

Duesenfeld

A woman wearing safety glasses and a dark blue shirt is looking through a machine. The machine has several metal components and nozzles. In the foreground, there is a large, dark, textured pile of material, likely recycled lithium-ion battery components. The background is slightly blurred, showing some industrial equipment.

**Ecofriendly Recycling of
Lithium-Ion Batteries**

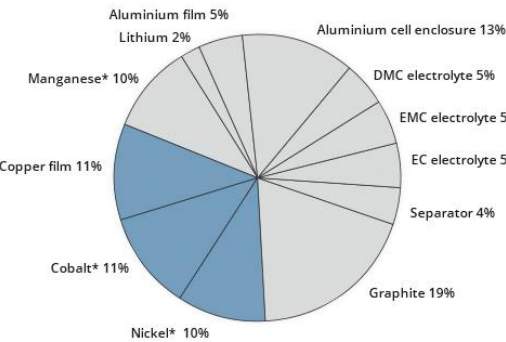
URT v. Duesenfeld
IPR2024-00887
Ex. 2053-001

Ecofriendly Recycling of
Lithium-Ion Batteries

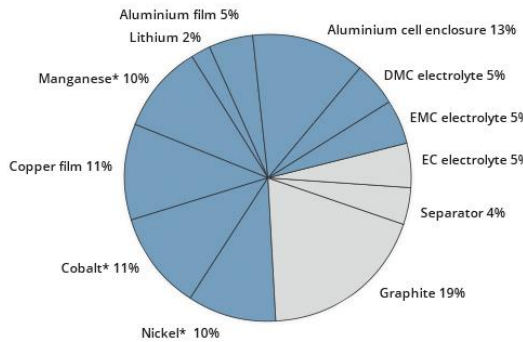
Duesenfeld GmbH researches and develops industry-oriented eco-friendly recycling processes for lithium-ion batteries, supplying graphite, electrolytes and lithium for material recycling in addition to the usual metals. Duesenfeld licenses the CO2 neutral and economical technology to automotive manufacturers, cell producers and recycling companies worldwide. Duesenfeld is constantly researching the best recycling technology ecologically and economically and continuously communicates solutions to license customers to meet upcoming regulatory requirements and beyond.

Recycling efficiency of a lithium-ion battery cell

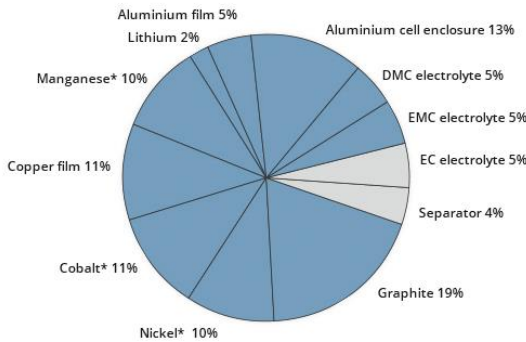
32% - current state of the art



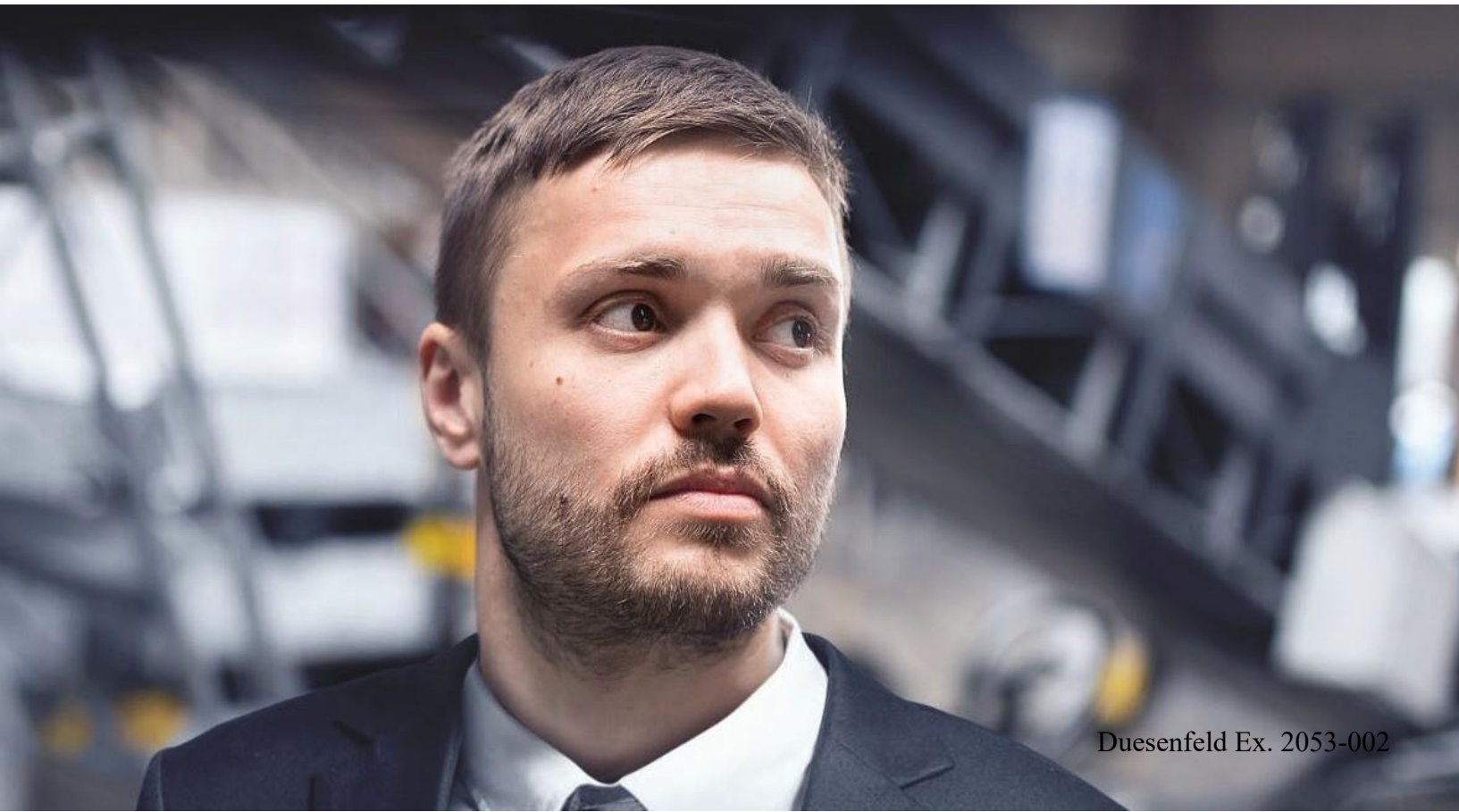
72% - Duesenfeld mechanically



91% - Duesenfeld mechanically + hydro

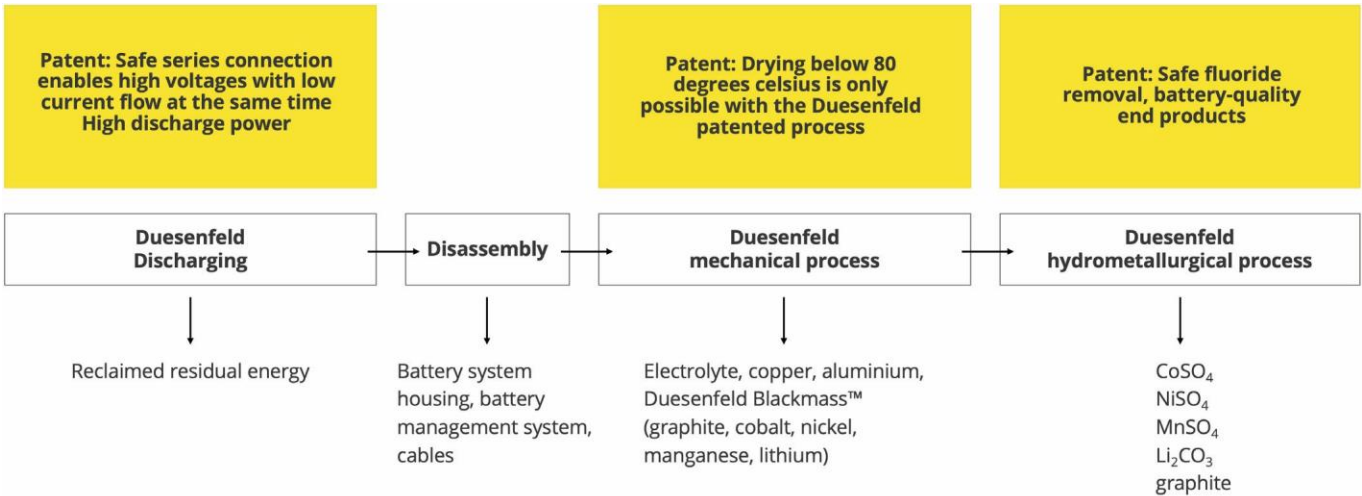


■ Material recycling ■ Disposal / repurposing as construction material * Oxides shown as elements for simplicity



Ecofriendly Recycling of
Lithium-Ion Batteries

Duesenfeld is the pioneer in the recycling of Lithium-Ion Batteries and has developed a basic technology. In more than ten years, we have developed and licensed processes that do not require melting down or high-temperature treatment of batteries. Since the beginning, our processes have been focused on Ecofriendliness, CO₂ avoidance and the highest recycling efficiency. Through this technology, Duesenfeld combines eco-friendly with maximum economic efficiency.



Discharging - Reuse of Energy

The recycling of Lithium-Ion Batteries starts with the patented deep discharge of the batteries and the use of the energy. The intelligent control software enables an automated deep discharge of the batteries regardless of the state of charge, the voltage, the age of the battery or the manufacturer. Due to the high linear discharge power, a high throughput and the highest possible efficiency are achieved. The recovered electricity is used to operate the recycling plant or fed into the grid.

- » Safety risks are automatically taken over by the control system
- » Reliable protection against operating errors
- » Very high linear discharge power leads to high throughput and high efficiency
- » Defined deep discharge - no further electrical danger.

Thanks to this patented technology, there is no further electrical risk for any of the subsequent process steps. There is no need for high-voltage trained personnel for the subsequent optional disassembly of lithium-ion battery packs, transports are safer. Duesenfeld discharging of Lithium-Ion Batteries ensures employee protection, process safety and high efficiency.



Vakuum drying – below 80 degrees

The Duesenfeld process with mechanical shredding of the batteries and further hydrometallurgical processing of the black mass is a low-temperature process. During mechanical shredding and inactivation of the batteries, the drying process takes place below 80°C and at a low vacuum. Only under these conditions is no exhaust gas scrubbing necessary. Only in this temperature range can also the solvents of the electrolyte, the graphite and the lithium be recovered in a purity so that they can be reused. Through this technology, Duesenfeld combines environmental friendliness with maximum economic efficiency.

- » no generation of hydrogen fluoride
- » Saving capital expenditures and operations cost for an exhaust gas scrubber
- » Purity of over 99.5% reuse condensed solvents of the Electrolyte for new Batteries
- » 100 % of Lithium stay in Duesenfeld Black™
- » Low operating costs save the most CO₂
- » Short drying time leads to higher efficiency



Hydrometallurgie – Battery grade

Duesenfeld has developed and patented its own process that enables full recycling through the production of battery-grade raw materials of the electrode active materials.

- » Lithium, cobalt, nickel and manganese are recovered in the form of salts, which serve as starting materials for the production of new cathode active materials
- » Removal of all disturbing fluorides by highly concentrated sulphuric acid at the beginning of the process.
- » Due to the low-temperature process, the graphite is not damaged and can be reused in new cells
- » End products: NiSO₄, CoSO₄, MnSO₄, Li₂CO₃ (battery grade) and graphite.

Regulations for the Recycling of Lithium-Ion Batteries

Worldwide, there are regulatory restrictions on CO₂ emissions, recycling rates by weight and product purities for the recycling of Lithium-Ion Batteries.

Thanks to the aforementioned advantages, the existing and announced requirements to minimize the carbon footprint of EV batteries can already be fully met by the Duesenfeld process. The extensive advantages of drying below 80 degrees are only possible with the patented Duesenfeld process.



Licensing of the Duesenfeld processes for ecofriendly recycling

Our business is the licensing of our processes and patents. Our licensing partners are car manufacturers, recycling companies, battery manufacturers, chemical companies and automotive suppliers.

» turnkey plants (EPC and EPCM) based on the Duesenfeld processes by plant engineering partners

» Industry-related research and development in the recycling plant enables a rapid reaction to possible changes in battery technology in order to continue to offer our license partners the most eco-friendly and efficient recycling process for Lithium-Ion Batteries in the future.

CO₂ savings - financial and environmental benefits

With a Life Cycle Assessment (LCA) calculation according to ISO standards EN ISO 14040, 14044 and 14071, our license customers can claim the lower energy and resource consumption to their customers and black mass purchasers. With a better Product Carbon Footprint (PCF) of Duesenfeld Black™, better prices can be achieved than with processes that emit more CO₂.



License inquiry

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