DOE Bipolar Plates Workshop

Approach to Provide a Metallic Bipolar Plate Module to the Industry

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USCAR Southfield, Michigan
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Dana Holding Corporation

- Founded in 1904
- Based in Maumee, Ohio
- 2015 sales: $6.060 billion
- 23,000 people

- Global operations and customers
  - More than 90 major facilities
  - 25 countries on six continents
  - Customers in 130 countries
  - 16 R&D centers
# Dana Overview

## Dana Business Units

<table>
<thead>
<tr>
<th>Business Unit</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Vehicle Driveline</td>
<td>41%</td>
</tr>
<tr>
<td>Commercial Vehicle Driveline</td>
<td>25%</td>
</tr>
<tr>
<td>Off-Highway Driveline</td>
<td>17%</td>
</tr>
<tr>
<td>Power Technologies</td>
<td>17%</td>
</tr>
</tbody>
</table>

## Dana Core Technologies

### Driveline Technologies

**Vehicle Driveline:**
Axles, driveshafts, transmissions, and tire management

### Sealing Solutions

**Vehicle Engine and Transmission:**
Gaskets and seals, transmission separator plates, plastic cam cover and oil pan modules, heat shields, and fuel cell plates

### Thermal Management

**Vehicle Engine and Transmission:**
Transmission and engine oil cooling, battery and electronics cooling, charge air cooling, and exhaust-gas and heat recovery

## End Markets

- **Light Vehicles**
- **Heavy Vehicles**
- **Off-Highway**
Fuel Cells

Optimized product solutions meet new fuel-cell system requirements, including bipolar plates and high-performance thermal- and water-management components.
metallic bipolar plate milestones at Dana:

- 2001  Stamped first metallic bipolar plate
- 2002  Joint fist metallic bipolar plate
- 2003  Customer MBPP with seal
- 2004  First progressive die to MBPP
- 2005  Provide coated MBPP to customers
- 2007  First bead seal plate in customer hands
- 2009  Standardization of MBPP product
- 2012  Launch of Serial production of standardized MBPP
- 2014  Launched production using progressive dies
Key elements for Industrialization

► Design for manufacturing
► Design to cost
DANA customizable
Metallic Bipolar Plate module standard

High speed stamping process for micro structured plates (≤ 100µm)

Proprietary, fully integrated bead seal with superior sealing performance

Joining process for micro channels and thin base materials

In-house low cost coating (material and process) on low cost substrates
Benefits:

- Sealing is integrated part of the metallic bipolar plate module
- Simultaneous production process of the seal together with the bipolar plate
- Minor gas permeation, due to metal
- Durable elasticity, minor creep
- Design flexibility – individual adjustment to plate, port geometry and soft goods
- Simplification of the port flow-field connection
- Simplification of the assembly process
Sealing approach MEA with an injection molded gasket

- **GDL**
- **PTFE**
- **GDE**
- **Kat.**

- Silicone/rubber
  - ca. 120°C
  - 35-90 sec.

- **GDE/GDL**
- **Membrane/CCM**
- **flush-cut**
- **5-Layer MEA**

30,000 vehicles per year

10,000,000 MEAs p.a (45 sec.) = 21 Injection molding cells
21 machines to mold seals to the MEA
Laminated framed MEA for Dana’s MBPP module

10,000,000 MEAs p.a = 12 m/min on one machine
Component simplification by integration

Metallic bipolar plate module with integrated seal and low cost coating

Integrated laminated MEA
Assembly simplification

Ideal pick an place structures
Bead seal demonstrator „Eva XXL“
## Evolutionary steps of AutoStackCore MBPP

<table>
<thead>
<tr>
<th></th>
<th>Evolution 1</th>
<th>Evolution 2</th>
<th>changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active area</td>
<td>300 cm²</td>
<td>300 cm²</td>
<td>-10%</td>
</tr>
<tr>
<td>Plate dimensions</td>
<td>410 x 157.6 mm x mm</td>
<td>410 x 141.7 mm</td>
<td>-10%</td>
</tr>
<tr>
<td>Active to passive ratio</td>
<td>46%</td>
<td>52%</td>
<td>+6%</td>
</tr>
<tr>
<td>Cell pitch</td>
<td>1.2 mm</td>
<td>1.0 mm</td>
<td>-16%</td>
</tr>
<tr>
<td>Nominal stack power</td>
<td>95 kW</td>
<td>101 kW</td>
<td>+6%</td>
</tr>
<tr>
<td>Power density at stack level</td>
<td>2.8 kW/l</td>
<td>3.5 kW/l</td>
<td>+12%</td>
</tr>
</tbody>
</table>

3D rendering by PowerCell

Published at AsC public stakeholder meeting 30th Jan. 2017
Performance of AsC short and full size stacks

**Stack Operating Conditions**
- Reactants A/C: 30% N₂ in H₂ / Air
- 2012 state of the art: H₂ / Air
- Temperature stack inlet: 68 °C
- Pressure stack outlet A/C: 220 / 200 kPa abs
- Dew Point @ inlet A/C: 49 / 53 °C
- 2012 state of the art: 55 / 60 °C
- Stoichiometry A/C: 1.4 / 1.8
- 2012 state of the art: 1.4 / 2.0

**Graph**
- **U / V** vs **i / mA·cm⁻²**
- **Target**
- **2012 state of the art**
- **Evolution 2 short stack**
- **Evolution 2 full stack**
- **Evolution 1 full stack**

Dr. Raimund Stroebel, 14th February 2017; DOE bipolar plate workshop; Southside, Michigan

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DANA process flowchart to the standardized metallic bipolar plate module

- Incoming Inspection
- Stamping and Cutting with Progressive Die
- Joining
- Coating Process
- Sealing process
- final inspection
- Packaging and Shipment
- Customer
Thank you for your kind attention!

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Dr. Raimund Stroebel, 14th February 2017; DOE bipolar plate workshop; Southside, Michigan