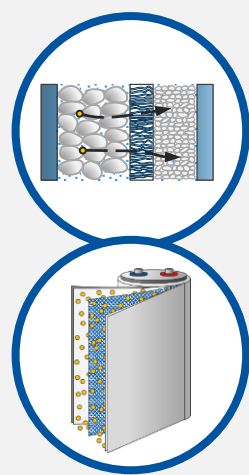
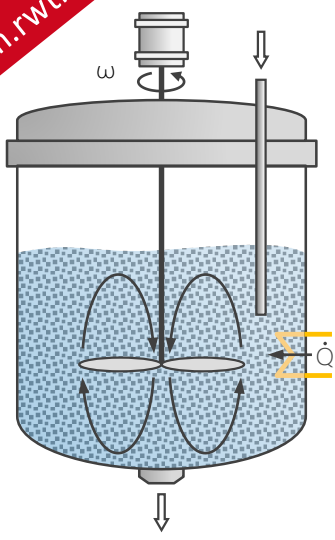


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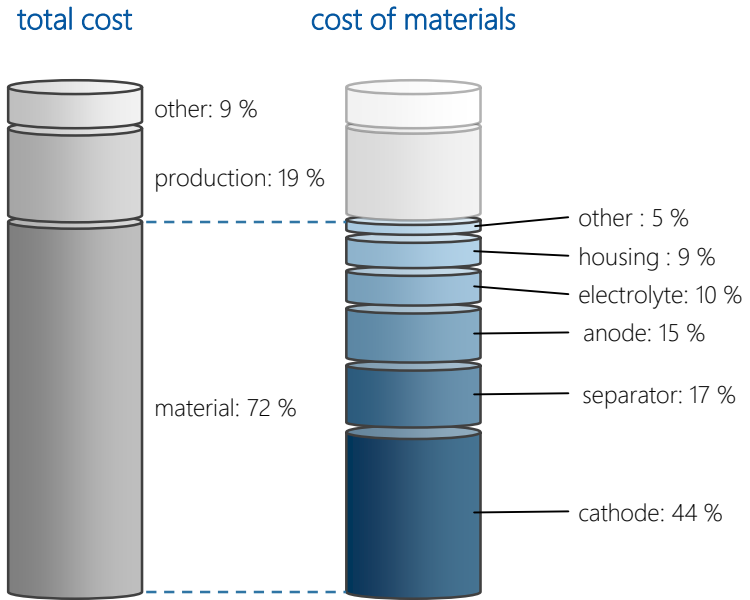
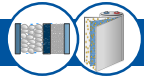


Manufacturing of lithium-ion battery cell components



In cooperation with:





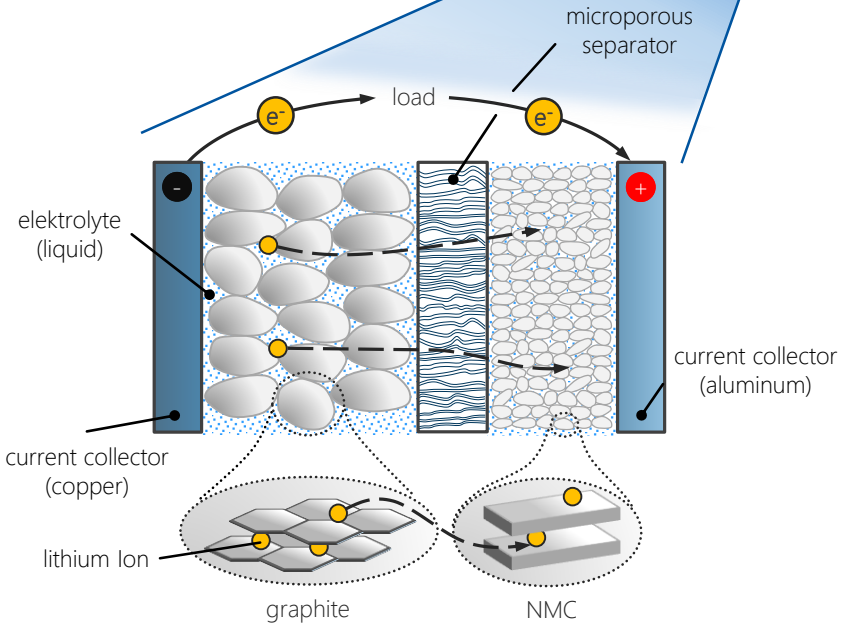
Costs

- With up to 50% of the total cost, the **battery** is the most expensive component of an electric vehicle. Therefore, the success of electric mobility is essentially determined by the price of the battery.
- One way of making the battery more powerful, more energetic and thus more successful is to use high-quality **component materials**.
- In the manufacturing of lithium-ion battery cells, **material costs** account for the majority of total battery costs.
- With 44% of the material costs, the **cathode material** is the most expensive component of the battery cell.
- With a material cost share of 17%, the **separator** also has a significant influence on total costs.

The following pages focus on the manufacturing processes of the active materials and the electrolyte. Subsequently, the electrode foil, the separator and the cell housing production are described.

Active Materials

Chapter overview



cathode

anode

electrolyte

The battery cell

- A battery cell consists of a **positively** and a **negatively** charged **electrode**, a separator and an **electrolyte solution**.
- The **positive electrode (cathode)** consists of a 15 - 25 μm thick aluminum foil as current collector, the active material (e.g. Lithium-Nickel-Manganese-Cobalt-Oxide - NMC) and additives.
- The **negative electrode (anode)** consists of an 8 - 18 μm thick copper foil, which is coated with active material (graphite) and additives.
- Both electrodes are electrically isolated from each other by the **separator**.
- After the cell assembly, the battery cell is filled with the **electrolyte**. Sufficient electrolyte wetting of the active materials and the separator is particularly important to ensure a high ion flow.

Function of the active material

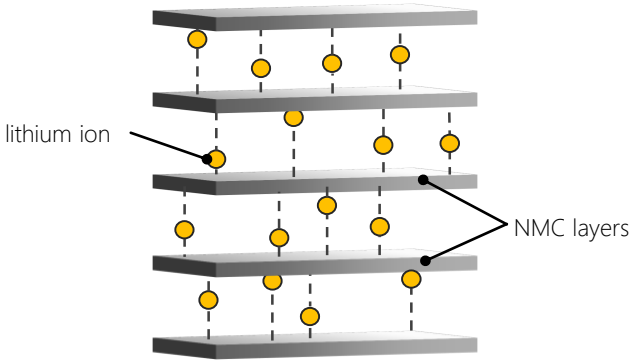
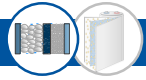
- Storage of the Li ions
- Absorption of the electrolyte solution

Function of the electrolyte

- Li ion conductivity

Cathode material

NMC precursor manufacturing



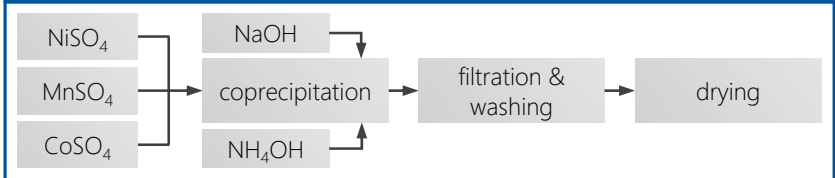
precursor production

solid state synthesis

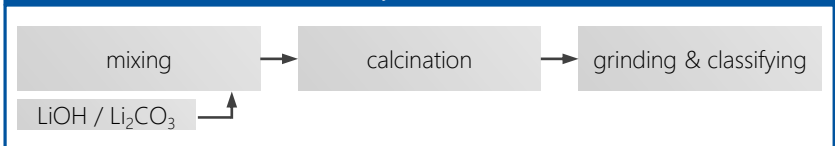
post-treatment

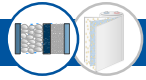
The figure above shows the layered NMC with embedded lithium ions. In the following, the production steps for manufacturing the **nickel-manganese-cobalt-cathode material** are illustrated. NMC is mainly produced industrially in a two-stage process, which is divided into three sub-processes: precursor production, solid state synthesis and post-treatment. The precursor can be synthesized either via the carbonate or the hydroxide process route. Due to the higher industrial relevance of the hydroxide precursor, it will be further discussed as an example.

preparation of the hydroxide precursor



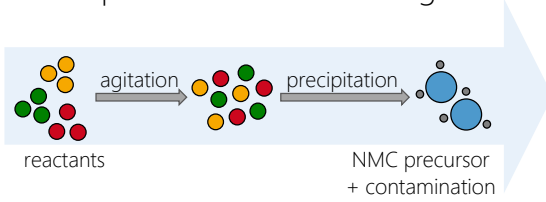
solid state synthesis to Li-NMC



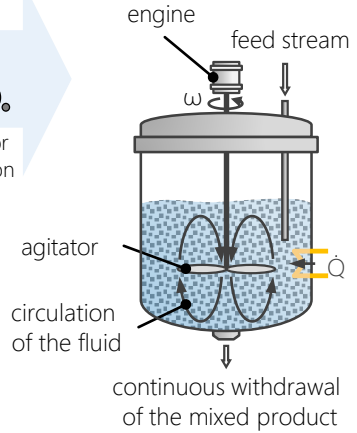


Cathode material

NMC precursor manufacturing



The process can be run either **continuously** or in **batch mode**. Despite a complex process control, a continuously operating reactor (**Continuously Stirred Tank Reactor**) delivers more consistent product quality.



coprecipitation

post-processing

Process steps

- Before coprecipitation, separate solutions contain the three starting materials nickel sulphate, manganese sulphate and cobalt sulphate.
- The starting materials must be of high **purity**, since impurities will form electrochemically inert phases and interfere with the transportation of lithium ions. This reduces the **reversible capacity** of the battery cell.
- The solutions are combined according the desired **material quantity ratio** of nickel, manganese and cobalt.
- A **precipitation reaction** takes place in the reactor while stirring rapidly, thereby reducing the risk of metal hydroxides precipitating independently from each other.

Process parameter

- Purity of the educts
- pH value: 11 - 12
- Stirring speed: 1.000 rpm
- Temperature: 35 - 80°C

Quality characteristics

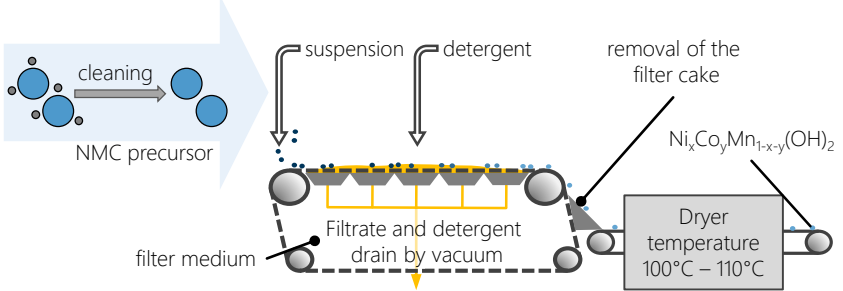
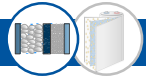
- Homogeneity
- Agglomerate formation
- Purity
- Gas inclusions
- Viscosity
- pH

Measuring and testing technology

- Residual moisture balance, laser scattering, X-ray diffraction (XRD), opt. emission spectrometry with inductively coupled plasma (ICP-OES)

Cathode material

NMC precursor manufacturing



After synthesis in the reactor, the NMC is present as a **heterogeneous mixture of substances**. In order to be able to process the precursor further according to the process principle of the solid state reaction, the substance must be **filtered, washed and dried**.

coprecipitation

post-processing

Process steps

- The suspension from the coprecipitation is placed on a **belt filter** to separate the NMC precursor from the suspension.
- The NMC precursor (filter cake) remaining on the belt filter is contaminated with lye from coprecipitation.
- To clean the filter cake and remove the remaining lye, a **detergent** is applied to the filter cake from above and sucked off again with the suspension liquid under the belt filter.
- During the drying process, the filter cake is continuously dried at a temperature of approx. 110 °C.
- As an alternative to separation with a belt filter and the subsequent dryer, a **spray dryer** can be used, which first atomizes the suspension and then dries it in a hot gas stream.

Process parameter

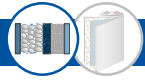
- Temperature during drying: 100 – 110 °C
- Pore width filter
- Detergent

Quality characteristics

- Residual moisture
- Particle morphology
- Purity

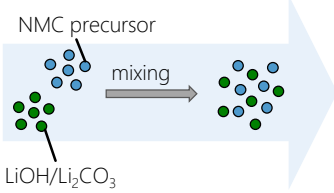
Measuring and testing technology

- Residual moisture balance, scanning electron microscopy (SEM), opt. emission spectrometry with inductively coupled plasma (ICP-OES)

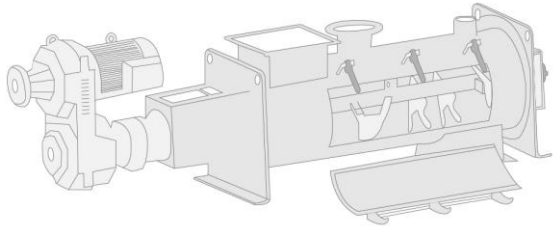


Cathode material

NMC solid state synthesis



ploughshare mixer



mixing

calcination

grinding

Process steps

- The two alternative starting materials for this process step, **lithium hydroxide** and **lithium carbonate**, are both available as solids. Therefore, the usage of intensive mixers in the dry mixing process is ideal.
- In the following, an almost complete **deagglomeration** of the raw materials plays an important role. A **defined fineness** or **large specific surface** of the starting materials must be guaranteed by their manufacturing processes in order to achieve a high reactivity of the later battery cell.
- Ploughshare mixers with knife heads are often used as **intensive mixers**. These have **machine linings made of ceramic, plastic or hard metals** to ensure iron-free synthesis conditions.
- A part of the lithium evaporates in the following step due to temperature treatment and must be compensated by a slight **lithium excess** of 5 - 10 % in the mixing process.

Process parameter

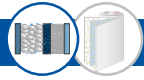
- Stoichiometry Li to NMC: 1,05 – 1,10
- Particle size: a few micrometers
- Stirring speed
- Iron-free synthesis conditions

Quality characteristics

- Particle size
- Uniformity of particle shape
- Purity
- Particle morphology

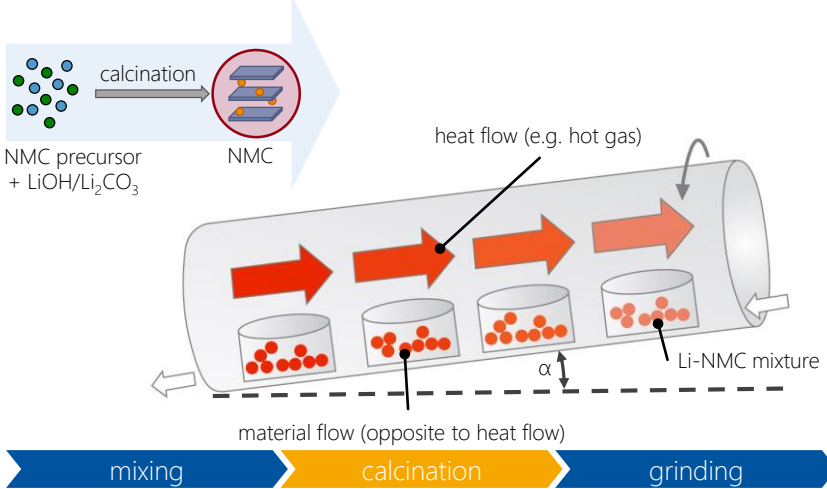
Measuring and testing technology

- Residual moisture balance, scanning electron microscopy, X-ray diffraction, opt. emission spectrometry with inductively coupled plasma (ICP-OES)



Cathode material

NMC solid state synthesis



Process steps

- **Calcination** is particularly important for the overall process, producing the final chemical composition of the NMC.
- In a **continuous furnace**, the Li-NMC is transported through the furnace in continuous rows in **ceramic batch containers**.
- The **temperature** significantly determines the particle size and influences the mobility of free electrons, crystal growth and the proportion of undesired side reactions, such as the evaporation of lithium.
- **Evaporation** absorbs large amounts of heat, resulting in the formation of temperature gradients. The **heating rate** of the furnace is deliberately kept low in order to prevent uneven temperature distribution.
- The purity of the final product can be influenced by the **reaction atmosphere**. The homogeneity of the atmosphere is directly reflected in the final product.

Process parameter

- Temperature: 800 - 1.000°C
- Homogeneity of the reaction atmosphere
- Temperature profile
- Reaction time: depending on NMC stoichiometry

Quality characteristics

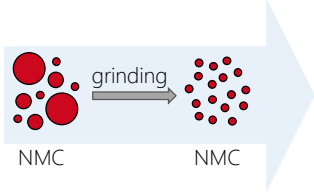
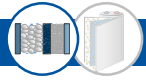
- Particle size
- Homogeneity
- Crystal structure
- Side reactions
- Purity
- Substance ratio

Measuring and testing technology

- Residual moisture balance, scanning electron microscopy, X-ray diffraction, opt. emission spectrometry with inductively coupled plasma (ICP-OES)

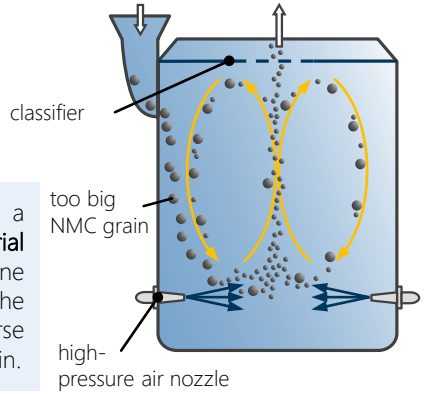
Cathode material

NMC solid state synthesis



The **continuous air flow** creates a circulation of the **grinding material** within the jet mill. Sufficiently fine powder passes through the sieve in the upper part of the mill, while too coarse grains fall back into the air stream again.

addition and removal of the grinding material



mixing

calcination

grinding

Process steps

- During calcination, the formation of larger **solid particles** is possible. These must be **ground** and **classified** in the subsequent step in order to produce a fine powder with homogeneous size distribution, which is required for further processing.
- The application of fine grinding is ideally carried out by an **air jet mill**, which can efficiently grind the material to be ground with a strongly accelerated gas flow.
- The NMC grains are accelerated to high speeds and shred through **collisions**.
- During **classification**, the ground NMC is sorted according to grain size. Grains that are too large fall back into the grinding process again, while grains of a defined size can pass through the classifier.

Process parameter

- Gas used: air
- Speed: 300 m/s
- Particle size: a few micrometers

Quality characteristics

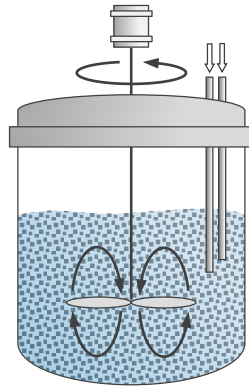
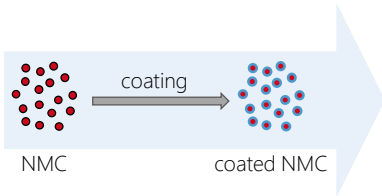
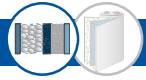
- Particle size
- Particle size distribution
- Uniform particle shape
- Particle morphology

Measuring and testing technology

- Residual moisture balance, scanning electron microscopy, X-ray diffraction, opt. emission spectrometry with inductively coupled plasma (ICP-OES)

Cathode material

NMC post-treatment



coating

Process steps

- After fine grinding, the cycle stability of the cathode material can be increased by **post-treating** the NMC particles.
- Suitable **coatings** for this include NMC particles with **ceramics**.
- The coatings can be applied by **wet chemical** or **chemical vapour deposition processes**.
- After the wet-chemical process, the coated NMC material must be **dried**.

Process parameter

- Coating material
- Coating thickness
- Coating processes

Quality characteristics

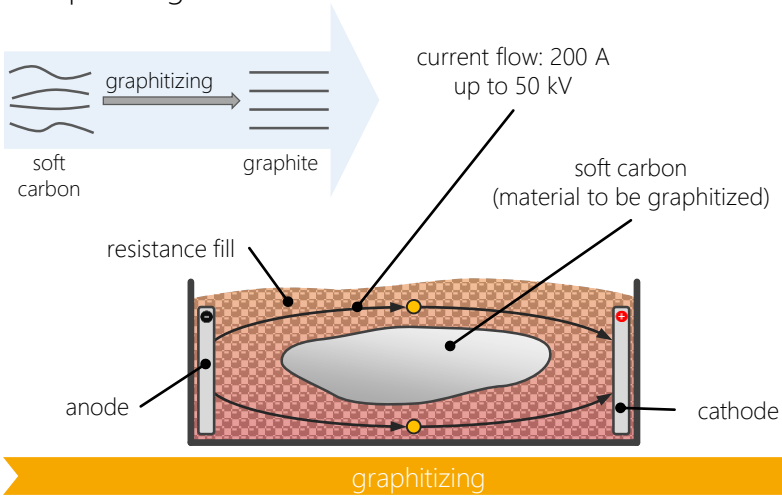
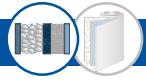
- Particle size
- Particle size distribution
- Uniform particle shape
- Particle morphology
- Homogeneous particle coating
- Purity of the particle coating

Measuring and testing technology

- Residual moisture balance, scanning electron microscopy, X-ray diffraction, opt. emission spectrometry with inductively coupled plasma (ICP-OES)

Anode material

Graphitizing



Process steps

- First, coke and pitch are mixed as starting materials at $> 200\text{ }^{\circ}\text{C}$ in an intensive mixer or kneader.
- In the **Acheson furnace**, the mixture is graphitized and forms its typical **graphite structure** in an arrangement of graphene layers.
- The soft carbon is surrounded by a **resistance bulk** (e.g. granular coke). When a current is applied, a great deal of heat develops due to the electrical resistance.
- High purities can be achieved by thermal or thermochemical modification of the process.
 - **Thermal**: The temperature and dwelling time are increased so that all impurities can evaporate.
 - **Thermochemical**: Additives convert the impurities into volatile compounds and diffuse from the graphite.

Process parameter

- Temperature: $1.800 - 3.000\text{ }^{\circ}\text{C}$
- Dwell time: a few hours to several weeks
- Voltage: e.g. $40 - 50\text{ kV}$
- Current: e.g. 200 A

Quality characteristics

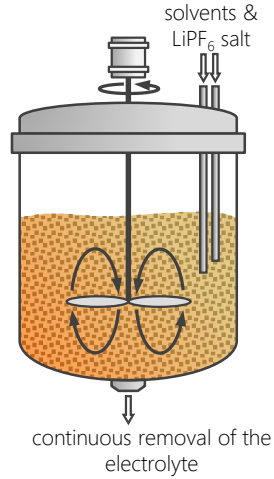
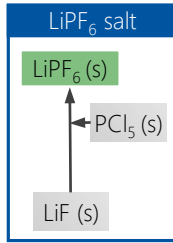
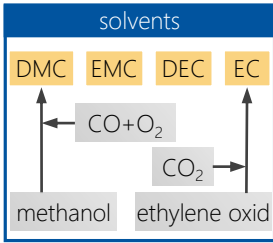
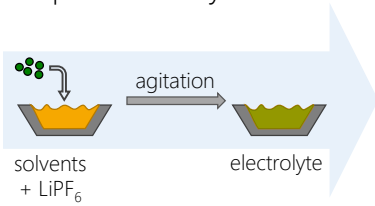
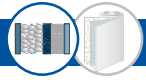
- Purity
- Particle shape
- Particle size
- Homogeneity
- Surface texture

Measuring and testing technology

- X-ray diffraction (XRD), Raman, porosimetry, opt. emission spectrometry with inductively coupled plasma (ICP-OES)

Electrolyte

Liquid electrolyte



liquid electrolyte production

Process steps

- The electrolyte consists of a conductive salt (e.g. lithium hexafluorophosphate (**LiPF₆**)) and a solvent (e.g. dimethyl carbonate (**DMC**), ethylene carbonate (**EC**), diethyl carbonate (**DEC**) or ethyl methyl carbonate (**EMC**)). These are brought together in the reactor.
- LiPF₆ is the most important component of the electrolyte as a conductive salt and accounts for the main share of the costs.
- Additives (e.g. vinylene carbonate (**VC**)) improve the **long-term stability** of the battery.
- Impurities with water will cause a **decomposition reaction** of LiPF₆. Residues and the formation of water must be avoided.

Process parameter

- Salt concentration: 0.8 - 2 mol/L
- Typical composition:
 - Salt: 12.6 wt%
 - Additives: 0 - 10 wt%
 - Solvent: approx. 85 wt%

Quality characteristics

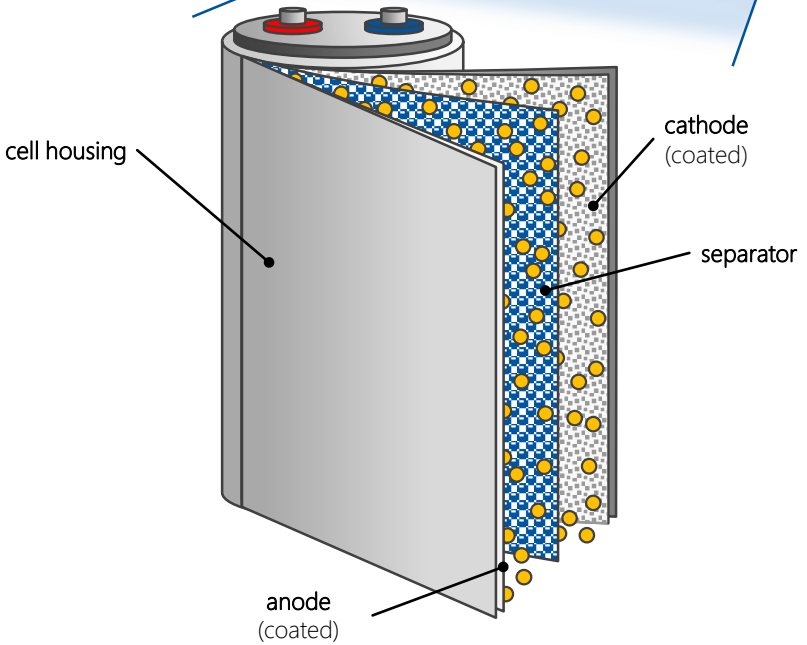
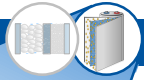
- Ionic conductivity
- Water content
- Temperature stability
- Purity of the raw materials
- Purity of the end product

Measuring and testing technology

- Gas chromatography with mass spectrometry coupling (GC-MS), opt. emission spectrometry with inductively coupled plasma (ICP-OES)

Inactive materials

Chapter overview



electrode foils

separator

cell housing

In the following, the production steps for manufacturing the **electrode foils**, the **separator** and the **cell housing** of a round or prismatic cell as well as a pouch cell are explained. The figure above depicts a cut-open round cell with a direct view of the cathode, anode and separator.

Function of the separator

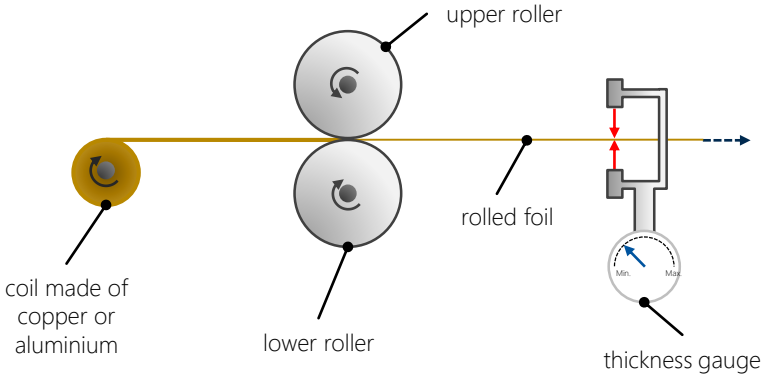
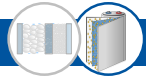
- Electrical insulator
- Enabling ion transport
- Absorption of the electrolyte solution
- Shutdown function (a fuse against thermal leakage)

Function of the cell housing

- Mechanical protection of the cell interior against external influences
- Avoidance of electrolyte leakage
- Avoidance of chemical reactions with the environment

Electrode foil production

Rolling process



rolling process electrode foil production

Process steps

- The copper or aluminum foil is rolled to a defined thickness by a **continuous rolling process**.
- The upper and lower rollers are arranged opposite to each other and compress the film to the desired thickness with a **defined line pressure**.
- **Line pressure** and **feed speed** of the foil are kept **constant** during the rolling process in order to achieve uniform compaction.
- To increase accuracy and reproducibility, the thickness of the film is measured after rolling.
- The **cleanliness** of the rolls is decisive for later processing, as foreign particles can lead to **surface damage**.
- The rollers and the foil can be cleaned by **suction** (in combination with compressed air) or by **brushing**.

Process parameter

- Constant feed rate
- Constant line pressure
- Roll diameter

Quality characteristics

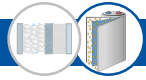
- Surface finish
- Impurities
- Uniform film thickness
- Surface roughness of the rolls

Measuring and testing technology

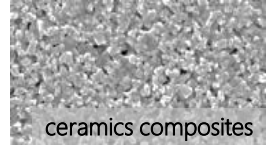
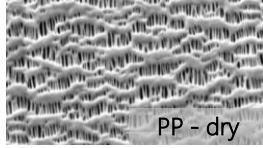
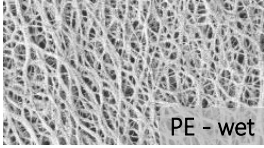
- Optical inspection, thickness measurement, scanning electron microscopy (SEM)

Separator

Overview



Separator types



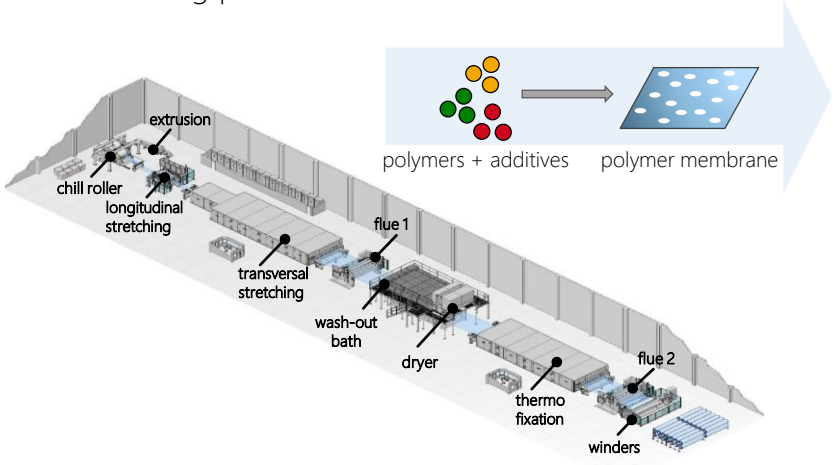
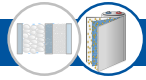
Several technologies exist for the production of microporous separators, which differ with regard to raw materials and production techniques. The manufacturing processes are shown in the following overview. The procedures commonly used in the industry are explained below.

manufacturing process subsequent processing

material	PE			PP			composite
type	wet		wet dry	dry			PET fleece + ceramic
cast process	chill roll	chill roll	chill roll	blown film	chill roll	chill roll	spinning fiber
stretching process	simultaneous biaxial	sequentiell biaxial	sequentiell biaxial	monoaxial	monoaxial	sequential biaxial	---
process steps							

Separator

Manufacturing process











wet process

dry process

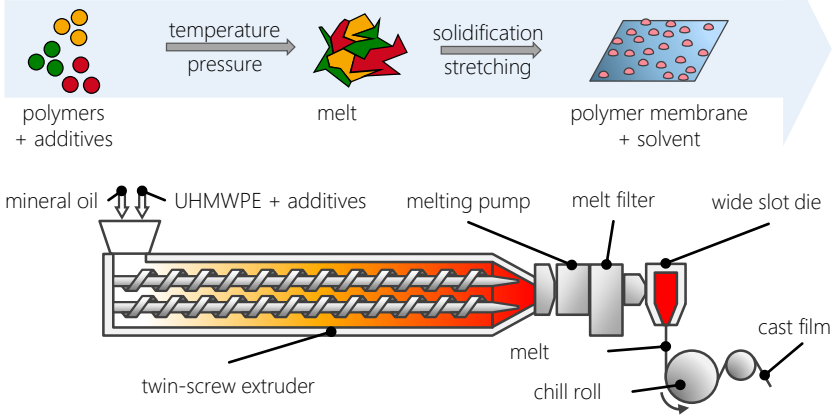
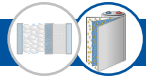
The wet process based on PE is the most common manufacturing process. The lines are up to 110 m long and can produce the separator foil with a working width of up to 5.5 m.

The wet process can vary, generally consisting of the process steps shown below:

- Extrusion  mixing ratio raw materials
temperature: 200 – 240 °C
- Cast film process  cooling
temperature: 20 – 40 °C
- Biaxial stretching  stretching ratio typ. 6x6
temperature: 100 – 130 °C
- Extraction  solvents
- Drying 
- Thermo fixation  temperature: 120 – 140 °C
- Removal / quality control 
- Rewind 

Separator

Wet process



extrusion

cast film

biaxial stretching

Process steps



- Mixtures of HDPE (high density polyethylene) or UHMWPE (ultra high molecular weight polyethylene), low molecular weight waxes or mineral oils as plasticizers, as well as some additives are used as **starting materials** for the **wet process**.
- The mixture is dosed in a co-rotating **twin-screw extruder**, where it is **homogenised and melted** by heat and shear. A **melt pump** generates a constant, high pressure with which the melt is conveyed to the **wide slot nozzle**.

extrusion

cast film

biaxial stretching

Process steps



- The **melt emerging** from the slot die **solidifies** through contact with the chill roll to form the cast film. An even cooling over the working width and circumference is crucial.

extrusion

cast film

biaxial stretching

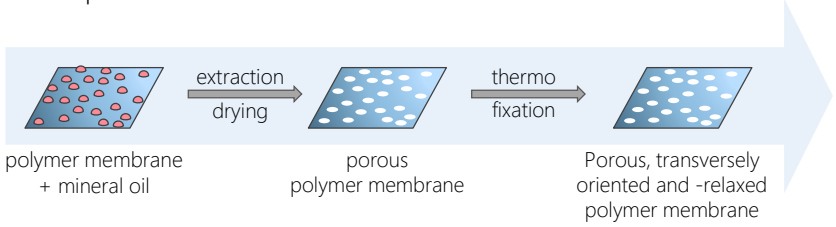
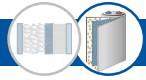
Process steps



- In **biaxial simultaneous stretching**, the film edges are held by clips whose spacing increases both in the **running direction** and **at right angles** to it.
- **Biaxial sequential stretching** involves stretching first in the **longitudinal direction** by rollers and then in the **transverse direction** by clips.

Separator

Wet process



Process steps



- The aim of the **extraction** is to wash out stains of mineral oil from the extruded, stretched film. The released molecules leave pores behind, creating the **microporous structure**.
- **Solvent alternatives** are chlorinated and fluorinated hydrocarbons. The most common is **DCM** (dichloromethane).
- For an economic production, a large **recycling** of the DCM and the mineral oil is necessary, which get reintroduced into the process.



Process steps



- Directly after the extraction the DCM is **dried** and removed from the pores by evaporation.



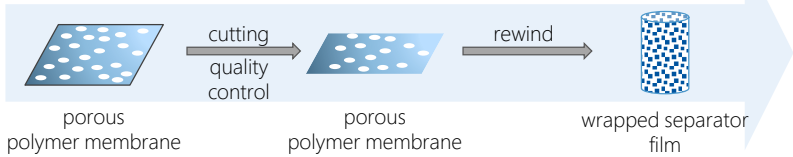
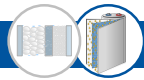
Process steps



- The film is fixed at the edges by retaining clips and passed through a further **stretching furnace** in order to carry out cross-stretching and cross-relaxing in **different temperature zones**.

Separator

Wet process



Process steps



- The separator foil, after leaving the heat setting, is trimmed at the edges in a **take-off stand** and undergoes an **inline quality control** (thickness, optical defects, etc.).



Process steps



- The final working step consists of a **controlled winding**, which usually takes place on a winder with a full **working width of max. 5.5 m**.

Quality-determining process parameters

- Homogeneity and purity of raw materials
- Temperature control quality
- Speed constancy
- Thickness control
- Tidiness
- Winding quality

Quality features membrane

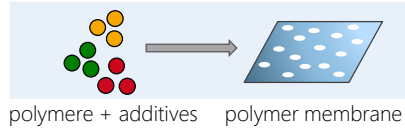
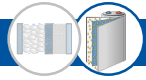
- Homogeneous film thickness and pore size distribution
- Electrolyte wettability

Measuring and testing technology

- Thickness, tensile test, puncture test, breakdown voltage
- Hg porosimetry, scanning electron microscopy, air permeability test according to Gurley
- Shrink measurement, DSC, TMA, Hot-Tip Test
- Ion conductivity, electrolyte wetting
- Optical inspection

Separator

Manufacturing process



wet process

dry process

In the drying process, the semi-crystalline thermoplastics PP or PE are used as starting materials.

The process steps explained below can also vary during the drying process.

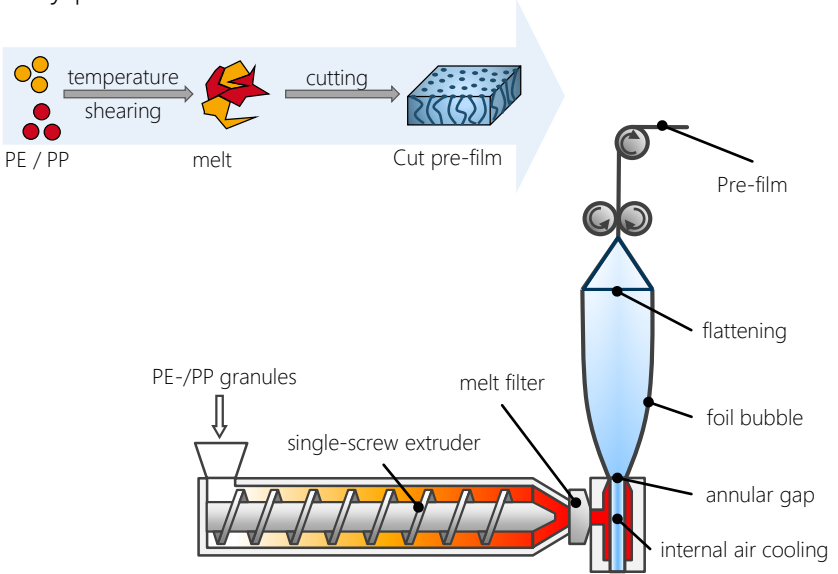
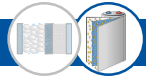
- Extrusion  extrusion temperature
- Cast film process 
- Blown film process  inflation ratio
- Cutting 
- Laminating 
- Longitudinal stretches  stretching parameters
- Biaxial stretching  stretching parameters
- Removal / quality control 
- Rewind 

Measuring and testing technology

- Thickness, tensile test, puncture test, breakdown voltage
- Hg porosimetry, scanning electron microscopy, air permeability test according to Gurley
- Shrink measurement, DSC, TMA, Hot-Tip Test
- Ion conductivity, electrolyte wetting
- Optical inspection

Separator

Dry process



extrusion

blown film process

cutting

Process steps



- In a single-screw extruder, the PE/PP granulate is **melted** and homogenised by heat input and shearing.

extrusion

blown film process

cutting

Process steps



- In the drying process, there is an alternative **cast film** and **blown film process**.
- In the blown film process, the melt is pressed through an **annular gap** to form a **tube**. Air flows through it from the inside, which results in a cooling from the inside as well as the outside.

extrusion

blown film process

cutting

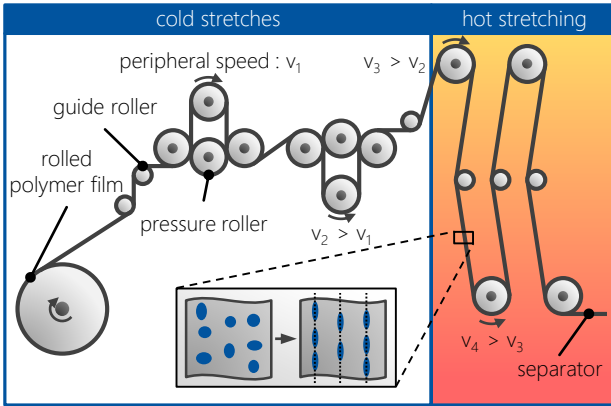
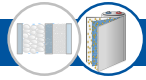
Process steps



- After rewinding, the pre-film is transferred batchwise to narrower rolls on a **cutting machine**.

Separator

Dry process



Process steps



- The roll goods are **laminated together** in a subsequent step with **several layers** under **pressure** and high **temperature**. Thus a „tri-layer“ structure PP / PE / PP can be created.



Process steps



- In order to create a pore structure, it is necessary to arrange **lamellae** in rows perpendicular to the machine direction. This structure is created by a 2-step stretching process.
- In **longitudinal stretching**, the stretching process is realized by different roll speeds at different temperatures.
 - **Cold stretching**: Initiation of pore growth
 - **Hot stretching**: production and enlargement of pores
- After stretching, the separator is then **thermofixed** using heated rollers in order to reduce the shrinkage values.



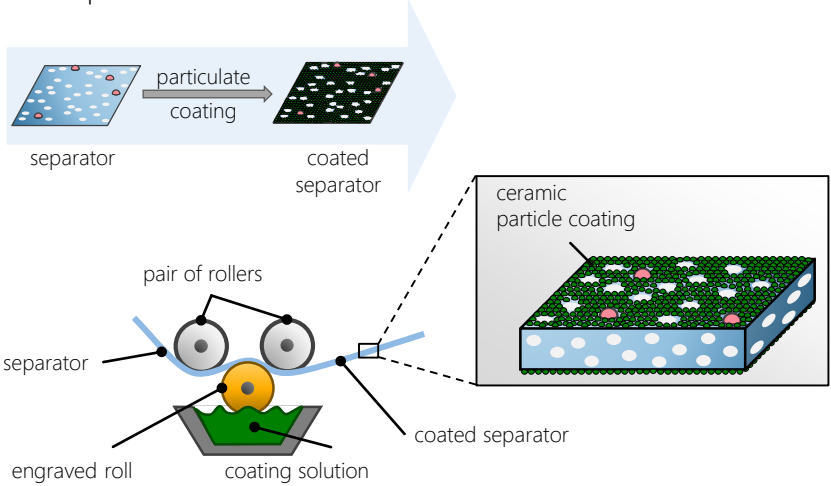
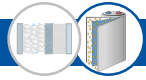
Process steps



- The separator is **trimmed at the edges** and an inline quality control (thickness, optical defects, etc.) is carried out.
- The separator is then **wound up**.

Separator

Composite membrane



All wet or dry PP and PE separators can be coated with functional materials to improve thermal stability or laminability. A ceramic coating or impregnation of PET nonwovens is also used for the production of high-temperature-resistant separators.

particle synthesis

coating

Process steps

- The **ceramic particles** of aluminum oxide (Al_2O_3), aluminum oxide hydroxide (AlOOH) or SiO_2 are produced from the respective metal chloride by a **thermal process** at high temperatures.
- A suspension of ceramic particles and binder is applied to the separator foil by an **engraving roller**.
- After the coating, which can be applied on one or both sides, **drying** is required.

Process parameter

- Duration for particle synthesis
- Choice of binder
- Hardness of the anilox roll
- Anilox roller cleaning cycle
- Temperature profile drying

Quality characteristics

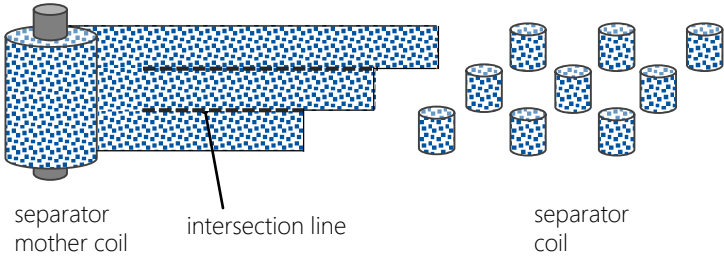
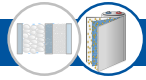
- Particle size distribution
- Particle shape
- Wettability
- Homogeneity coating
- Coating thickness

Measuring and testing technology

- Thickness measurement, optical inspection, scanning electron microscopy (SEM), contact angle, Gurley measurement, shrinkage measurement, porometer, adhesion test, electrolyte absorption/wettability, hot tip test, hot ER test (electrolyte conductivity as a function of temperature)

Separator

Slitting



After production or coating, the separators are cut to the width required for cell production by cutting machines.

slitting separator

Process steps

- Slitting involves cutting a wide separator belt (**mother coil**) into narrower separator belts (**coils**).
- The cutting process usually requires a **primary cutting operation**, e.g. to reduce the working width from 5.5 m to 1.5 m. The primary cutting operation is usually carried out by a single operator. The **secondary cutting process** is then carried out in order to produce the width required for cell production.
- Dust and foreign particles are then removed by special **cleaning devices**.
- Important quality criteria are the **cutting quality** of the resulting edges and the **cleanliness** of the separator web.

Process parameter

- Cutting speed
- Cutting width
- Winding tensions

Quality characteristics

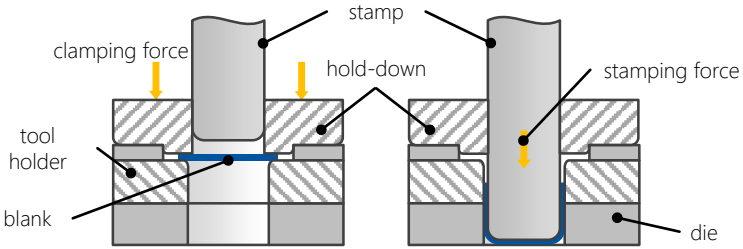
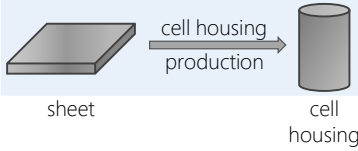
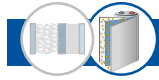
- Burr formation
- Degree of contamination
- Cutting edge geometry
- Web edge accuracy

Measuring and testing technology

- Optical inspection, scanning electron microscopy (SEM), thickness measurement, ultrasonic sensor technology, length and width determination

Cell housing manufacturing

Round cell / Prismatic cell



deep drawing

washing/drying

testing

Process steps

- **Deep drawing** is a tensile compression forming process in which sheet metal blanks are pressed into a hollow body open on one side. Due to a simple process control, this process is particularly suitable for mass production. The investments in machines and tools are especially high.
- The raw material is pressed through a die with a **stamp** to create a round or prismatic housing. This procedure is repeated in several stations with different tool geometries (punch and die) until the desired shape of the finished housing is created.
- Following the last deep drawing step, the excess material is cleanly separated at the upper end.
- Finally, the housing is **washed, dried** and **tested**.
- **Backward extrusion** can also be used as an alternative to cell housing production.

Process parameter

- Component format (round or prismatic)
- Component size (height)
- Material
- Sheet thickness
- Forming force
- Drawing speed

Quality characteristics

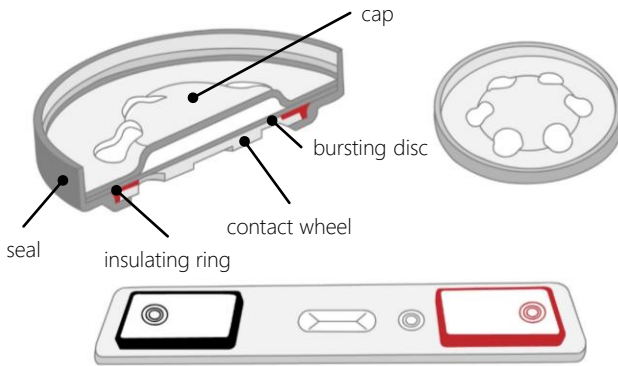
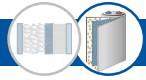
- Dimensional accuracy
- Uniformity of wall thickness
- Edge condition
- Surface finish
- Tidiness
- Residual particles
- Stress in the material

Measuring and testing technology

- Optical testing, eddy current test, pressure test, leak test

Production of cell lids

Round cell / Prismatic cell



component manufacturing

assembly

checking

Process steps

- The individual components of a cover assembly consist of **metallic components** as well as **plastic components**. The metallic components are produced by stamping, fine blanking, cold forming, deep drawing, etching or friction welding, some of which are subsequently galvanised. The injection moulding process is used for plastic components. Due to the sensitivity of components, which have to perform safety-relevant tasks in the assembly, some components are also provided in taped form or oriented in special component carriers for assembly.
- The **assembly** of a lid module is partly carried out in clean rooms with **fully automated systems**. In addition to handling the individual components of a lid assembly, assembly processes such as laser welding, riveting and dosing of sealants are used. Various components include Poka-Yoke elements to guarantee error-free assembly.
- **Optical and electrical tests** are carried out during and after assembly. Leak tests of laser welded joints are also required.

Process parameter

- Cover assembly size
- Accuracy of fit of the components
- Number of components
- Assembly speed

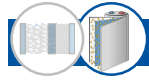
Quality characteristics

- Tidiness
- Residual particles
- Geometric dimensional accuracy
- Tightness

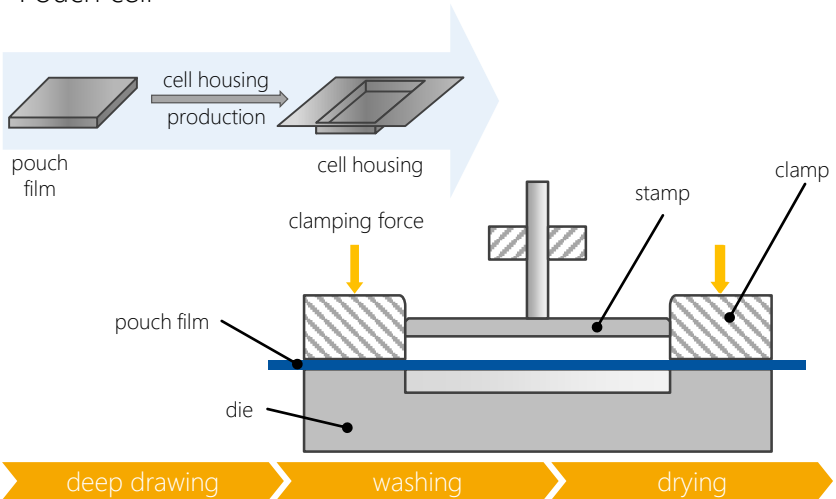
Measuring and testing technology

- Optical test, leak test, electrical resistance test, electrical breakdown test

Cell housing manufacturing



Pouch cell



Process steps

- The **pouch film** consists of a **plastic composite film**. **Polyamides** and **polypropylene** are used as plastics. **Aluminum** serves as a diffusion barrier for water and the electrolyte.
- The pouch foil is supplied via a **discontinuously** working spool.
- In the press, the unwound film is held in place by two clamps with a defined **clamping force**.
- The stamp presses the foil into the **die** so that the final shape is created. The excess material is separated cleanly at the upper end.
- **Stamp force** and **stamp speed** have a significant influence on the quality of the housing.

Process parameter

- Stamp size
- Stamp shape
- Die height
- Clamping force
- Compressive force
- Stamp speed

Quality characteristics

- Surface finish
- Impurities
- Uniformity of wall thickness
- Cracks in the material
- Edge condition
- Film thickness

Measuring and testing technology

- Optical testing, leak test



Batterieproduktion

The PEM of RWTH Aachen University has been active in the area of lithium-ion battery production for many years. The field of activity covers automotive as well as stationary applications. Through a multitude of national and international industry projects with companies throughout the entire value chain as well as leading positions in notable research projects allow PEM to offer a broad range of expertise.

The German Mechanical Engineering Industry Association (VDMA) represents more than 3200 companies in the mechanical engineering sector, which is dominated by SMEs. The battery production department focuses on battery production technology. Member companies supply machines, plants, machine components, tools and services in the entire process chain of battery production: From raw material preparation, electrode production and cell assembly to module and pack production.



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Any questions?

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Frankfurt am Main, July 2019
PEM der RWTH Aachen and VDMA,
1st Edition
ISBN: 978-3-947920-07-5