transfer requirements. The number of fans, fan power and airflow required to meet the requirements due to temperature differential is significantly more when compared to a typical IC engine application. Systems integrators and OEM's must take the airflow and fan noise into account during the design phase to appropriately locate the thermal management systems, so the systems do not get negatively impacted with the hot air-recirculation and loud sound levels during vehicle operation.

Please reach out to Vykram Vijayasekaran if you have any questions on this topic or inquiries related to fuel cell thermal management systems for your applications at sales@akg-america.com or 919-563-4286.

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