Determination of Process-Structure-Performance Correlations and Development of Alternative Production Processes by the German Cell-Production Research Cluster “ProZell”

Arno Kwade and Henrike Bockholt
Institute for Particle Technology and Battery LabFactory, TU Braunschweig
Battery Cell Production, Demand and Utilization

Global Cell Production Capacities (2013 to 2016)

Existing cell factories are fully utilized

+ Strong increasing demand of battery cells, prediction of up to 400 GWh/a in 2025

Continuous increase of manufacturing capacity is required to satisfy the demand and avoid bottlenecks

According to: Fraunhofer Institute for Systems and Innovation Research ISI
Electrode production

- Material
- pre-treatment and mixing
- coating and drying
- calendering

Cell production

- cutting and drying
- package forming
- contacting
- housing and sealing

Cell Conditioning

- electrolyte filling
- formation and aging
- electrochemical quality check
- Cells
Calculation Model for Cell Production

Influencing Factors
- cell parameters
- production parameters
- economical parameters

Calculation Model
- calculation with combined input

Results
- factory design
- cost planning

Cost of a Battery Cell

Manufacturing Cost 188,96 €/kWh

- Material 135,98 €/kWh 72,0 %
- Direct Labor 22,09 €/kWh 11,7 %
- Depreciation 15,56 €/kWh 8,2 %
- Capital 5,20 €/kWh 2,8 %
- Energy 5,70 €/kWh 3,0 %
- Other* 4,43 €/kWh 2,3 %

Material Cost dominated by exogenic factors

Production Cost accessible cost potential

* maintenance, insurance, imputed area rent

J.-H. Schünemann – Modell zur Bewertung der Herstellkosten von Lithiumionenbatteriezellen, Dissertation, iPAT Schriftenreihe, Sierke-Verlag
Electrode and Cell Production @ Battery LabFactory Braunschweig

Facts and Figures
- Battery research since 2008
- 7 institutes of TU BS and PTB
- 900 m² pilot processing area (+ 500 m² laboratories)
- 160 m² dry room
- approx. 50 researchers and technicians
Research Strategy of BMBF and BMWi
Battery Research Germany

Economically Attractive Lithium-Ion Battery Cells with Excellent Performance

Material Science
Electrochemistry

Process Engineering
Production Engineering

Application-related Technologies

Batterie 2020

6. Energieforschungsprogramm

ProZell
Competence Cluster for Battery Cell Production (ProZell)

Members

11 research projects
1 accompanying project
22 research institutes
12 locations

(5 Institutes)

(4 Institutes)

Fraunhofer

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Bundesministerium für Bildung und Forschung
Competence Cluster for Battery Cell Production (ProZell)

Aims

Superior Aim:
Long-term, holistic and profound scientific basis for erection and sustainable further development of an international competitive battery cell production in Germany and Europe
Research Aims of ProZell Projects
with specific focus on one particular process step

**Roll-it** – R2R intensive drying

**LoCoTroP** – low-cost dry coating

**Cell-Fi** – process optimization for efficient electrolyte filling

**KonSuhl** – continuous slurry processing

**MultiDis** – multiscale simulation of slurry processing

**ProKal** – modelling the calendering process

**OptiZellForm** – energetic optimization of formation
Research Aims of ProZell Projects with a more holistic view on the manufacturing

**HiLo** – processes and electrode structures for high-load cathodes

**QS-Zell** – QA methods in the production of large-format LIB-cells

**HighEnergy** – high-capacity structured electrodes

**Sim2Pro** – multi-level simulation of process-product-interactions
Continuous processing of battery slurries by extrusion

- Enhancing the efficiency in production
- Reducing the mixing and dispersing time (dwell time ~ 3 - 6 min)
- Possibility to decrease dryer length

Prediction of carbon black destructuring in planetary mixers of different geometry

- Simulation on different scales (particle scale and machine scale)
- Structure characterization
- Decease of Carbon Black usage
Cluster Objectives Electrode Production

Development of thick and multilayered electrodes
- Reducing the amount of inactive cell materials (current collector e.g.) to enhance energy density
- Enhancing binders, particle size distributions, use of material blends
- Decreasing material- and production costs
- Electrode structure optimization by simulation tools to ensure maximum transport performance

Dry and water based coating of battery electrodes
- Massive cost reduction, especially energy and solvent usage
- Mixing and structuring of materials
- Electrostatically enhanced spray coating, also multilayer deposition

Source: ZSW, Ulm

Source: IPA, Stuttgart

Cluster Objectives Electrode Finishing

- Defined porosity- und structure-adjustment by defined calandering
  - Enhancing energy- and power-density and life time expectation by prediction of favourable calandering parameters
  - Increasing the operability of calendaring machines by dynamic machine model

Roll to roll continuous IR dryer
- Fast heat and solvent transport
- Short drying times and controlled remaining solvent content
- Prevention of water reuptake

Source: ZSW, Ulm
Cluster projects „HighEnergy“
Design and production of high-load electrodes

- Decreasing failures and enhancing quality
- Increasing production rate
- Decreasing costs and production failures
Cluster Objectives Cell Finishing

Accelerating, homogenization and inline process control of electrolyte filling
- Decrease of filling time and costs
- Simulation of wetting processes during cell filling
- Effect of separator and cell design

Accelerating formation and decreasing aging time
- Systematic approach to optimize formation routines
- Investigation of chemical and electrochemical parameters
- Effect of production parameters on formation
Cluster project „Sim2Pro“
Simulation of cell production chain

Quality assurance in lithium ion battery cell production
- Investigating of crucial process steps for cell quality
- Development and investigation of new measurement methods and overall quality assurance concepts

Frame for process simulation and performance prediction
- Coupling process models to calculate production rates, energy and labour demand etc.
- Effect of processes on cell performance
Connection of the individual projects of the cluster
Systematic cooperation
Competence Cluster for Battery Cell Production (ProZell) Networking with Industry

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ProZell provides knowledge for today´s and future cell factories
Conclusions

- ProZell will provide detailed knowledge about cell production processes and their costs
- Detailed process knowledge will help to strengthen the existing German medium-sized cell manufacturers and to establish a mass cell production in Europe both in intermediate- and long-term
- Many other fields for use of battery cells are known beside electro mobility
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