The Aluminum Air Battery and its Long Term Benefits in Recreational Vehicles

By: Ryan McFadden

Audience: Basic understanding of chemical reactions and elemental properties/relations and how batteries dissipate energy (at or above a scientific education at the collegiate level – for example at PSU you should have taken Chem 110 and Chem 112 to have a basic understanding of the paper)

Introduction

The earth is dying, and fossil fuels are to blame. Research has been completed into battery technology. These batteries have the capacity to output voltage necessary to power small vehicles such as golf carts. They are viewed as the stepping stone to large scale battery powered vehicles. The aluminum air (AlO₂) battery is ready to move into that stage of planning. The AlO₂ battery is an energy dissipation device whose concept design and operation has been around since about 2008. The issue when the concept was first released was the global dependence on fossil fuels. People were not open to the idea of being completely dependent on battery powered devices. Now as the environmental concerns begin to grow exponentially, the aluminum air battery has advanced to the forefront of the energy race.

Understanding the Battery

The aluminum air (AlO₂) battery is a type of energy storage device which utilizes a chemical reaction involving aluminum, water, and oxygen to supply voltage to an electrical system. A computer generated model displaying a simplified design of the battery has been placed below (Figure 1). In this design, the aluminum plate is placed between two condensed oxygen areas. These areas are filled with water which represents the electrolytic material.
The Chemical Reaction

Microscopic Level

The battery utilizes a variable amount of aluminum (Al) plates which depend on the desired voltage output. The aluminum anode plates are alternated with highly concentrated oxygen and electrolyte rich areas. From the naked eye, the battery produces energy from a chemical reaction between this aluminum anode and the air cathode (electrolytes) surrounding the plate. The reaction is sustained by putting water into the battery to replenish the electrolytes used in the process.

Atomic Level

At the atomic level, the picture is much clearer. The higher the concentration of the electrolytes, the more powerful the battery. This is related to reaction kinetics in chemistry. The kinetics correspond to the speed at which the chemical reaction occurs. When there is a higher concentration of the chemicals, there is a higher chance of collision between atoms. These atoms are moving at high velocities, and carry a large amount of momentum in their movement. By the principle of conservation of energy, whatever energy is lost by one particle is gained by another. Therefore during these high speed collisions between atoms, a large amount of energy is released. This change in energy is reflected in the chemical reaction output as a gain of energy by the system, more specifically the voltage output that comes from this reaction.
The Flow of Energy

Steps of the Energy Flow (Refer to Figure 2 below to follow the process)

Using Figure 2, the process of the battery can be understood from a different angle.

**Step 1: Air Cathode**

The air cathode forces oxygen (O₂) atoms into the space containing the KOH electrolytes (H₂O is a suitable replacement).

**Step 2: KOH Electrolyte area**

As the air is pumped into the tightly confined space, the oxygen particles are combining with the electrolyte’s elemental composition and gaining momentum in the process. The momentum from the combined chemical travels rapidly towards the aluminum anode.

**Step 3: Aluminum Anode and the released electrons (e⁻)**

As the collisions between the anode plate and the electrolytes occur, energy is released. This energy is in the form of electrons and travels towards the load.

**Step 4: The Load**

The load can be considered to be any electrical device which is powered by the electrical output of the chemical reactions. The electrons travel towards this load with a high velocity from the collected energy. The load collects these electrons and applies their energy towards the electrical system it is powering. After the voltage has been collected by the load from the electrons, the process begins again until there is an absence of electrolytes.

**Figure 2: Front View of AlO₂ Battery**

Sketch created by Ryan McFadden (2013)
Benefits of the Process

As this electricity is produced by the battery, hydrated aluminum is produced as a byproduct of the reaction. The hydrated aluminum is a main reason why the battery is so desirable. When Al reaches this state, it can be recycled and placed back into the battery. This property makes the aluminum air battery self-sustainable.

Management of the Battery (Specific to golf carts)

The battery would be assembled once, but the aluminum plates would need to be replaced approximately every 1,000 miles. These plates could simply be recombined with the hydrated aluminum, put through a refining process, and then reused in the battery. Each individual aluminum plate is good for about 20 miles, and depending on your specific design, the battery can be used for 20 times the amount of plates in the battery (Yang and Knickle). Once the plates have been eroded, the aluminum will either be totally replaced or recycled and reused. Additionally, the electrolytes will need to be replenished approximately every 200 miles. This needs to be done to sustain the chemical reaction.

Power Comparisons to Internal Combustion Engines

The weight ratio of the aluminum is essential when thinking about the potential power output of the battery in comparison to Internal Combustion Engines (ICE). Since the aluminum would consist of more than 90% of the battery composition, the potential power output is completely dependent on the amount of aluminum present (Yang and Knickle). At maximum productivity, the battery will produce around 2.7 Volts, and have a substantial energy density of about 8.1 kWh/kg-Al. Basically, these numbers can match if not surpass internal combustion engines (Yang and Knickle). The battery can produce a fuel efficiency range between 15-20% in comparison to an internal combustion engines, (includes diesel and other engines) which have an efficiency rate of about 13% (Yang and Knickle).

Conclusion

The aluminum air battery utilizes high concentrations of electrolytes in combination with the aluminum plates to force a chemical reaction. This produces energy in the form of electricity, which can be applied to the load of choice in the system. The battery will produce hydrated aluminum along with the electricity, and this aluminum byproduct is essential in regards to the sustainability of the battery. The hydrated aluminum will be recombined with the used aluminum and placed back in the battery, creating an infinite supply of aluminum for battery usage. The efficiency of the battery in regards to its eco-friendly parameters and its power storage capabilities are why the AlO$_2$ battery is the future of clean energy for recreational vehicles.
Works Cited