A High Energy Density System by Thin Metallic Bipolar Plates

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Graphite bipolar plates are typically used in fuel cells because of their electrical conductivity and corrosion resistance; however, graphite plates are also brittle and expensive to manufacture. The brittleness of graphite plates requires them to be relatively thick compared to the channel and rib dimensions. Metallic bipolar plates exhibit good conduction but poor corrosion resistance. Metallic plates offer the advantages of easy manufacturability and ductility over graphite plates. The ductility of metallic plates allows them to be made very thin which reduces weight and/or allows additional cells in the same volume that carbon plates would take. The metallic anode and cathode plates presented in the study are shown in Figure 1. The anode is similar to a carbon anode plate except that it is 0.1 mm thick. The cathode plate is a straight through design so a fan can easily blow air through the stack. The exploded view shows that air flowing through the cathode serves two functions, providing oxygen and cooling air.

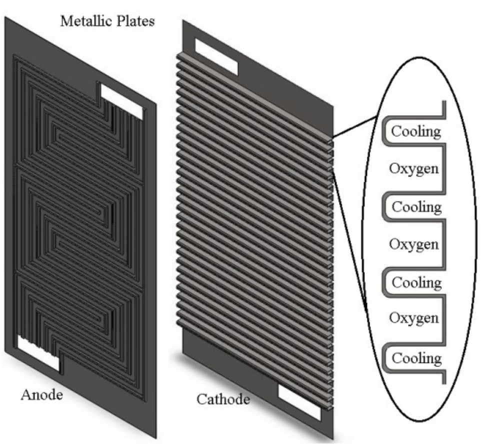

Figure 1. Anode and cathode metallic flow plates.

The focus of the fuel cell discussed here is unmanned aerial vehicles (UAV). A successful fuel cell for an UAV application must be compact, lightweight, and efficient. Traditional fuel cells, especially lab built and tested fuel cells, are often very efficient; but, they are almost always heavy when compared to batteries with a similar output. Traditional fuel cells are also generally not compact; they have multiple components, such as humidifier, pump, etc. that make them bulky and heavy. The goal of this work is to remove the dependency on outside components and reduce the weight of the fuel cell stack.

To achieve our goals, many fuel cell designs were studied and contemplated. Unique designs often tackle one specific issue but give rise to others. In order to avoid issues such as leakage and poor flow field; we opted to build off of the traditional rectangular fuel cell design. In the fuel cell presented, shown in Figure 2, metallic plates will be used for both cathode and anode. Metallic plates can be made very thin which will increase conductivity and reduce weight. Metallic plates can also be produced using a stamping technique which is easily adapted to mass manufacturing. The disadvantage when using metallic plates is that they are not very corrosion resistant and must have some sort of corrosion resistant thin film to increase its lifetime.

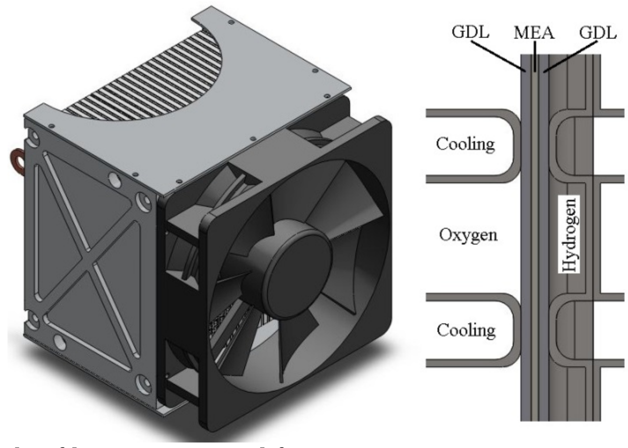

Figure 2. FC stack with 27 cells and cut view showing channel and rib positions.

A change was also made to the ribs of the fuel cell channels. The ribs in a fuel cell make contact with the GDL and allow electrons to be pulled away, into the plate, from the hydrogen molecule. Typically these ribs are on the same plane as the contacting surface around the channels (a seal is typically placed on this contact surface). With the ribs on the same plane as the surrounding contact surface, the GDL must be compressed outside of its plane to make good contact with the ribs, which is essential in reducing contact resistance; as seen in the study by Bates et al. [1]. The fuel cell presented here was designed so that the contacting surface is on a plane that is offset from the top of the ribs, away from the GDL. This means the channel ribs can move into the plane of the GDL making good contact. The gasket or seal will now have the role of controlling that contact pressure by changing its thickness. Since gaskets are cheap, this is a good way to allow optimization of fuel cell contact pressure by varying gasket thickness. In previous studies we have found that contact pressure on the GDL increases toward the center of a stack [1]. With the design presented hear, the gasket width simply needs to be increased toward the center of the stack so that contact pressure is even throughout all cells of the stack.

The cathode plate is designed to support forced convection cooling of the stack. This will decrease the balance of plant weight because only a fan is needed to keep the stack operating at low temperature. Since the anode and cathode plate are to be made from a stamping process, the ribs will be rounded at the point of contact with the GDL. This is an advantage as it increases the region that reactions may take place. To further aid reaction, the channels and ribs of the anode and cathode side match up. This means the active regions will be adjacent throughout the majority of the cell, shown in Figure 2.

Reference:

[1] A. Bates, S. Mukherjee, S. Hwang, S.C. Lee, O. Kwon, G.H. Choi, S. Park, International Journal of Hydrogen Energy, 38 (2013) 6481-6493.