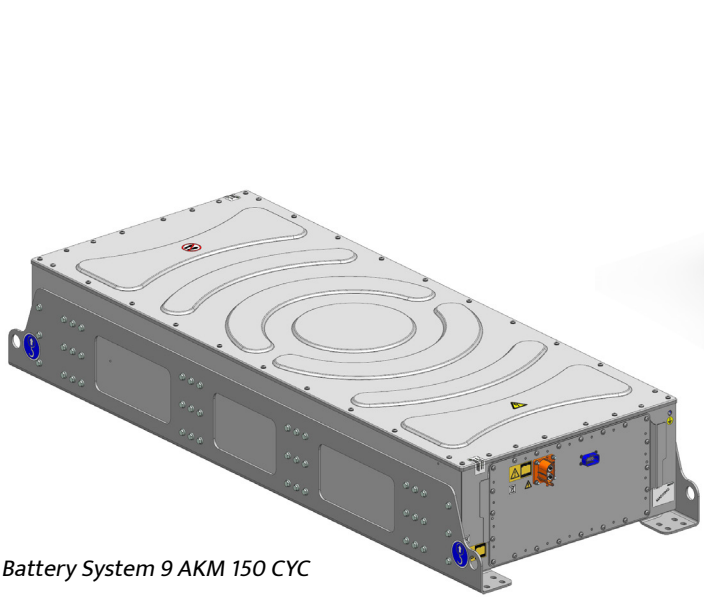
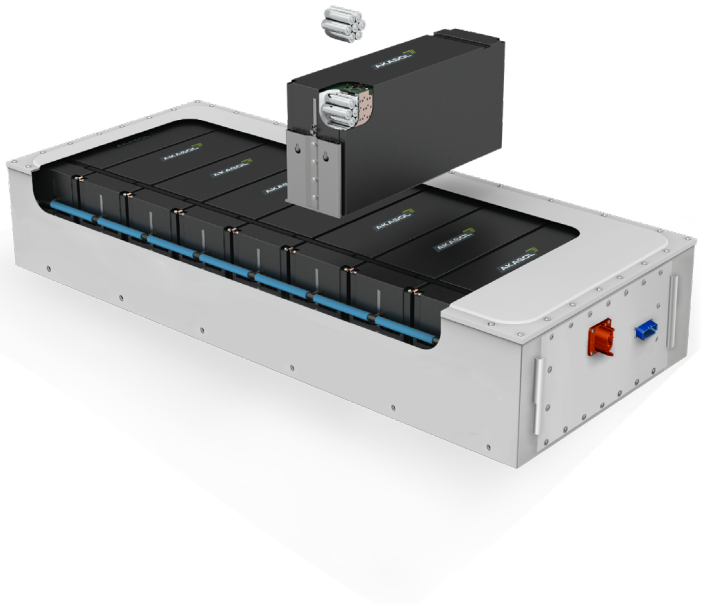
BorgWarner

Ultra-High-Energy Battery System for Electrified Commercial Vehicles



Battery System 9 AKM 150 CYC

9 AKM assembly



BorgWarner's ultra-high-energy battery system exploits the full potential of its battery technology to lower the total cost of ownership for electrified commercial vehicles.

History and Background

Different types of batteries have been tried for use in vehicles since the early 1900s, but there is no universal battery than can be used for all types of vehicles. Instead, batteries must be specifically designed for the needs of each type of vehicle. The electrified commercial vehicle (eCV) market is experiencing rapid growth, since buses and trucks can improve sustainability by providing higher transportation efficiency compared to smaller vehicles. To properly realise these advantages, the power source needs to be tailored to the operational demands of each type of eCV.

In 2018, BorgWarner visited major electric bus and truck suppliers to gain a thorough understanding of their future needs. In 2019, this resulted in the battery module design that now forms the major building block of the battery pack discussed here.

BorgWarner's UHE battery system is rated as a highly sustainable battery solution according to a TÜV (Technischer Überwachungsverein) audited calculation method in Germany.

Battery Optimisation for eCVs

Compared to a passenger battery electric vehicle (BEV), an electrified commercial vehicle (eCV) demands significantly different priorities from its batteries. For cars, initial purchase cost, energy and power density are primary considerations, but for the eCV market, the total cost of ownership (TCO) is critical, and this largely depends on how many times the battery must be replaced throughout the vehicle's life. Mechanical robustness, longevity, compact dimensions, and light weight of the battery assume much higher importance for the commercial vehicle market, where continuous, long-term usage must be assured while keeping vehicle payload capacity as high as possible.

To address this need, BorgWarner has developed an ultra-high-energy (UHE) battery system for energy-intensive electric drivetrain applications operating at up to 750V. As BorgWarner's award-winning cylindrical cell (CYC) battery module already sets the benchmark for energy density in the eCV market, this is employed as the power source in the UHE battery pack. The new system provides battery life of up to 4,000 cycles. It is also sufficiently versatile to be matched to a customer's usage profile; cells can be optimised towards maximum power density to take advantage of quick charging stops (opportunity charging) for urban buses, or they can be optimised towards maximum energy density for long-distance traffic where overnight charging is used.

CYC Module: The Battery Pack Building Block

The design of the CYC battery module is based on the 21700-format cylindrical lithium-ion (Li-ion) cell. To achieve the high energy density required and the necessary charging and discharging power, the type of cell chosen is specially designed for professional and commercial applications with an additional focus on cycle life. Each CYC module contains 600 cells; in standard form, these are configured as 20 serial connections of 30 parallel-linked Li-ion cells, providing a maximum module voltage that is below the electrical shock threshold for safe handling during production and maintenance. However, alternative cell configurations are possible by altering the current path routing within the side PCBs of the battery module. The module achieves an energy density of about 221Wh/kg.

Ultra-High-Energy Battery Pack Specification

Nine CYC modules are connected in series to create a 9 AKM battery pack providing 98kWh of energy. Being compact and energy-dense, this solution means city buses and intercity coaches can have battery system capacities of 400kWh to 1000kWh, twice as high as the present generation of batteries.

Production of 6 AKM battery packs is also planned. The smaller packs could be used in conjunction with 9 AKM packs for vehicle applications where a mix of different pack sizes would make the most efficient use of available space. Mixed pack sizes can be handled with ease by the multistring battery management technology.

Battery Management and Cooling

The battery management system consists of a battery management unit (master) & cell supervising circuits and their corresponding software. It provides primary safety functions including overtemperature, over/undervoltage and overcurrent protection but also performs detailed diagnosis of all actuators and sensors as well as innovative high-level battery management functions, e.g. battery state estimation.

The UHE battery pack is equipped with extremely effective liquid cooling at module level. This is indispensable for safety as well as for performance, ensuring a high availability of power and energy, and contributing to the slow ageing and long life of the battery cells.

Safety in Operation

The main safety consideration during the battery pack development was the prevention of any fire or explosion hazard. A combination of active and passive

safety devices at both CYC module and battery pack-level provides maximum protection against fire propagation resulting from a thermal event.

Within the CYC module, each cylindrical cell is physically separated from the next by a defined gap determined from deep evaluations by simulation and validation, and covered by an optimised potting compound.

Further software and hardware safety elements are incorporated at battery pack level. The CYC module is robustly constructed to protect the complete battery pack against damage. The system is shielded from external thermal loads and an efficient cooling system and predictive algorithms add a further layer of safety.

The intrinsic safety of the UHE battery packs is proven in use, as the first buses and trucks to be equipped with them have been running in major cities since 2020 without incident.

Charging and Maintenance

The UHE battery pack can be charged, dependent on cell type, at a rate of up to 1C with quick charging and is also suitable for use in fast charging infrastructure up to 500kW power on vehicle level. All significant electronic parts aside from the CYC modules are placed in a removable contactor box. In the unlikely event of a field failure due to a fault in the battery electrics or electronics, the unique service concept of the UHE system allows this electronics compartment to be exchanged easily without the need for high-voltage trained technicians or the necessity to demount the battery pack from the vehicle.

Environmental Sustainability

BorgWarner's UHE battery system is rated as a highly sustainable battery solution according to a TÜV (Technischer Überwachungsverein) audited calculation method in Germany. Several factors can be cited to demonstrate its sustainability:

- It is lightweight: the high energy density reduces the total weight of the system, therefore overall energy consumption
- Longevity of battery cells: the very high cycle life of carefully chosen battery cells is extended by intelligent mechanical and thermal integration and sophisticated sensors

Module with cylindrical lithiumion cells

- Extended circular value stream of the batteries: this includes maximum recyclability of the raw materials, and/or finding second life applications for used batteries
- Higher availability of energy from the vehicle's batteries: the consequent increase in operational range facilitates further intercity bus and light, medium and heavy-duty truck applications to be electrified

Summary

Mechanically robust, intrinsically safe, easily scalable and offering relatively low investment costs per kWh, BorgWarner's ultra-high-energy solution for long-distance transport sets new energy density standards for bus and truck applications and firmly positions BorgWarner as an innovation driver in the field of high-energy batteries.

Read the full **white paper**.

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