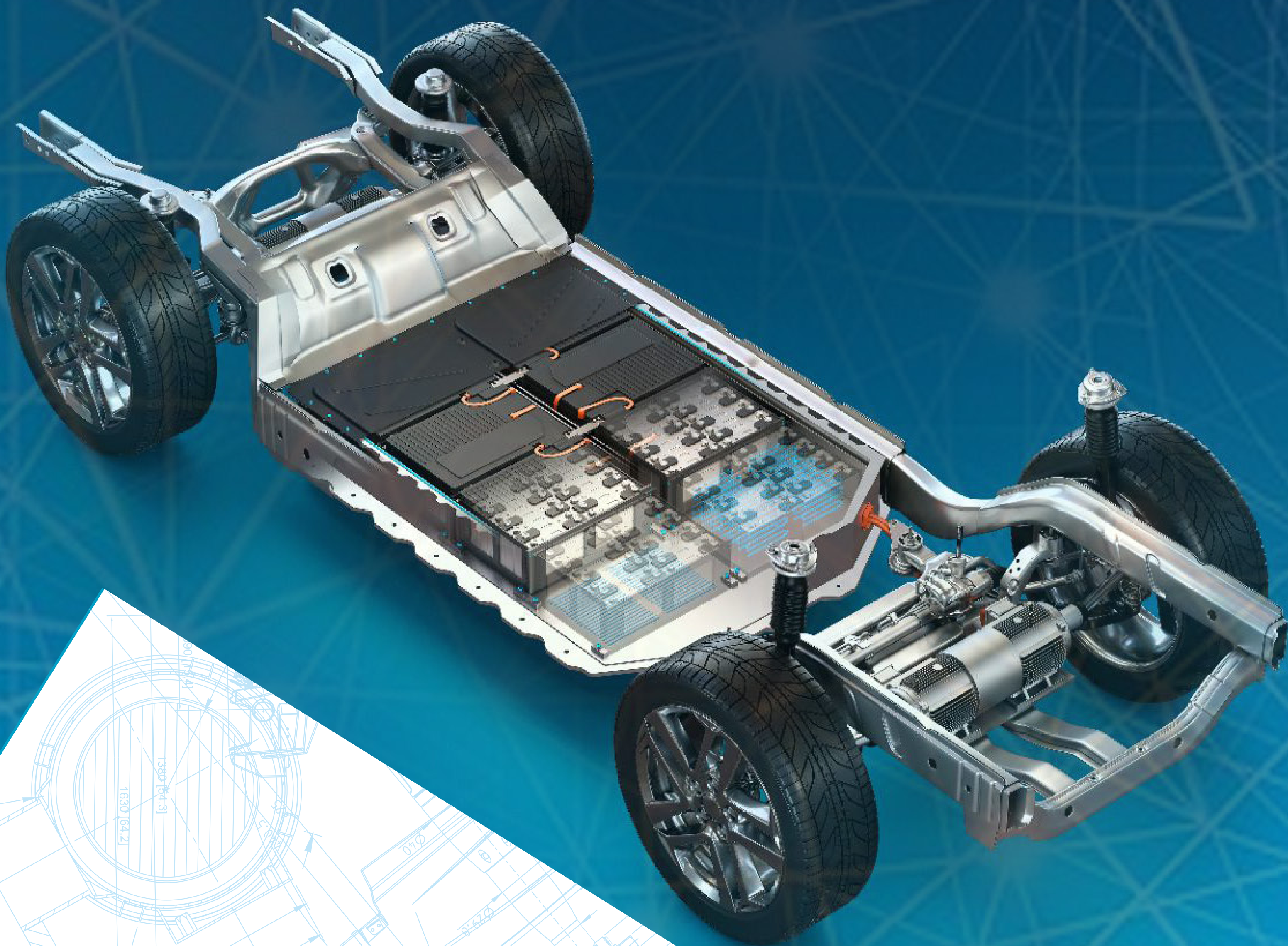


Electric & Lightweight

The future for electric vehicle battery assembly solutions

Contents

Introduction

The future for cars is electric and lightweight

In response to climate change, the global automotive industry is in a period of significant transition. Government legislation declaring a fundamental shift away from internal combustion engine vehicles towards fully electric powertrains means a range of new challenges for vehicle manufacturers, when it comes to materials, battery and joining technology.

This has led to the market for electric vehicles (EVs) expanding significantly, with the International Energy Agency (IEA) reporting global sales of 2.1 million light-duty EVs in 2019, representing a 40% year-on-year increase. Looking ahead, the IEA's Sustainable Development Scenario, which is based on the aims of the Paris Climate Agreement, forecasts global EV growth of 36% annually, reaching 245 million vehicles in 2030, which is over 30 times above today's level.

Rapid growth in EV demand presents a range of new challenges for vehicle manufacturers, when it comes to production in terms of materials, battery systems and joining technology due to the need for light weighting, a critical factor in the reduction of CO^2 emissions. The heavier the car, the more energy it will consume.

As the weight of batteries is considerable, engineers are tasked with developing new techniques to make new electric cars as light as possible, whilst improving range capacity. Both of these objectives require the increased use of lightweight materials such as aluminium and carbon fibre composite.

Alongside weight reduction, the various types of batteries used in automotive drivetrains need to be optimised for safety, durability and performance. As a result, these revolutionary changes in automotive production demand joining technologies that help to realise high-performance assembly processes.

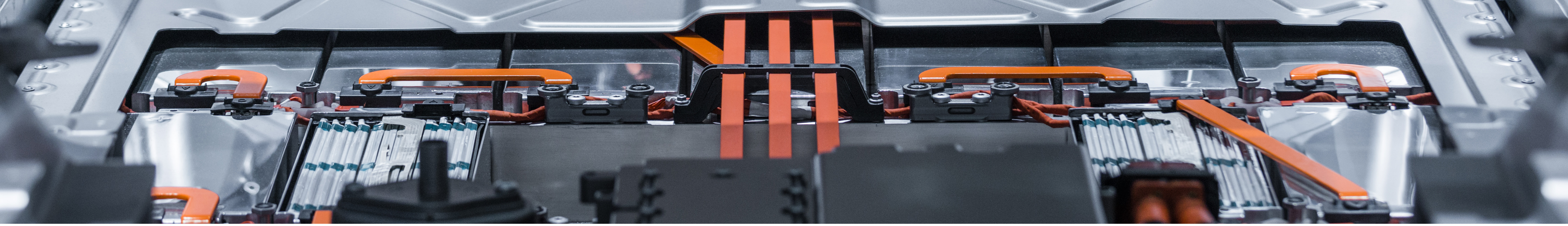
Assembly solutions for electromobility

Atlas Copco Tools and Industrial Assembly Solutions is at the forefront of next generation manufacturing and understands the challenges faced by vehicle manufacturers in the quest for electromobility. Working in close collaboration with its customer partners enables the smart innovation of advanced, highly efficient assembly technologies, which include tightening, self-pierce riveting, adhesive dispensing and flow drill fastening. These systems and technologies are designed from the outset to provide vehicle manufacturers with fully integrated and connected assembly solutions across the entire production process: From body in white (BIW) construction, to drivetrain and battery assembly and ultimately, final assembly.

Atlas Copco enables vehicle manufacturers to fully realise the advantages of Industry 4.0 in production through its Smart Connected Assembly philosophy, where advanced industrial software combines with state-of-the-art joining technology and smart accessories to create a fully integrated assembly solution. Smart Connected Assembly provides manufacturers with effective data driven solutions that enable the delivery and management of joining and tightening strategies throughout the production process. The use of data is key to maintaining quality control, minimising errors and increasing uptime in production critical operations.

Context

This white paper examines the challenges relating to electric vehicle production with a specific focus on battery assembly.

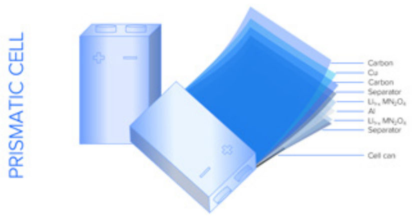


Assembling EV Batteries

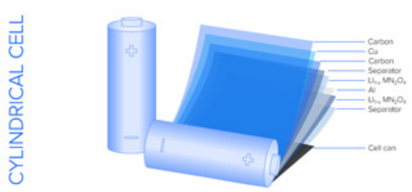
A new approach to joining and tightening strategies

The rise of electric powertrains creates new joining and tightening needs in relation to battery manufacture and assembly. As platforms evolve to become fully battery electric vehicle (BEV), batteries have become an integrated part of the vehicle structure, making lithium ion cell assembly and their integrity a safety-critical issue. In order to achieve this, every step of the battery assembly process demands the use of smart, secure and safe joining technologies.

The assembly process of a high voltage EV battery pack has a strong influence on the safety, performance and durability of the battery. Choosing the right joining technology for the special requirements of battery manufacturing is therefore of crucial importance.



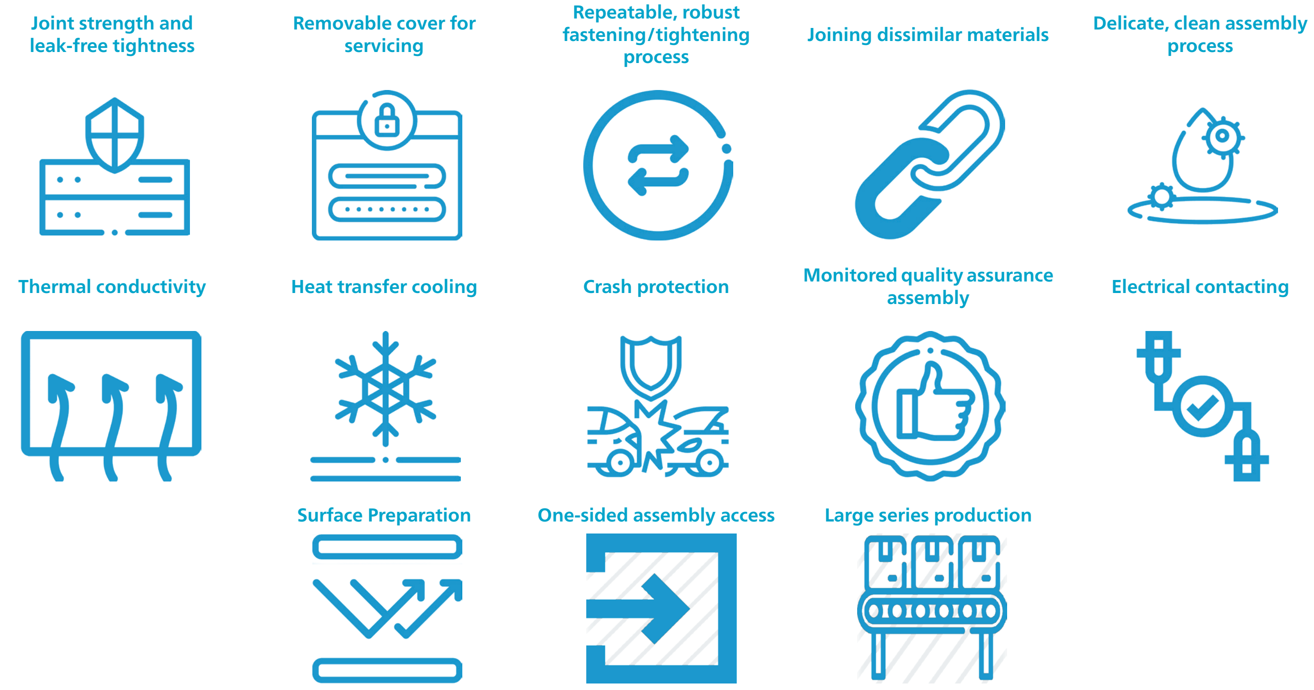
Lithium-Ion Rectangular Prismatic Cells make optimum use of space by utilising a layered approach and are mounted to blocks of nine or 18 cells. Encased in aluminium or steel for stability, Prismatic Cells offer good space utilisation and allow flexible design. Compared to the cylindrical design, these cells are more expensive to manufacture, less efficient in terms of thermal management and have a shorter lifecycle.



Similar to batteries used in the consumer products, Lithium-Ion Cylindrical Cells are mounted in units of up to 100 cells. Cylindrical Cells are easy to manufacture and offer good mechanical stability and recyclability, however they are also heavy and have a low packaging density due to space cavities.

Featuring a soft outer shell, Lithium-Polymer Pouch Cells need to be enclosed in a metal or plastic. The laminated architecture of a Pouch Cell is light and cost-effective by providing a simple and efficient use of space with packaging efficiency of 90 – 95%. However, pouch swelling of 8 – 10% over 500 charge cycles, as well as potential exposure to humidity and high temperatures can shorten service life.

The Challenges of EV Battery Assembly



Safety in assembly is a key issue

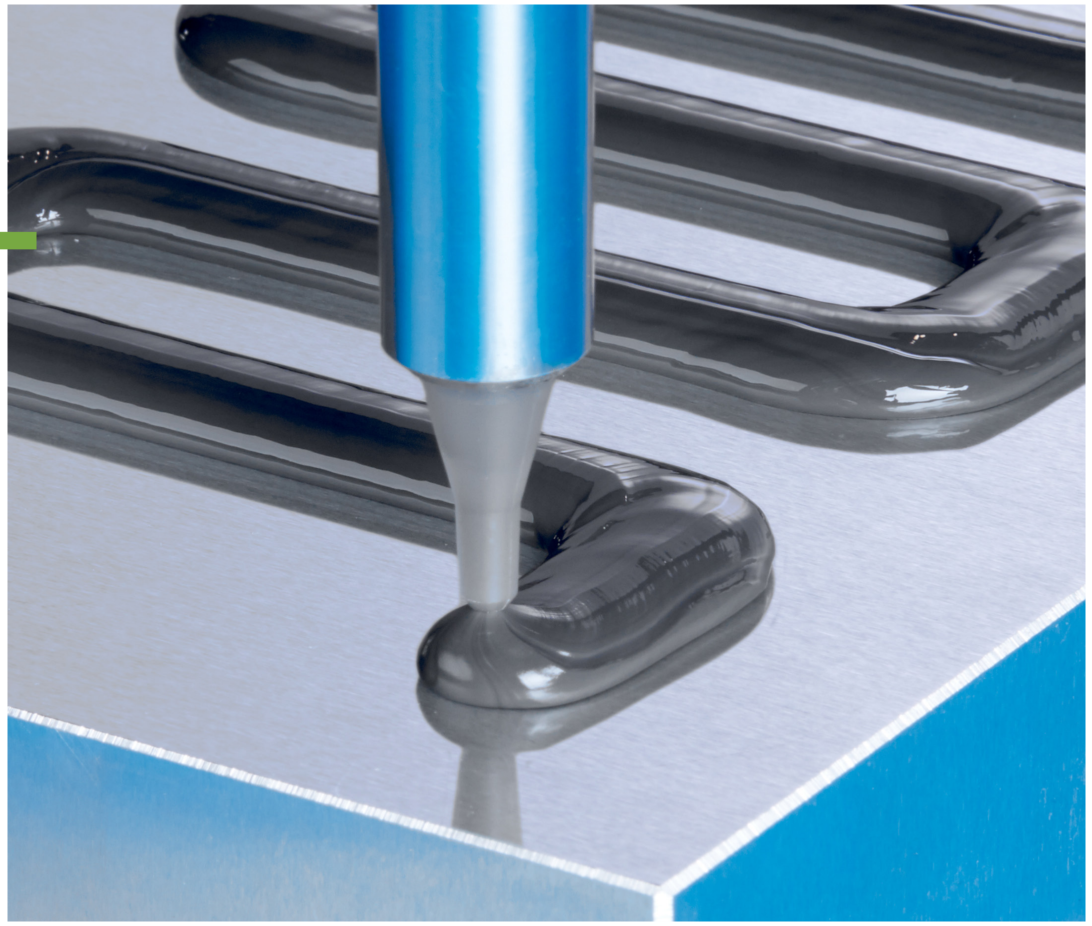
Ensuring operator safety in the production of EV batteries is critical because the cells and modules that make up the battery are already electrically charged and are therefore 'live' with voltage levels ranging from a few hundred up to 1,000 volts DC. Exposure to voltages higher than 120V DC, as well as electric arcs or exploding batteries can cause significant injuries and death.

As a result, risk assessment needs to be carried out and operators working on live terminals must be trained in safe working practices for EV battery assembly and provided with the special tools needed. Atlas Copco enables manufacturers to mitigate risk through a range of measures, which include its development of fully insulated sockets and quick change adapters, as well as insulated tool covers and 'Slip-Off' protection for handheld electric assembly tools.

Six things to know about EV battery joining

1

Cell-to-cell bonding: Bubble free for enhanced safety



To supply the required energy, lithium-ion prismatic battery cells must be firmly attached to cell stacks. This presents a major challenge because the cells are quite delicate. As a result, no heat or force can be applied in the joining process.

By using two component (2C) adhesive bonding, no external heat is required for hardening, which results in a joint that meets the highest levels of rigidity and crash behaviour. Through the use of light elastic adhesives, vibrations are absorbed during operation, which increases the lifetime of the battery. Cell-to-cell bonding also allows the cells to expand slightly when charging and discharging.

To achieve these advantages, adhesive application needs to be precise and reliable to avoid air pockets and crucially, to ensure full contact and insulation. In case of a vehicle collision, air pockets in the battery can lead to short circuits that present a major safety issue in high voltage EV power systems. While 2C adhesive bonding is suitable for cell-to-cell joining, the dispensing technology used to apply the bonding must be bubble free to ensure safety.

As a world-leading provider of bonding and dispensing technologies, Atlas Copco's range of SCA adhesive dispensing and Quiss vision quality inspection systems enable precise application to avoid air pockets and ensure process reliability. Depending on the requirements of the design, Atlas Copco offers one component (1C) and 2C applications. 2C applications are often used for cell-to-cell bonding because no external heat is required for hardening. In addition, the high metering accuracy and mixing quality of Atlas Copco SCA dispensing systems allows the most advanced 2C requirements to be met, whilst maintaining high speed and process reliability.

2

Reinforcement of cell stacks: Cold joining is required

To protect the battery in the event of a collision, cell stacks can be reinforced with lateral braces. However, common joining techniques like spot welding are not suitable for this because they create heat and welding splatter, that can harm the sensitive battery cells.

The solution is to apply a clean cold joining technology such as Atlas Copco's self-pierce riveting (SPR). Self-pierce riveting is a method of joining two or more pieces of material using a rivet without the need for a pre-drilled hole. The basic self-pierce riveting process involves driving a rivet at high force through the material layers into a die which causes the tail of the rivet to flare out and form a joint.

This clean and purely mechanical joining process brings no heat into the cells and does not generate any hazardous vapours or weld spatters. In addition, Atlas Copco SPR can join multiple layers of different materials such as aluminium or steel, providing electrical conductivity for grounding. The joining process is highly reliable with short cycle times, enabling design freedom and maximum safety, whilst maintaining desired productivity levels.

3

Gap filler: Dispensing thermal-conductivity paste is a challenge.

Temperature management is a major challenge in battery manufacturing, as battery cells must be operated within a specific temperature range to preserve performance and avoid overheating. For this reason, a heat-conducting paste is applied. In order to guarantee thermal conductivity, a bubble-free paste application result is crucial. This does present a challenge as the liquid gap filler material is applied in high volume.

Atlas Copco SCA dispensing technology addresses this challenge by providing precise gap filler application and metering through the use of laser or camera-based systems to monitor the position of the bead to ensure a precise result. Application errors are also automatically recognised, enabling them to be rectified immediately. This keeps cycle times short and reduces rework or quality assurance costs.

It is also important to recognise that gap filler materials are highly abrasive and have the potential to quickly wear out the dispensing equipment. To address this challenge, Atlas Copco SCA dispensing system components, such as material supply applicators, nozzles and meters, are designed to handle high volumes of challenging materials.

4

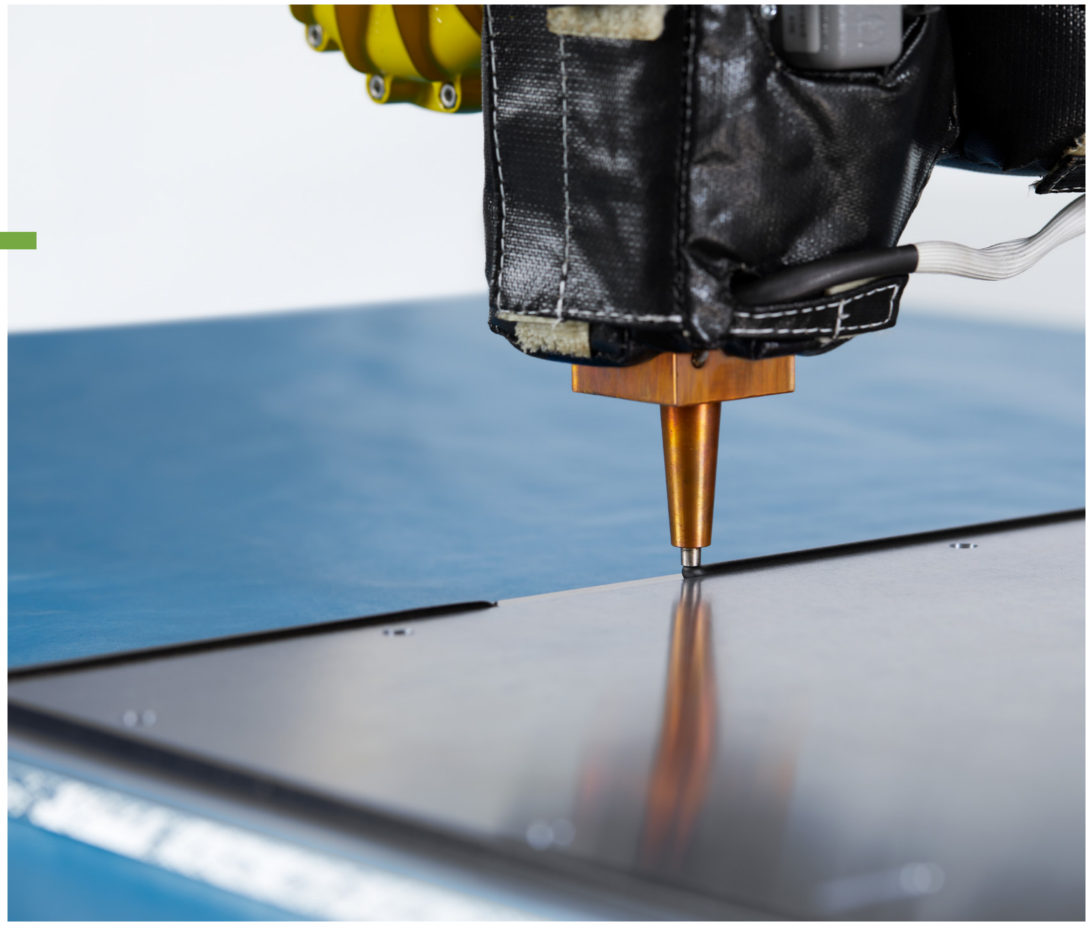
Module mounting: soft joints need controlled tightening

The battery modules need to be mounted on top of the liquid gap filler paste at the bottom of the battery tray. While this can be achieved with tightening, the soft joint behaviour of the gap filler presents a challenge due the tendency of the paste to squeeze out easily, causing air to remain within the battery module.

To guarantee even distribution and full contact between the battery modules and the thermal compound, the tightening process needs to be fully controllable. Atlas Copco's industry-leading nut-runners provide an electronically controlled multi-spindle solution, which delivers a uniform tightening process. This in turn ensures quality, productivity and traceability. By working synchronously in the final tightening process, the assembly cycle time is reduced and each module is fixed evenly in the tray. Optimum contact is achieved by employing a programmed tightening strategy that takes the behaviour of the liquid conducting paste into account.

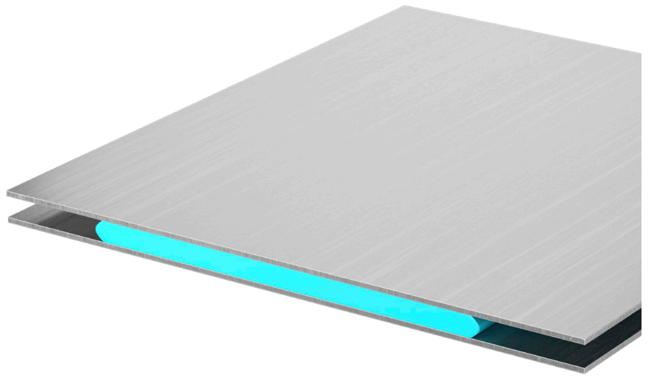
5

Cover Sealing: Protection against moisture and gases is crucial



Once all modules are tightly fixed and the battery management system is installed, the tray must be sealed. It is crucial to avoid any penetration of moisture, otherwise the battery power deteriorates dramatically, leading to damage and corrosion. Furthermore, the battery produces toxic gases that can be harmful if they enter the passenger compartment. As a result, the internal space must be sealed completely both from inside and outside, through the precise and uninterrupted application of sealant.

Atlas Copco SCA dispensing technology enables sealant to be applied on either the battery cover or tray. Because the battery cannot be exposed to heat, materials such as 1C hot butyl,
2C polyurethane or 2C silicone that do not require oven curing are suitable sealants. Regardless of the material, Atlas Copco SCA dispensing enables uniform application with a precise start and finish of the bead to ensure a tight seal.



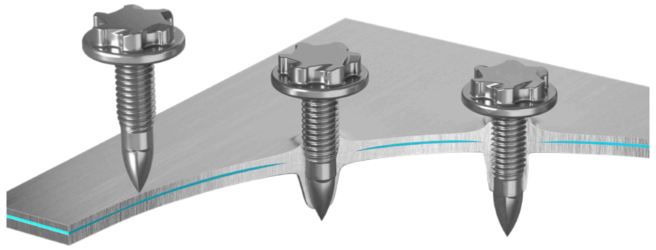
6

Cover to tray joining: Serviceability calls for reversible joining

The final stage of battery assembly involves the mounting of the cover onto the battery housing. It is important to note that at this stage, the housing is only accessible from the outside and this needs to be considered when selecting an appropriate joining technology. This bond should also be detachable to facilitate maintenance and dismantling, for the purpose of end of life recycling.

Atlas Copco K-Flow drill fastening technology meets these requirements perfectly. A specially designed screw is rotated at high speed, utilising pressure to warm up the material. This allows the fastener to push through the material stack, cutting the thread in a 'one shot' process, providing an efficient and flexible joining technology for multi-material stacks. The K-Flow process provides reliable mechanical bonding, is reversible and requires only one-sided access.

A further advantage of K-Flow in battery cover-to-tray joining is that the process does not require surface preparation. This ensures that the metallic components are in a conductive bond and form a 'Faraday cage' to prevent electromagnetic interference.

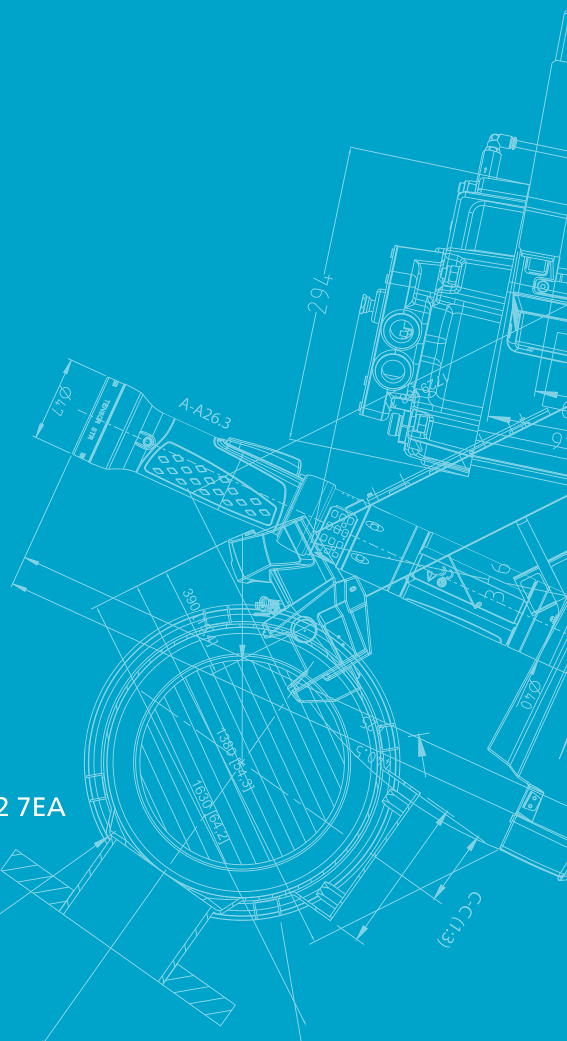


Conclusion

The future for cars is looking good!

As identified in this whitepaper, the rise of electromobility has created a number of new challenges relating to the assembly of EV battery packs. These include the need for innovative joining techniques and productive assembly solutions, which are fully traceable to ensure quality, as well as safe due to the 'live' state of batteries in production.

As joining experts, Atlas Copco Tools and Industrial Assembly Solutions continues to develop innovative ways of handling all types of joining at every stage in the EV production process. These combine leading edge assembly technologies like tightening, self-pierce riveting, adhesive dispensing and flow drill fastening to create smart connected assembly solutions that realise the vision of Industry 4.0.



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