A234-012: Hydrogen Generator

ADDITIONAL INFORMATION
N/A

TECHNOLOGY AREAS:
Battlespace | Materials

MODERNIZATION PRIORITIES:
Biotechnology | Space

KEYWORDS:
Hydrogen; Storage; fuel; battlespace; tank; refuel point; electrification; generator; generation system; power supply

OBJECTIVE:
The purpose of this topic is to develop an on-demand hydrogen generation system that can be used to quickly refuel a vehicle in situations where its main fuel tank is empty. The end user for this system would be fuel cell system operators. In the event a fuel cell system depletes the main fuel tank and battery power (assuming a hybrid fuel cell/battery electric architecture), this system can be used to provide hydrogen to the fuel tank (or directly to the fuel cell) to allow the system to provide power and return to safety. The system would be sized to be portable while providing enough energy to travel back to base, similar to how jerrycans are currently used.

DESCRIPTION:
As the Army moves towards more electrified platforms, new challenges arise, such as running out of fuel or energy while executing a mission. Current vehicles can be refueled quickly from a jerrycan, allowing them to travel to the refueling point. Fully electrified platforms are not as easily refueled on the side of the road, which puts both Soldiers and materiel in danger. As the Army explores electrification technologies, preparing for situations such as this are important to keep both Soldiers safe and protect next generation platforms. Hydrogen fuel cells are a potential electrification technology that can provide near-silent power and mobility for military vehicles while providing high torque with inherently scalable power and energy, capable of providing range beyond that of purely battery-powered electric vehicles. Hydrogen can also be refueled more quickly than batteries can charge, providing an opportunity to solve the problem of a fuel-depleted vehicle on a mission. Several technologies exist that can provide hydrogen on-demand from solid materials that can be easily and safely transported and stored. One such technology of interest is aluminum alloys that react with water to provide hydrogen.

Note: Hydrogen generators that utilize aluminum alloy and water are like an extra fuel tank, but less volatile. Aluminum powder can be safely handled and stored as a solid material, unlike liquid fuel. Several recent advances in the technology allow for the material to be manufactured at scale from scrap aluminum, providing a large source of energy in an inexpensive manner (1, 2). Compared to domestically sourcing lithium for battery production (and in order to meet future energy needs), this technology provides significant energy density without requiring rare earth metals, while at the same time needing significantly less infrastructure be developed. When exposed to water, the alloys produce hydrogen rapidly and at pressure, allowing a vehicle to be fueled quickly while providing enough energy to travel back to safety or a refueling point. The system can be designed with safety at the forefront, incorporating pressure relief devices and intrinsically safe controls.

PHASE I:
It is important to note that this is a Direct to Phase II topic. To justify a Direct to Phase 2, This Direct to Phase 2 effort should have data demonstrating the operation of an aluminum-water hydrogen generation system. The data should show the flow rate of hydrogen from the system, pressure during operation, temperature of the system, the amount of aluminum and water used, and control over the reaction (data showing a controlled stop/start cycle of the reaction). The proposal should also demonstrate the hydrogen from the reaction is pure enough to operate a fuel cell by either providing performance data from a fuel cell connected to the system or analysis of the hydrogen purity.

PHASE II:

Design a hydrogen generation system that can be man-portable while providing a meaningful range for vehicles in the case that fuel is depleted. Manage the thermal performance of the system, reducing both the exterior touch temperature to safe levels and overall thermal signature. Fabricate and demonstrate such a system. Demonstrate aluminum alloy production capable of supporting the manufacturing of several systems. Testing required for this technology would include measuring the flow rate of hydrogen from the system, demonstrating that the system can operate at the designated pressure, maintaining a safe external touch temperature, and effectively removing heat from the reaction.

PHASE III DUAL USE APPLICATIONS:

There is high dual-use potential for hydrogen fuel cells, as users across industries continue to adopt this technology, especially in vehicles and industrial power. The high CAGR indicated rapid, significant projected growth across all sectors. Popular use cases for fuel cells in general include power generation for electric individual and mass transportation vehicles, industrial processes, data centers, and utilities, as well as residential heating. Hydrogen fuel cells can be used to build stacks, which can allow for modular power systems that can adapt to energy requirements based on the use case.The proposed technology has potential use within the Army Small Business Innovation Research Program as well as other Army Research Centers and acquisition programs.

REFERENCES:

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