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ELECTRIPLAST BASED, LOW COST, HIGH VOLUME MANUFACTRABLE BIPOLAR PLATE DESIGN FOR *LEAD* ACID BATTERIES

Background

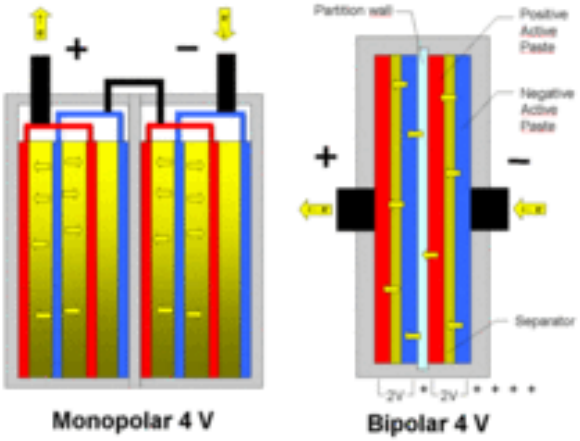
The Bipolar Battery concept was published in early 1920's and there are multiple patents awarded for design of the bipolar battery and bipolar plates. However, there are no commercially viable, high volume capable design solution for a bipolar battery and bipolar plate resulting in this technology being available only for low volume, cost non-sensitive applications. The reason is, nonexistence of a practical, fully defined and high volume manufacturable design of the bipolar plate using conventional high volume production processes.

A Performance Advantage

The evolution from monopolar to bipolar technology (as shown in **Exhibit 1**) eliminates the use of top lead to connect the plates. Thereby, reducing weight and reducing overall size. However, commercialization has been hampered by challenges ranging from corrosion to current leakage. The bipolar capabilities remain attractive because of the energy and power capabilities that could be packaged into a relatively low cost offering.

The development of an operationally reliable and manufacturable bipolar battery will further extend lead acid capabilities and also prove disruptive to the energy storage industry.

Exhibit 1: An Illustrative Comparison



Source: Volvo Group

Addressing Hurdles to Scalability

ElectriPlast redefines bipolar plate design based on a plate core made of conductive loaded resins and with metal covered surfaces.

While there are patents issued for bipolar plates designs based on this concept, they do not define:

(1) bipolar plate chemical composition (definition of the base polymers and composition of the compounding conductive materials);

(2) method of conductive loaded material manufacturing;

(3) method of plate manufacturing;

(4) treatment methods of the conductive resin based plate surfaces used to allow adhesion of the metallic layers to the conductive particles on the plate surface and electrical connection between conductive particles and the metallic layers;

(5) definition of the metallic layers composition and methods/processes for their application to the core bipolar plate made of conductive polymers; and,

(6) electrical performance requirements and bipolar plate qualification test methods.

This has prevented the commercialization of these patents into the commercially viable and high volume manufacturability.

The ElectriPlast Advantage

Our ElectriPlast plates provide performance enhancements that also leads to a lower cost bipolar battery. The advantages include:

- high conductivity, as the current path between the positive and negative terminals is shortened;
- corrosion resistance, as the plates are made using polymers and metals inherently resistant to Sulphuric acid (ABS and BASF Ultrason polymers, lead and lead alloys and other metal oxides proven to work in lead acid battery environments);
- flexibility as the plates can be molded while maintaining properties of the base polymer – suitable to forming reliable seals between bipolar plate and the battery assembly using established plastic parts assembly processes (from sonic/vibe/thermal welding/bonding to chemical bonding);
- ability to be molded into the any desired shape using standard polymer molding processes;
- surfaces that can be executed with multiple finishes using established molding techniques to allow good adhesion of the active paste materials;
- inherently mechanically robust based on properties of the ElectriPlast material and design features common for polymer based products; and,
- cost effective replacement for existing lead acid battery technology (gravimetric and volumetric efficiency) and even more cost effective as the replacements for LiIon and NIMH batteries.

Data Highlights Superior Performance

Our analysis shows the current carrying capacity in cross direction for ElectriPlast bipolar plates is higher than for lead plates of the similar size and that the temperature raise over ambient, as well as voltage drop, is lower than for lead plates at the same loading currents.

The maximum roa for the set of 6 ElectriPlast bipolar plates was 49 ^{o}F at loading current of 20.5 amps, which is well below allowed 86 ^{o}F (some specifications allow higher roa for lead acid batteries). We tested a set of 6 bipolar plates, which represented a 12 Volt (V) battery as every bipolar plate created a cell of 2V. The set of 6 plates has passed continuous current testing for 20 A application.

Our ElectriPlast material technology and proprietary treatments of the molded bipolar plates allowed for the modification of the electrical properties to satisfy electrical performance requirements of any application.

Due to its large surface and short path for current conduction, equivalent electrical resistance of the bipolar battery stack (6 plates 5x5 in, 3mm thick) vs. linear connection of the same plates is over 1000 times lower ($R=r\,l/s$, r = material resistivity, l = length of the conductor, s = cross section of the conductor) resulted in high current carrying capability and low thermal losses.