Press Release: Batteries 101--How Lead-Acid Batteries Work

General Motors Media Press Release

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Batteries 101--How lead-acid batteries work

FLINT, Mich. -- A storage battery is an electrochemical device for converting chemical energy into electrical energy. In internal combustion powered vehicles, it supplies electrical power to starting and ignition systems, supplies extra power when the vehicle needs more than the charging system is providing or when the engine is not running, and acts as a voltage stabilizer in the electrical system. Batteries also propel electric vehicles and power battery energy storage systems. A simple basic battery is formed when two dissimilar plates and one separator are placed in a solution called "electrolyte." Due to the chemical reaction that occurs between the electrolyte and the dissimilar plates, a voltage, or electrical potential, of about two volts exists between the two plates. When the positive and negative plates are connected to a 2-volt bulb, electrons flow (current) from one plate through the electrolyte and highly porous separator to the other plate, then through the bulb to complete the circuit. When the bulb lights, the battery is discharging, or converting chemical energy into electrical energy. The current consists of electrons flowing through the outside circuit and charged ions flowing between the plates inside the battery.

The voltage of a lead-acid storage battery is determined by the dissimilar material used in its construction. Lead dioxide (PbO_2) is used on the positive plate, sponge (porous) lead (Pb) is the active material on the negative plate, and a solution of sulfuric acid (H_2SO_4) and water is the electrolyte.

When a battery is connected to an external load, the battery begins to discharge. The lead dioxide (PbO_2) in the positive plate is a compound of lead (Pb) and oxygen (O_2). Sulfuric acid is a compound of hydrogen (H_2) and the sulfate radical (SO_4). As the battery discharges, lead (Pb) in the active material of the positive plate combines with the sulfate (SO_4) of the sulfuric acid, forming lead sulfate ($PbSO_4$) in the positive plate. Oxygen (O) in the active material of the positive plate combines with hydrogen (H) from the sulfuric acid to form water (H_2O), which reduces the concentration of acid in the electrolyte.

Concurrently, in a similar reaction, lead (Pb) from the negative plate combines with sulfate (SO_4)

from the sulfuric acid to form lead sulfate (PbSO4) in the negative plate.

So, during discharge, the active material of both plates is converted to lead sulfate (PbSO4). The plates become more alike and the acid solution becomes weaker. Consequently the voltage drops, since voltage depends upon the chemical difference between the two plate materials and the concentration of the acid. Eventually, the battery will not deliver electricity at a useful voltage, and is considered discharged.

A discharged storage battery can be recharged by passing a direct electrical current through it in the opposite direction of the discharge, restoring active materials to their original composition and the battery to its full power. The chemical reactions within a battery during a charge cycle are basically the reverse of those that occur during discharge. The sulfate (PbSO4) in both plates is split into its original form of lead (Pb) and sulfate (SO4), The water is split into hydrogen (H) and oxygen (O). As the sulfate leaves the plates, it combines with the hydrogen and is restored to sulfuric acid (H2SO4). At the same time, the oxygen combines chemically with the lead of the positive plate to form lead dioxide (PbO2).

As discharge progresses, the sulfuric acid of the electrolyte is diluted by the water being created, reducing the specific gravity of the electrolyte. During the charging cycle, water is replaced by sulfuric acid, increasing the specific gravity of the electrolyte. Specific gravity can be measured with a hydrometer, which provides an accurate and convenient method for determining state-of-charge of a battery.

The discharge cycle can be repeated over and over, until fatigue and erosion caused by electrode material changes and corrosion of the positive grid cause the battery to fail.

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