New method to detect when hydrogen fuel cells are experiencing a failure

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Scientists from Graduate School of Systems and Information Engineering at the University of Tsukuba introduced a new technique for detecting when a hydrogen fuel cell is experiencing reduced efficiency due to periods of excess or insufficient water. By using sensors that measure magnetic flux density, the amount of current

generated can be monitored noninvasively, which can signal a problem. This work may lead to technology that can improve the reliability of fuel cells, while also significantly reducing the carbon footprint of cars.

As the search continues for ecofriendly transportation technologies to replace the internal combustion engine, cars powered by hydrogen fuel cells are looking better every day. In addition to producing zero carbon emissions, these electrical energy generation devices are highly efficient and operate at lower temperatures compared with other methods. One main type is called a proton exchange membrane fuel cell (PEMFC). In it, a membrane that is permeable to hydrogen nuclei (which are just single protons) separates oxygen and hydrogen compartments. When protons travel across the membrane to combine with oxygen atoms, electrons flow through a wire to complete a water molecule, which is the only product besides electricity. However, a PEMFC is susceptible to failure owing to either becoming dried out, or excess water flooding the system. To ensure peak performance, new detectors are required that will quickly sense when this is happening, especially in stacks of fuel cells in which it can be difficult to pinpoint where the problem is occurring.

Now, a team of researchers at the University of Tsukuba have developed a new system based on the magnetic flux produced by electrical currents inside the fuel cell. When the system is operating correctly, the electrical currents produced will generate a characteristic pattern of magnetic fields that can be detected by sensors. This allows failure states to be immediately registered owing to the changes in the magnetic flux. "Water conditions make fuel cell performance unpredictable and unreliable, even under nominally identical operating conditions," author Professor Yutaro Akimoto says.

The team tested their system with an air-cooled 50-Watt PEMFC stack consisting of five fuel cells. The magnetic flux density was measured

using sensors that were placed inside cooling holes. If a fault was detected, the appropriate control measured could be implemented. "Our research opens the possibility for automated control systems to be integrated into future fuel cells," Professor Akimoto says. This can pave the way for more efficient and practical zero-emission vehicles.

The work is published in *Fuel Cells* as "Experimental investigation of stable PEMFC control using magnetic sensor probes."

More information: Yutaro Akimoto et al, Experimental investigation of stable the proton exchange membrane fuel cell control using magnetic sensor probes, *Fuel Cells* (2022). DOI: 10.1002/fuce.202100057

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