Innovations in Enhanced Flooded Lead-Acid Batteries

Daramic’s new lineup of separators are specifically designed to support start-stop vehicle battery work requirements, enabling enhanced flooded lead-acid batteries to deliver reliable battery power in start-stop vehicle applications.

As a result of innovative design and development, the Daramic® EFS™ line of separators* offer solutions that withstand voltage drop, decrease electrical resistance, and increase cycle life in enhanced flooded lead-acid batteries.

---

**PROBLEM**

- Start-stop vehicles can experience up to 70 restart events during a single commute. Each event creates voltage drops in the battery. If the voltage drops below a certain level, adverse effects, including dimming of lights and loss of power to the radio and other accessories, can occur, leading to poor vehicle perception.

**SOLUTION – DARAMIC® EFS™**

- Daramic® EFS™ separators* implement a unique shish-kebab polymer network that improves puncture resistance at higher porosity, lowers separator electrical resistance, and extends the operational duration of the battery by up to 44% before reaching minimum voltage.

---

**MARKET NEEDS**

- **Power Output**
- **Cycling in Partial State of Charge**
- **Dynamic Charge Acceptance**

**FEATURES**

- Low Electrical Resistance
- Patented Rib Design for Mixing
- Special Material Reduces Shedding
- Increase Amount & Speed of Electrification

**CAR & BATTERY BENEFITS**

- Improved Battery/Vehicle Perception – no dimming lights, major systems remain on
- Longer Battery Life
- Fuel Economy Saving
- Less CO₂ Emission
- Fuel Economy Saving
- Less CO₂ Emission

---

**PROBLEM**

- Acid stratification causes poor charge acceptance, shorter life and higher internal resistance, limiting the useable energy and durability of the battery. Other battery designs that limit acid stratification have high cost implications.
- In flooded lead-acid batteries, limited mixing of acid requires costly equipment in order to increase electrolyte uniformity.

**SOLUTION – ACID MIXING SOLUTION**

- By simulating the start-stop motion resulting from vehicle acceleration and braking, computational fluid dynamic (CFD) modeling has enabled Daramic to design a separator that promotes electrolyte mixing, providing better utilization of electrodes. These factors reduce acid stratification and improve Partial State of Charge (PSoC) performance in enhanced flooded lead-acid batteries.

---

*Daramic Proprietary IP

Mechanical properties can be maintained at a higher porosity by using a shish-kebab polymer structure.
ACID MIXING SOLUTION DEVELOPMENT PROCESS
CYCLING IN PARTIAL STATE OF CHARGE (PSoC)

DESIGN 1
STANDARD SOLID RIB SEPARATOR
With a standard PE separator, the solid ribs act as baffles which contain the lateral movement of acid only yielding marginal (5%) improvement in acid mixing.

DESIGN 2
SERRATED RIB SEPARATOR*
A serrated rib separator design expanded the mixing interface and allowed localized mixing to occur. Combined with the start-stop motion, a 10% improvement in acid mixing was achieved.

DESIGN 3
SERRATED RIB SEPARATOR* WITH NEGATIVE ENVELOPING
Utilizing negative enveloping allows for greater mixing while the serrated rib profile enables acid to move across the surface of the plate. Used in combination, acid mixing can be improved by 18%.

DESIGN 4
OPTIMIZED SERRATED RIB DESIGN* WITH NEGATIVE ENVELOPING
Finally, the design of the separator profile was optimized with the goal of converting start-stop motion into vertical acid mixing. By changing the angle, column space and height of the serration, substantial improvements in acid mixing were observed, leading to a combined improvement of 23% in mixing uniformity.

* Daramic Proprietary IP

MIXING UNIFORMITY SCORECARD

<table>
<thead>
<tr>
<th>DESIGN</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – START-STOP MOTION</td>
<td>+5%</td>
</tr>
<tr>
<td>2 – SERRATED RIB*</td>
<td>+5%</td>
</tr>
<tr>
<td>3 – CHANGE TO NEG ENVELOPE</td>
<td>+8%</td>
</tr>
<tr>
<td>4 – OPTIMIZED SERRATED PROFILE*</td>
<td>+5%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>+23%</td>
</tr>
</tbody>
</table>

Daramic is leading enhanced flooded lead-acid battery separator innovations

Daramic, LLC Corporate Headquarters, America
11430 N. Community House Road, Suite 350 • Charlotte, NC 28277 USA
Phone: +704-587-8599 • Fax: +704-587-8796
www.daramic.com

Daramic, LLC, EMEA
BP 90149
25 Rue de Westrich
Sélestat Cedex, 67603 France
Phone: +33 3 86 82 40 00
Fax: +33 3 86 92 85 73

Daramic, LLC, Bangladesh, India, Pakistan, Sri Lanka (BIPS)
Plot No. 25, KIADB New No. 5, BBMP
3rd Main Road, 1st Phase Peenya
Bangalore, India 560058
Phone: +91 80 4256 1103
Fax: +91 80 4256 1106

Daramic, LLC, North East Asia
Building 18, No. 88 Maji Road
Waigaoqiao Free Trade Zone
Shanghai 200131, PR China
Phone: +86 21 3813 9910
Fax: +86 21 3813 9911

Daramic, LLC, South East Asia
Plot No. 25, KIADB New No. 5, BBMP
3rd Main Road, 1st Phase Peenya
Bangalore, India 560058
Phone: +91 80 4256 1103
Fax: +91 80 4256 1106

Daramic is leading enhanced flooded lead-acid battery separator innovations

www.daramic.com