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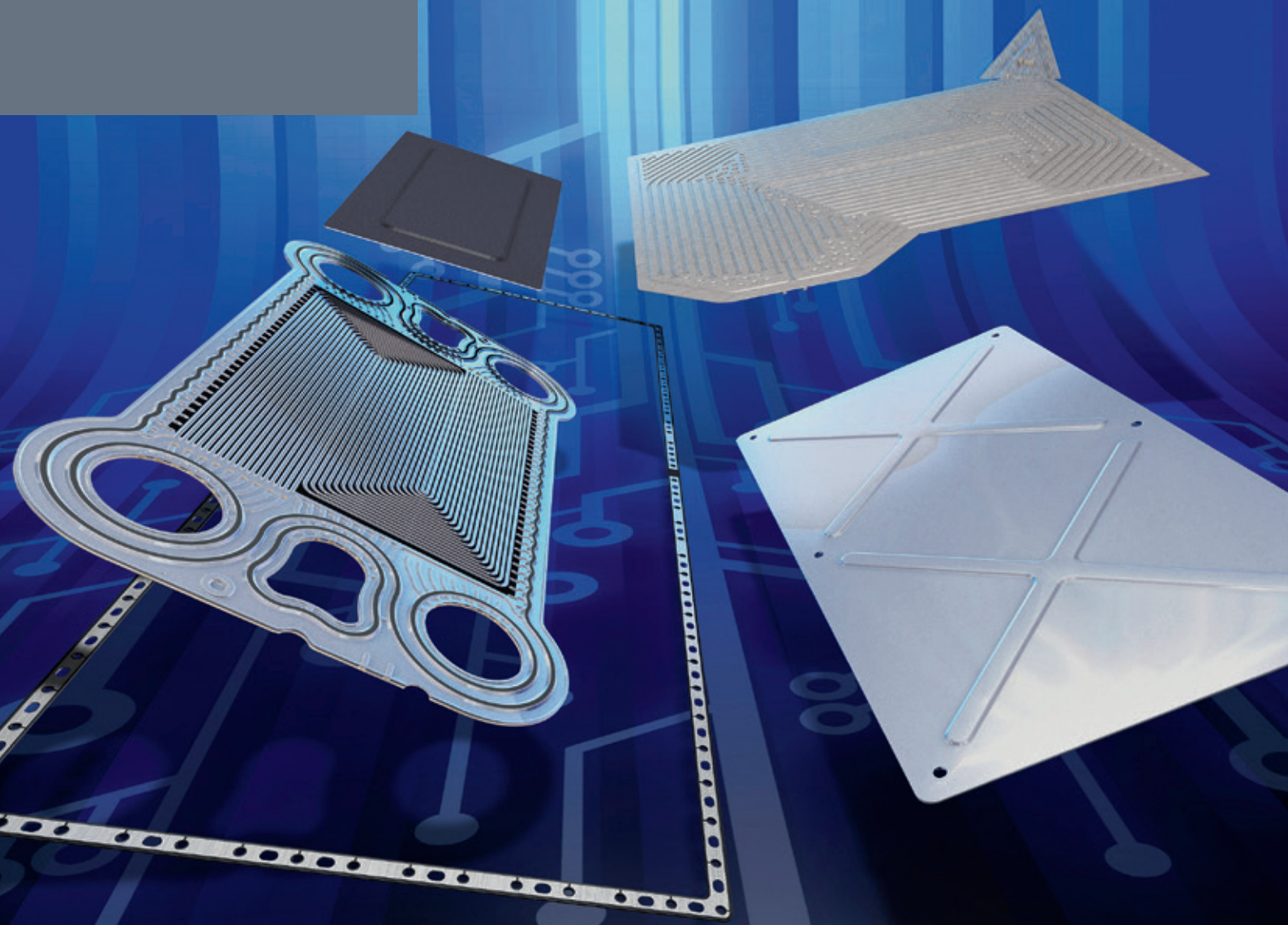
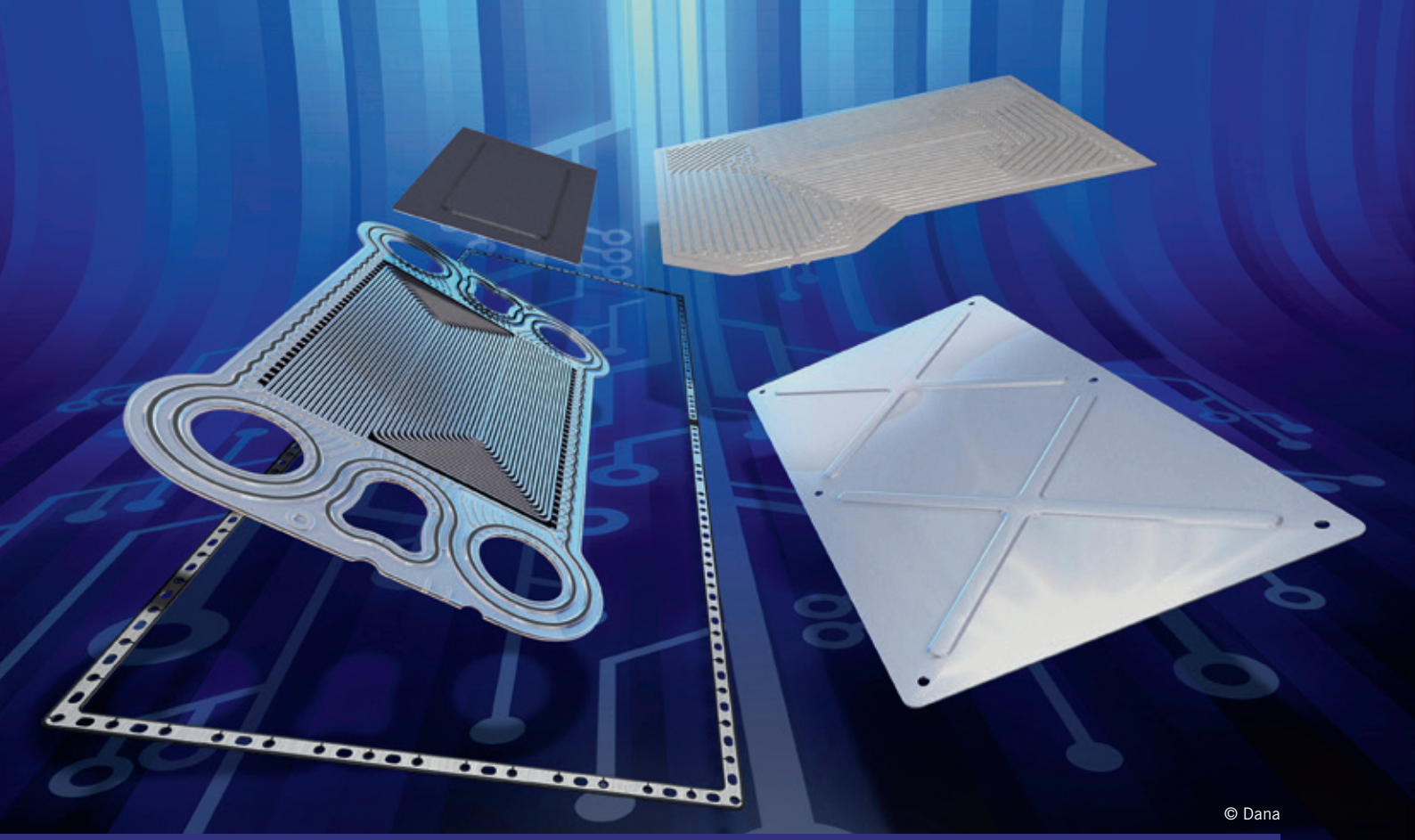


Focus on Electromobility

Dana Product Strategies for a Technical Transformation

DANA



Product Strategies for Technical Transformation in the Automotive Supply Industry

Electromobility is transforming the automotive industry, and doing so faster than expected. Already today, suppliers that are producing components for gasoline and diesel units must also provide innovative solutions for electric vehicles and high-voltage battery technology. The best strategies for the future are sustainable strategies for technically transforming product portfolios. Therefore, Dana Incorporated focuses its existing manufacturing and product expertise in the traditional areas on the requirements of electric mobility.

Dana Incorporated has been manufacturing sealing technology, including thermal-acoustical protective shielding for engines, for over 100 years. At Dana's Neu-Ulm (Germany) production location, all the signs point toward transformation. Research and development uses technologically unique selling points and competitive advantages from the world of internal combustion engines to develop innovations for electrifying mobility – from batteries to fuel cell technology. The focus is on metallic bipolar plates and seals for fuel cells, as well as heat shields, coolers and compensation plates for high-voltage battery-electric vehicles. These are solutions that decisively improve the efficiency of electric vehicles.

METALLIC BIPOLAR PLATES

The central element of hydrogen propulsion is the fuel cell. The core is the fuel cell stack, which is a stack of bipolar plates and membranes connected in series. Metallic bipolar plates have been a major area of research and development at Dana for 20 years. The currently highly integrated plate reduces manufacturing

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costs, providing a decisive competitive advantage on the road to emissions-free mobility. It incorporates the technological expertise of multi-layer cylinder-head gaskets – from optimized steel processing to coating technology, **FIGURE 1**. The future is promising: By 2025, the Neu-Ulm plant is to produce several million bipolar plates.

FOLDING SEALS FOR BATTERY COMPARTMENTS

Housing sealing for high-voltage batteries presents enormous challenges even just because of the size. The seals must securely seal the battery compartment from both the inside and the outside when installed. When installed, the seals must reliably seal the battery housing both internally and externally, but with dimensions of up to 2000 mm in length and 1400 mm in width, they are extremely difficult to transport under normal conditions, **FIGURE 2**.

Here, Dana's Neu-Ulm facility modifies manufacturing processes for rubber-metal sealing technology for cylinder head gaskets in truck engines. The

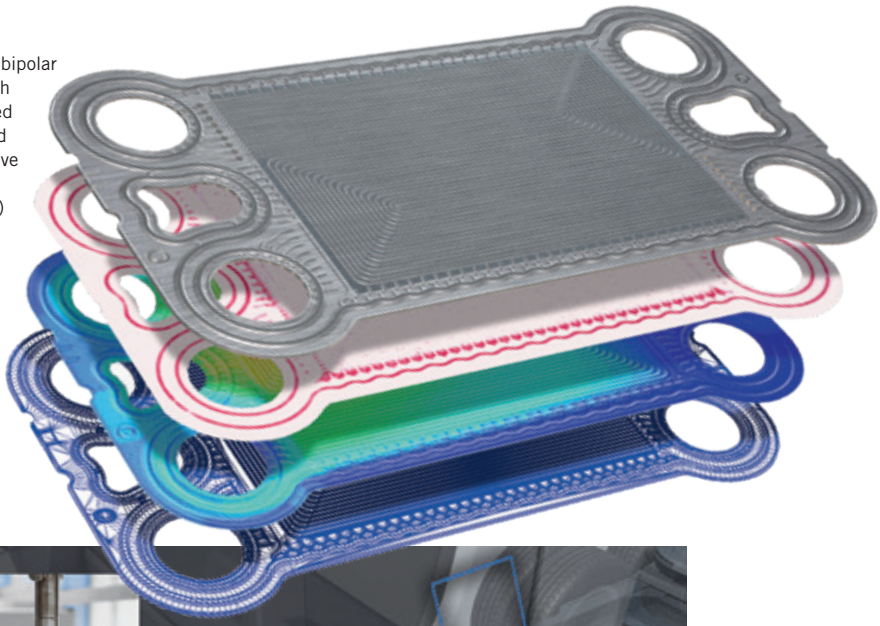

FIGURE 1
Metallic bipolar plate with integrated seals and conductive coating (© Dana)

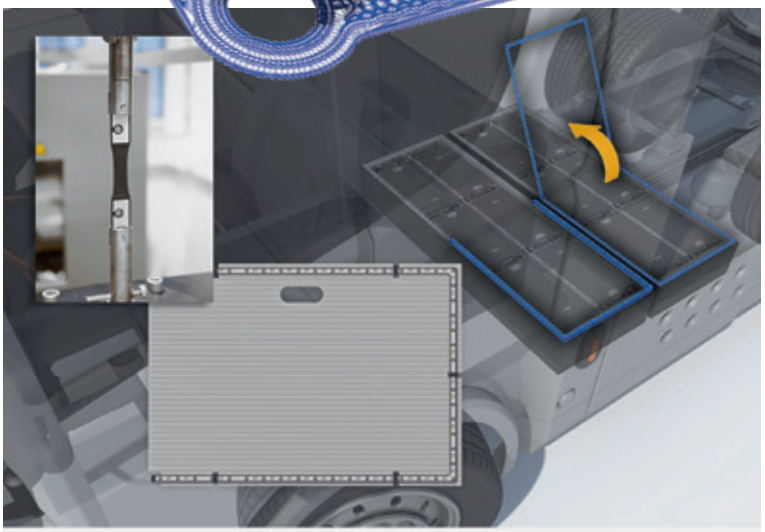

FIGURE 2 Pluggable seal test arrangement under tension, installation aid and logistics concept (© Dana)

FIGURE 3 Cell module with battery heat shield (1) and swelling compensation sheet (2) – explosion caused by short-circuiting a charged cell (© Dana)

result is folding seals that can be used with almost any battery compartment and also facilitate logistics and assembly.They meet requirements using a flat carrier plate with a double-sided rubber seal. At least two permanently integrated rubber elements interrupt the metal carrier. The result is an uninterrupted circumferential sealing profile with one or more sealing lips around the entire edge of the battery compartment. Each screw hole can also be sealed to ensure corrosion protection. The edge-molding polymer with self-extinguishing properties complies with UL 94, which states that silicone ignited with a Bunsen burner must extinguish itself within seconds. No external flames can reach the high-voltage battery.

Puzzle solutions and liquid seals for battery compartments have significant disadvantages relative to the folding seal. Puzzle seals require the customer to assemble individual parts like pieces of a puzzle. If there is expansion or compression, there may be leakage at the interfaces. Puzzle seals also have no continuous sealing contours and can compensate for very little tolerance. The folding seal, on the other hand, compensates for tolerances in the millimeter range without any problem thanks to its elastic folding elements and can withstand pulling, bending, and shearing forces. The leakage risk is greatly reduced because of the lack of interfaces. Liquid seals are easy to apply, but if service is needed, removal is time-consuming. It may even make the battery compartment cover unusable.

The very large, entirely continuous folding seal's rubber folding elements offer decisive advantages. For transport, the seal is folded at the folding elements from 2000 × 1400 mm to not more than 1100 × 700 mm, so it fits on a euro pallet. To install the seal, the customer only needs to use the integrated installation aid to fit it to the battery compartment and unfold it. There is no danger of faulty assembly. The battery compartment cover supplier can also pre-install the folding seal. The seal is equipped with insertion nubs for the cover to facilitate this.

HEAT SHIELDS FOR HIGH-VOLTAGE BATTERIES

The new, highly efficient heat shields for high-voltage batteries from Dana, point 1 in **FIGURE 3**, are the result of years of experience in developing and manufacturing thermal-acoustical protective shielding for internal combustion engines. The shielding is placed between the high-voltage battery and the passenger compartment, protecting passengers from a cell short circuit or, if there is an accident or damage, from an explosive fire and flying fragments. If the cell modules are not on the same level, but arranged one on top of the other, the heat shield is also placed between cell module levels to prevent thermal runaway from affecting the adjacent module. The specifications require a highly resistant material that guarantees at least five minutes of absolute protection from burn-through under high temperature with particle impact.

Dana's three-layer "sandwich" shielding solution is composed of a thin-walled, deep-drawn stainless steel sheet, an insulating layer, and a cover plate of stainless steel or aluminum. A stainless steel plate can withstand temperatures of up to 1500 °C. Thermal insulation is provided by a perforated sheet with rolled-on, heat-resistant mica or a glass mat. Weight is between 2.5 and 3 kg/m^2, depending on dimensions. Typical competing solutions consist of a single-layer body panel that weighs 15 kg/m^2.

To adapt the high-voltage battery heat shield to the available space, structures must be self-supporting when flat, but still moldable into 3-D structures. Dana relies on proven production technology for classic heat

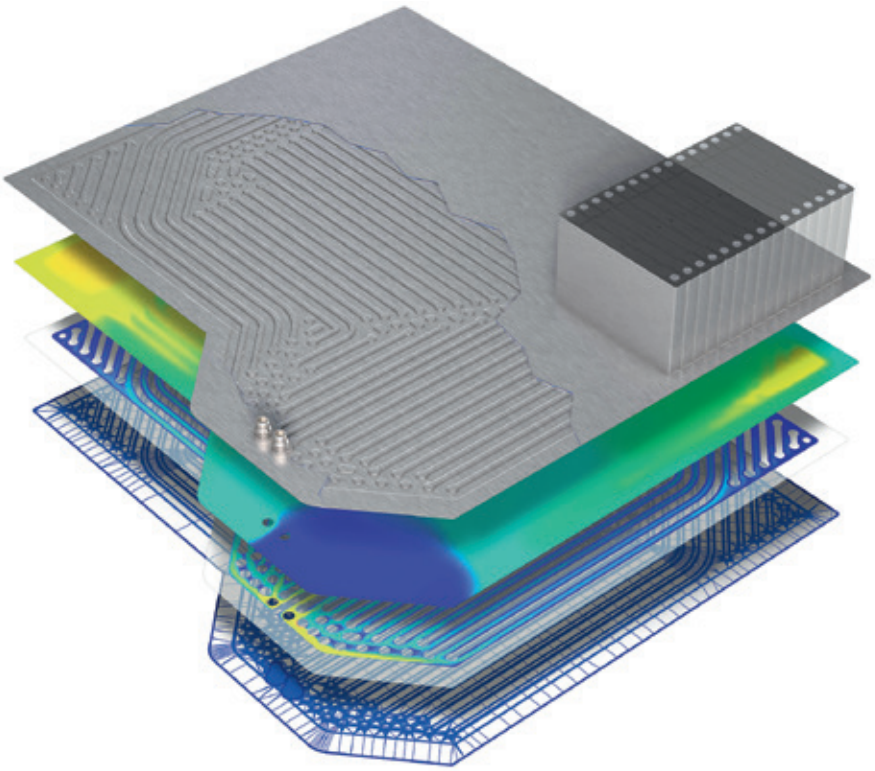

FIGURE 4 Two-layer cold plate with prismatic battery cells, from design to flow and heat arrangement to finished product (© Dana)

shields for internal combustion engines.

Tests in test chambers with cameras and sensors show that the shielding solution exceeds requirements. To simulate accidents or damage, an internal short circuit is generated in fully charged battery cells, causing the cells to explode. The explosive gases and particles flowed through the cell's vent hole to the shielding part at a temperature of up to 1500 °C and did not burn through. The transmission factor was 30 %, compared to 50 % for single-layer body panels. In other words, the new heat shields for high-voltage batteries shield around 70 % of the temperature load.

COOLERS FOR HIGH-VOLTAGE BATTERIES

In parallel with the battery heat shields, Dana is presenting a production concept for manufacturing cooling plates for high-voltage batteries, **FIGURE 4**. These plates are needed not only for cooling, but also for heating, depending on ambient temperature, and thus provide thermal balancing for the battery. The aluminum component includes a structural layer which forms the fluid channels, and a flat layer which provides good contact with the battery cells, which are joined together to create a fully self-contained, leak-free solution. The coolant fluid used is typically a mixture of 50 % ethylene glycol and 50 % water. Depending on application needs, Dana can adjust the formed fluid channel structure whereby the cooler height can range from 2 to 5 mm. The two plates have a thickness that is less than one third of the finished cooler. The cooler dimensions can be as large as the underbody of the vehicle.

The manufacturing expertise comes from almost all product areas; this expertise includes laser cutting, laser welding, forming, and punching. An especially important and new sustainability factor is provided by aluminum laser welding. Heat input into the component is focused on thin welding seams that are preserving the overall physical material properties, allowing the use of thinner aluminum plates. As a result, the weight can be reduced by around 30 % and the manufacturing energy by around 50 %, which leads to lower CO_2 emissions.

In the future, almost any three-dimensional component design – such as applications for cylindrical battery cells – will be achievable with this process. This means that laser welding technology is not reserved for battery coolers alone, but can also be used in other product segments for aluminum and stainless steel alloys.

COMPENSATION PLATES FOR PRISMATIC BATTERY CELLS

Another focus is on research into new types of compensation plates for prismatic battery cells, point 2 in **FIGURE 3**. The development project is called Swelling Control. Battery cells breathe during charging and discharging. The more cycles the cell goes through, the rounder it becomes. Battery capacity and thus vehicle range become sub-optimal. This is why cells are clamped individually – layers of felt and punched parts inserted between individual modules ensure compensation and insulation. Over time, materials that were previously fibrous or compounded harden and lose their elasticity – cell pulsation is no longer absorbed. Studies have observed forces of up to 10 kN within a cycle for tightly clamped batteries.

Initial prototypes – developed as part of the Swelling Control project – show that the spring plates with special shapes based on the seal design improve the capacity of the battery over its service life through adapted compression. The engineers counter swelling with spring sheets with an integrated corrugation geometry. This solution ensures optimal elastic pressure throughout the cell's service life and prevents uncontrolled expansion of cell walls. For thermal and electrical insulation, the sheet is given a special coating which keeps the adjacent cells from overheating, prevent-

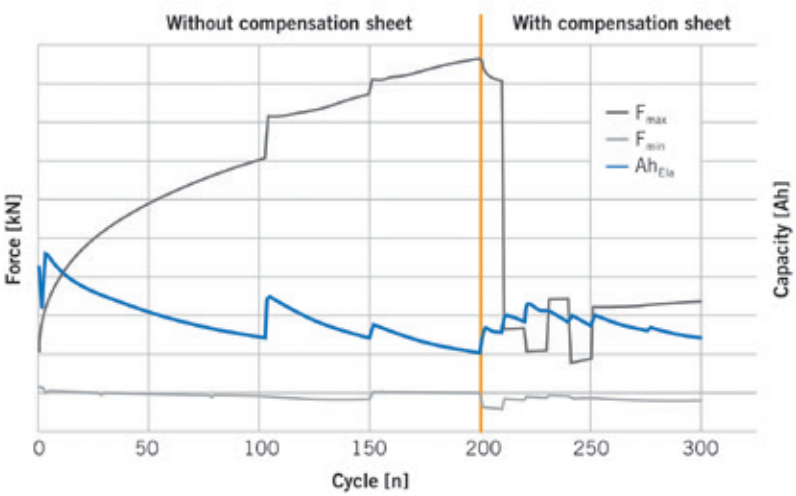

FIGURE 5 Battery capacity optimized with compensation plates (© Dana)

ing thermal runaway. Temperatures as low as 120 °C can cause cells to contaminate each other.

Cyclical charging and discharging fatigue tests show that compensation plates with integrated corrugation have a positive effect on cell capacity and greatly slow the aging process. This significantly increases high-voltage battery degree of use, **FIGURE 5**.

SUMMARY

In Germany, the number of electric vehicles and plug-in hybrids approved have almost quintupled in 2020. Dana shows that the transition to fuel cell and electric technology can be made successfully. Identifying products and manufacturing processes that can be transformed to enhance electromobility will become an increasingly important sustainability strategy for the automotive supply industry.

A topic-specific technical article on Dana's metallic bipolar plate will follow in MTZworldwide 09/2021, detailing the plate's structure, processes and production.

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