

Battery Recycling and Filtration

A technical paper by MSE Filterpressen GmbH on the role of solid-liquid separation in hydrometallurgical battery recycling processes.



Increasing Demands in Battery Recycling

As European battery recycling capacities expand, the demands placed on process stability, raw material recovery and operational safety are increasing significantly. At the same time, the recovery of strategically important materials such as lithium, nickel, manganese, cobalt and graphite is becoming increasingly relevant to the circular economy and security of raw material supply. The EU Battery Regulation is reinforcing this development by setting binding recovery targets for lithium, cobalt and nickel. High metal yields are therefore no longer merely an economic objective, but also a regulatory requirement.

Hydrometallurgical processes have become established as a key processing route. Unlike purely thermal or dry processing methods, they enable particularly efficient recovery of valuable raw materials while also being regarded as a safe and resource-efficient approach to industrial battery recycling.

Industrial operation shows, however, that economic viability is not determined by individual process steps, but by their stability under real and variable conditions.

In hydrometallurgical processes, battery materials are typically treated under the following conditions:

- Leaching at 60–80 °C
- pH values in the acidic range (≈ 1)
- Dissolution of nickel, manganese, cobalt and lithium from the Black Mass
- Subsequent multi-stage precipitation processes

Filtration separates solids from the process slurry and ensures that downstream steps such as precipitation, refining and crystallization can operate with defined media qualities.

Why Filtration Is a Critical Process Lever

Filtration does not affect just one isolated process step; it influences several key performance parameters at the same time:

- Metal recovery yield
- Filtrate quality (TSS)
- Efficiency of downstream processes
- Chemical and water consumption
- Plant availability
- Compliance with environmental and safety requirements

Cake washing efficiency is a particularly decisive factor. High washing performance removes unwanted accompanying substances and directly influences the purity of the recovered materials.

In industrial applications, modern filter press systems achieve cake washing efficiencies of more than 97%. This means that over 97 % of the soluble impurities are removed from the filter cake, directly reducing the purification effort

required in downstream process steps. However, such values are only attainable when plant technology, process control and media characteristics are precisely coordinated. Since 2018, MSE has focused intensively on filtration solutions for battery and recycling processes and develops customized concepts together with well-known companies in the industry across the entire battery life cycle.

This significantly reduces the processing effort required in downstream process steps. High purity also has a positive impact on the performance of subsequent batteries, including their energy density and range.

The degree of dewatering also plays a central role:

- A high dry solids content reduces
 - Energy demand for drying
 - Transport volume
 - Handling effort in downstream processing



Typical Challenges in Practice

Battery and metal recycling processes usually combine several demanding influencing factors. These include:

Abrasive
metal oxides

Fine **particles** that
are difficult to filter
(e.g. graphite)

Strongly fluctuating
particle size
distributions

Variable
viscosities

High **cake washing**
requirements

Increasing require-
ments for **emission**
control, exposure
minimization and
occupational safety

The filtration system must process slurries that often contain a very high proportion of fine particles. Graphite particles in particular place high demands on filter media and process control due to their morphology and small particle size.

In practice, this combination frequently results in:

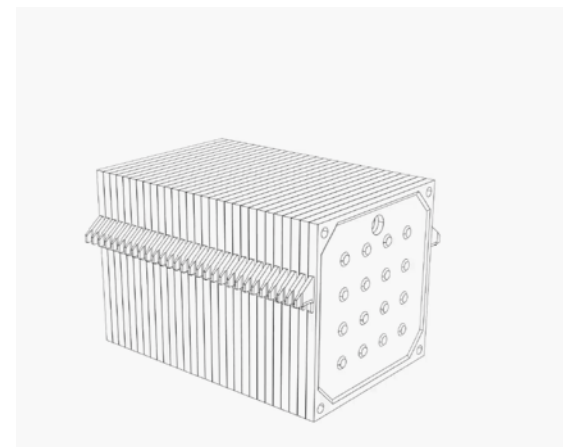
- Fluctuating filtrate quality
- Fluctuating filter cake purity
- Increased washing liquid consumption
- Unstable cycle times
- Increasing mechanical load on the plant
- Additional effort in downstream process steps

Consequences of Inadequate Filtration

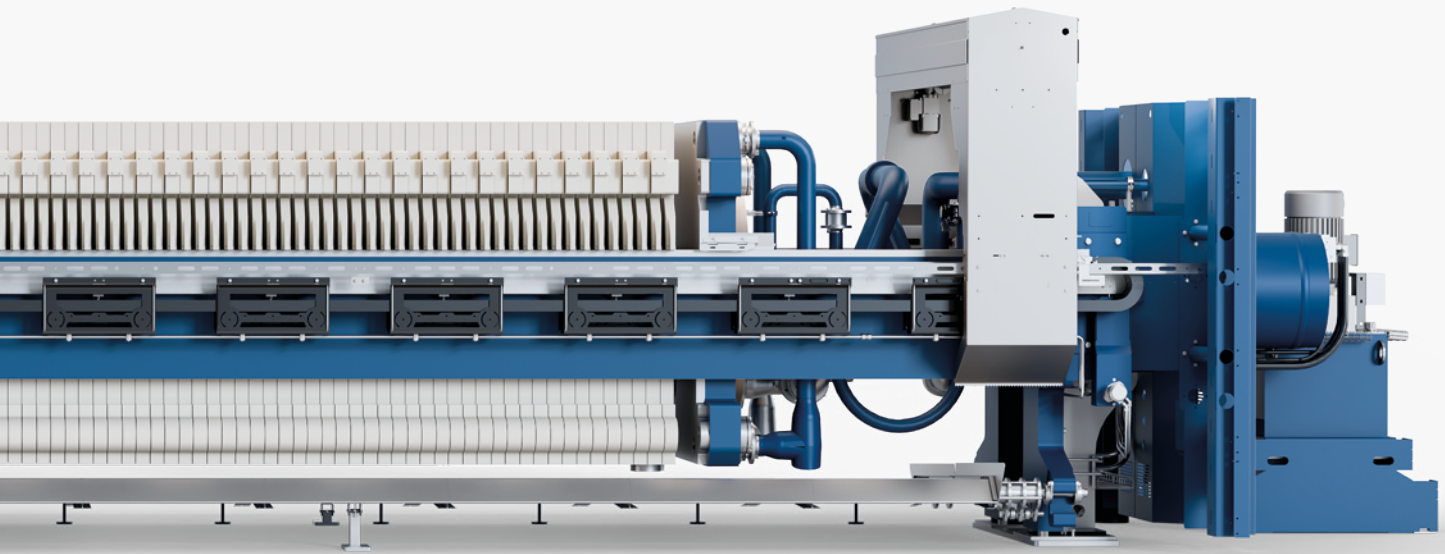
When solid-liquid separation does not operate reliably, it creates direct economic and operational risks. A calculation based on NMC filtration illustrates the scale: with a batch output of 2.4 tonnes and an average material value of approximately €50/kg, each batch represents a material value of around €120,000. A yield loss of just one percentage point therefore costs approximately €1,200 per batch and can quickly add up to six-figure amounts per year in continuous operation. By comparison, the filter press's annual operating costs amount to less than 1.5% of the initial investment. Typical risks associated with unstable filtration include:

- Loss of valuable metals due to insufficient separation
- Increased chemical consumption due to inefficient washing processes
- Disruptions to downstream processes (e.g. precipitation and refining)
- Reduced plant availability due to wear and malfunctions
- Increased emission, exposure and safety risks

Safety considerations are particularly relevant in battery recycling. Fine metal and graphite dusts may be generated during processing, including respirable cobalt particles. It is therefore essential for plant concepts to provide the highest possible level of closed process operation.



Filtration is therefore not merely a sub-process, but a key factor in process stability and economic efficiency. Efficient cake washing and high dewatering performance support material purity, reduce the effort required in downstream processes and can lower drying, transport and handling costs.



Technical Requirements for Industrial Filtration Solutions

To operate reliably under real process conditions, filtration systems must meet several requirements simultaneously. A media-oriented design is crucial, taking filtration, cake washing, dewatering, automation and safety requirements into account as an integrated whole.

Key requirements include:

- Controlled and closed media handling
- Reproducible process conditions despite fluctuating feed characteristics
- High mechanical robustness against abrasive media
- Efficient and controllable cake washing
- Minimization of emissions and exposure
- Scalability from pilot to production scale



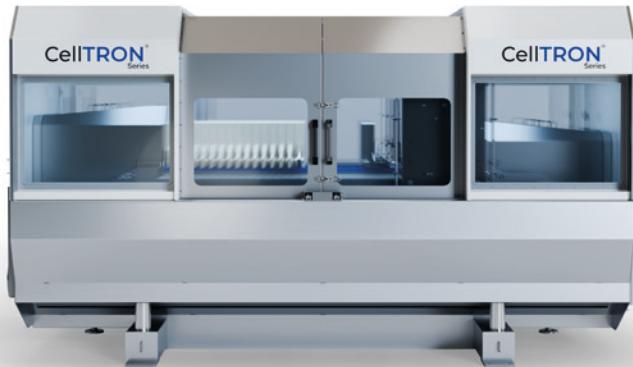
In addition, filter media and filter plates must be specifically designed for hydrometallurgical applications in order to ensure high filtrate quality and dewatering performance, as well as stable cycle times and reproducible filter cake structures.

The decisive factor is not the individual component alone, but the interaction of system design, control technology and process control. This applies from pilot scale, where media behavior and process parameters are validated, through to industrial scale-up.



Closed Filter Press Systems for Demanding Battery and Recycling Processes

In battery and recycling processes, it is not sufficient to view filtration solely as a conventional separation step. Particularly with fine particles, abrasive media or high purity requirements for recovered materials, the interaction of filtration, cake washing, dewatering and process control determines the overall performance of the plant.



Efficient cake washing plays a central role. High washing efficiencies require not only suitable filter media, but also an in-depth understanding of the relevant process conditions and media characteristics. Key factors include:

- Correct sizing of the filter press
- Uniform flow through the filter cake
- Materials matched to aggressive or abrasive media
- Appropriate design of piping and media handling
- The ability to carry out different process steps within the filter press (e.g. cake washing, post-treatment and drying)
- Suitable automation and control technology

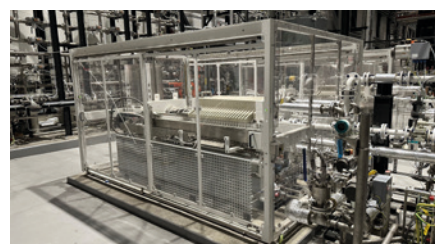
Only the coordinated interaction of these factors enables stable and reproducible results on an industrial scale.



Closed filter press systems offer additional advantages, particularly with regard to process control, occupational safety and plant stability. Key features include:

- Complete enclosure of the plant
- Defined and controlled media handling
- Reduced operator exposure
- Stable process conditions even with varying media
- High plant availability in continuous operation

This allows process stability and occupational safety to be improved in a targeted manner.





MSE CellTRON Series

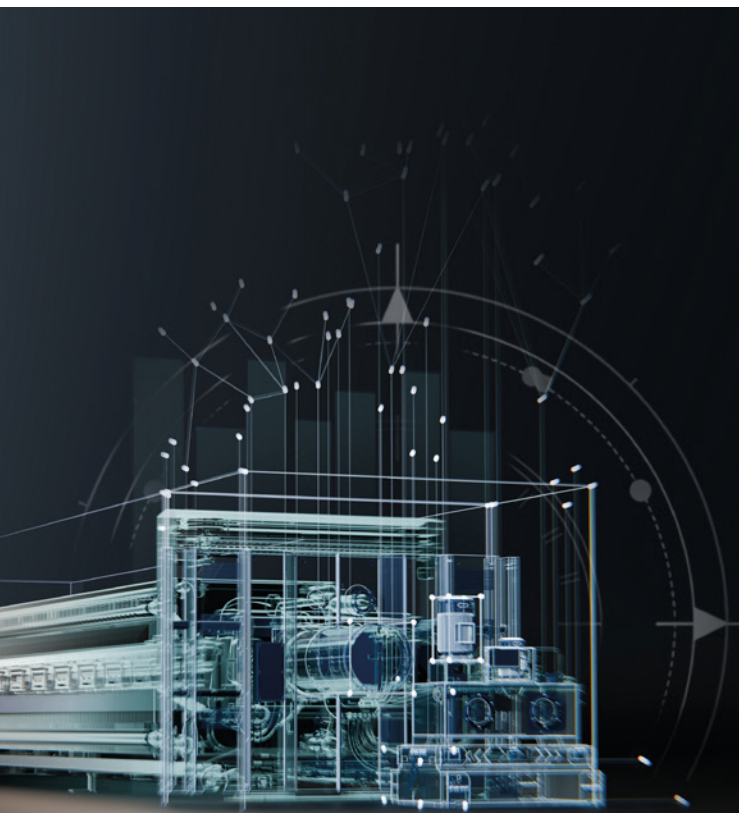
With the CellTRON series, MSE offers a filter press system specifically designed for battery and metal recycling processes. MSE does not view the filter press as an isolated component, but as a media- and process-oriented part of the entire process chain.

MSE contributes more than 40 years of experience in solid-liquid separation and extensive project expertise in the battery sector. Since 2018, the company has been developing solutions together with well-known industry players for different applications across the entire battery life cycle.

The systems are frequently engineered on a project-specific basis to accommodate different media characteristics, process parameters and capacity requirements.

Technical features:

- Fully enclosed plant concept
- Integrated CIP cleaning systems
- Robust design for abrasive media
- Flexible process control within the filter press
- Scalable from pilot scale to industrial plant
- Designed for high availability in continuous operation



AI:PureLogic

Filtration can also be further optimized using adaptive control systems. AI:PureLogic enables dynamic adjustment of:

Pressure
profiles

Washing
cycles

Filling
behavior

Cycle
times

Filter cloth
condition

Real-time analysis of process data enables filtration and washing processes to be continuously stabilized and configured for reproducible operation.



Validated Performance Data from Battery Processes

The following results are based on real applications and more than 100 trials conducted in battery and recycling processes at both pilot and production scale:

	Black Mass Filtration after Leaching	NMC Precipitation Filtration	Impurity Precipitation	Downstream Battery Production (Graphite)	Upstream Battery Production (CAM Precursor)
Throughput (l/m ² /h)	551	608	—	—	—
Filter cake production (kg/m ² /h)	147	139	—	—	—
Dry solids content in the filter cake (%)	>70	>60	>55	>68	>94
Filtration (°C)	up to 80 °C	up to 80 °C	up to 80 °C	up to 80 °C	up to 80 °C
Plant availability (%)	>98	>98	>98	>98	>98
TSS in the filtrate (ppm)	<100	<90	<150	<50	<200
Cake washing efficiency (%)	>97.3	>97.3	>97.3	—	>99
Washing liquid ratio	3:1	3:1	3:1	—	4:1
Key feature	High process stability with fine particles				

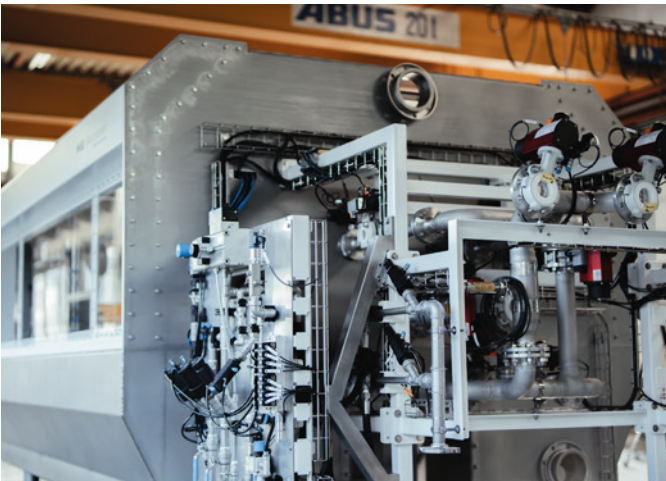
*Cake washing efficiency based on soluble impurities;
wash liquid requirement expressed as the ratio of wash volume to filter cake pore volume.*

Recovery Rates of Up to 96 %

In customer projects, MSE filter presses have achieved metal recovery rates of up to 96%. Filtration is the decisive upstream step: only material that is reliably retained in the filter cake is available for the subsequent recovery stages. In terms of purity and performance, the recovered materials can be comparable to primary materials and, in individual applications, may even exceed them.

The decisive factor is the combination of high cake washing efficiency, stable process control and reproducible dewatering performance. Alternative machine concepts such as centrifuges, belt filters or drum filters reach process-related limitations when handling fine, difficult-to-filter particles. Due to their design, they can only provide the combination of high dry solids content, controlled cake washing and closed process operation to a limited extent.

These results demonstrate that stable and reproducible filtration with high recovery rates can be reliably achieved even under the most demanding media conditions.





Filtration as the Stability Anchor of Modern Recycling Processes

Efficient battery recycling requires process steps that function reliably even under variable conditions and economically support the recovery of strategically important raw materials.

Filtration plays a key role in this:

- **It stabilizes downstream processes**
- **It reduces operating costs**
- **It increases plant availability**
- **It improves occupational safety**

Systems that treat filtration as an integrated and controlled process therefore make a decisive contribution to the economic and safe scale-up of recycling plants, while strengthening the foundation for an industrial circular economy in the battery sector.

Next Step

If filtration plays a critical role in existing or planned processes, a targeted analysis of the process parameters is worthwhile – including pilot trials with your original slurry at the MSE technical center. This allows system design and scale-up to be validated using the actual process medium.



**Request a non-binding process
analysis or pilot trial**
mse-filterpressen.com