The world is going to change

Climate change
• Drastic reduction of CO₂ Emissions
• Government Subsidies and Regulations

Growth of cities
• 2007: For the first time, more than 50 percent of mankind lives in cities
• 2050: 70 percent of mankind will live in cities

World population
• 2012: 7.1 billion people
• 2050: 9.3 billion people
• Rising life expectancy

Future of energy
• Fossil fuel resources are becoming scarcer
• Increasing focus on renewable energy

New concepts for mobility and energy
Key technology: Battery
Industrie 4.0 –
The next level of manufacturing

Siemens terms its approach to Digitalization in industry and its way towards Industrie 4.0 the “Digital Enterprise”

Sources: BITKOM, BCG
The Battery environment – three main segments and high variation of applications

Battery Technology
- Lithium Ion
- Lead Acid
- Li-S/Li-Luft
  Solid State Graphite

Applications
- Automotive
- Industry
- Storage

The vast experience of Siemens in different project can be used for future projects

- f.e. Stacker crane
- f.e. eBus
- f.e. eCar
- f.e. Energy Storage Systems
- f.e. Crane
Growth battery market with Li-Ion technology worldwide

ESS and eCar business are major market drivers for Li-Ion batteries

Source: Gesamt-Roadmap-Lithium-Ionen-Batterien 2030 Fraunhofer-Institut für System und Innovationsforschung ISI, Karlsruhe, Dezember 2015
Siemens Engagement in the battery production – since many years
Battery communities – Research and Development – Institute

Through these engagements many relationships have been established – Strategical impact on new projects
Siemens is globally present with experts in the main markets of battery productions.
Various applications with growing demand for batteries – Siemens is able to cover the whole subsections of battery manufacturing

Demand for Batteries

- Automotive
- Storage
- Industry

Battery production process

- Cell production process
  - Electrode production
    - Mixing dispersion
    - Coating & drying
    - Calendaring
    - Drying
  - Battery cell production
    - Slitting & punching
    - Electrolyte filling
    - Formation
    - Grading
    - Packaging
  - Battery module production
    - Assembly
    - Housing, sealing

Battery pack process

- Battery pack production
  - Module assembly
  - Contacting
  - Pack assembly
  - BMS
  - BMS
  - Climate control
  - Charging/Flashing
  - Final assembly
  - Test

1) BMS: Battery Management System
In order to remain competitive manufacturing companies need to achieve enormous improvements in their processes

- Reducing the time to market
  - Shorter innovation cycles
  - More complex products
  - Larger data volumes

- Flexible production
  - Individualized mass production
  - Volatile markets
  - High productivity

- Full process transparency
  - Closed loop quality processes
  - Traceability and integrated genealogy

- Optimized production resources
  - Energy efficiency and resource efficiency as key competitive factors

- Increasing efficiency

- Product and production integrated

- Increasing Quality
  - Full process transparency

- Flexibility
Comprehensive solution of the digital enterprise for the whole workflow of Battery Manufacturing

This integration provides essential a contraction of time-to-production and risk reduction.
Driving the digital enterprise in battery manufacturing
Digital Enterprise Suite – Siemens’ answer to requirements throughout the manufacturing industry

Lifecycle and DataAnalytics
Product/Factory/Plant

PLM
Teamcenter/NX

TIA
SIMATIC/SINUMERIK/SIRIUS

MES
SIMATIC IT

Product design  Production planning  Production engineering  Production execution  Service
The Digital Twin in detail
Integrating technical domains into ONE data model
Product Design for Battery

Battery Simulation & Design Toolbox

Battery Design Studio (BDS)

Single Cells studies

1. Complete Battery Definition, including all the geometric details of cells, electrodes and a numerical model of battery’s performance under load already built-in.
2. Test of the model under appropriate discharge and thermal conditions
3. Study of the cell response and definition of its limiting factors

Battery Simulation Module (BSM)

Module & Pack Analysis

1. Import (TBM File) and creation of 3D CAD model
2. Creation of the Pack
3. Calculation of batteries performance within the thermal environment and of the heat generation due electrical loading

Product design

Production planning
Production engineering
Production execution
Service
Material flow simulation with “Plant Simulation”
Easier planning – Faster analysis – Smarter decisions

Tecnomatix

- Graphical modeling
- Visualization
- Simulation and optimization of products
- Logistics and business process of the battery manufacturing
- Material flow simulation
- Bottleneck analysis
- Energy and media consumption
- What if scenarios and optimization
- Improved productivity of existing facilities
- Reduced investment in planning of new facilities
- Reduced inventory and throughput time
- Optimized system dimensions, including buffer sizes
- Lowered investment risks through early proof of concept
- Maximized use of manufacturing resources

Virtual

Whole line simulation
Buffer Analysis
Energy Consumption
Shift Comparison
Power Consumption
Resource Statistics

Real

Product design  Production planning  Production engineering  Production execution  Service
Virtual Commissioning

• Realistic simulation models for complex handling operations
• Integration of real control logic
• Virtual commissioning reduces the down time in the shop floor
• Hardware in the loop is the basis for the current virtual commissioning solution, with integration of PLCSim advanced also software in the loop will be possible

Features
• Debug PLC and HMI code with virtual 3D environment
• Validate robot programs
• Validate Safety Scenarios
• Review all zone signals

Values
• Shorter time to production
• Quicker change cycle
• High quality PLC code
• Optimized performance
• Reduce risk of production stop
• Reduce Cost of prototype parts

Simulation and virtual commissioning reduces time to introduce new manufacturing processes to the shop floor
The portfolio for the Digital Enterprise with efficient interoperability of all automation components

Added value in all automation tasks

- Integrated Engineering
- Industrial Data Management
- Industrial Communication
- Industrial Security
- Safety Integrated

Totally Integrated Automation Management

Product Lifecycle Management and Enterprise Resource Planning (ERP)

- Product design
- Product data management
- Production planning

Manufacturing Execution System

Totally Integrated Automation Portal

SCADA System

Energy Management

Control

- Controller
- HMI
- IPC
- Communication
- Motion Control
- CNC

Field

- Power Supply
- Industrial Identification
- Distributed I/O
- Drive Systems
- Industrial Controls

Product design

Production planning

Production engineering

Production execution

Service

18
Manufacturing Operation Management for Battery Production Process – One solution for the whole Plant: “wall-to-wall” solution

Manufacturing Operation Management System (MOM)

- Mixing Room Area Management System
- Area/Line Management System
- Area/Line Management System
- Area/Line Management System
- Area/Line Management System

Material preparation (dosing, mixing)

Electrode manufacture

Battery cell manufacture

Battery module/pack assembly

Battery system inspection, EOL

Logistics, warehouse management, storages, material flow

Product design

Production planning

Production engineering

Production execution

Service
Monitoring SCADA System for the Battery Production Process with SIMATIC WinCC

Maximum plant transparency and productivity

- Fast adaption on customer wishes
- Flexibility in monitoring
- Paperless Manufacturing
- Guarantee Quality

SCADA with WinCC

Monitoring Management

- The scalable and open SCADA system for maximum plant transparency and productivity
- Easy scalability and efficient production analysis
- Universal applicability – solutions for all sectors and technologies
- Software expansions for individual requirements based on options

Recipe Management

- Administration of recipes
- Faster production adjustment

Manufacturing Quality Management with Traceability

- Line utilization
- Equipment utilization
- Line Monitoring and Asset Management

Product design

Production planning

Production engineering

Production execution

Service
Digitalization in battery machine building
Holistic approach for machine builders

Concept Design
- MCD

Mechanical Design
- NX

Electrical Design
- SIZER

Software Development
- TIA-Portal

Commissioning (virtual)

Operation

Tools for the engineering processes

Plan

Design

Build

Operate

Services

Machine builder

Machine user

Integrated Production

Integrated Engineering

Target: Consistency and short time of development, best productivity and reliability of the machines
Chain of integrated engineering software landscape for a shorter time-to-market and consistent engineering
Simulation offers decisive advantages

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Virtual</th>
<th>Real</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commissioning can be done in parallel to production of the machinery. Thus shortens the Time-to-Market!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No costs for machines, space, energy, operator, lubricants etc.</td>
<td></td>
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<tr>
<td>No risk of machine damage (e.g. due to collisions), no health risk for the operator</td>
<td></td>
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<tr>
<td>Failures can be tested as well – e.g. failures of sensors, miss operations</td>
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<tr>
<td>Interaction with other, surrounding equipment can be tested, such as handling</td>
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<td></td>
</tr>
<tr>
<td>Optimization possible, thus best productivity and reliability can be made sure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Further use cases: Training, Demonstrations/Pre-Sales-Support, Service</td>
<td></td>
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</tr>
</tbody>
</table>
Integrated engineering (machine building) –
Time reduction from the first idea to real machine

Today
- Planning
  - Requirements
  - Mechanical concept
  - Electric/Fluid
  - Software

Concept design
- Concept design
- Mechanic

Detailed Engineering
- Detailed Engineering
- Electric/Fluid
- Software

Commissioning
- Commissioning
- Real Machine
- Real Commissioning

Tomorrow
- Systems Engineering
- Requirements
- Mechanical Concept

Concept Design
- Electric/Fluid
- Mechanic
- Software

Interdisciplinary Engineering
- Digital Machine
- Virtual Commissioning

Commissioning
- Real Machine
- Real Commissioning

Siemens Products support already today modern machine development methods

30% faster
Time-saved
Battery Converting Toolbox – solutions for battery cell manufacturing
Standardized applications for converting processes

Battery Converting Toolbox
Standardized automation packages with tested know-how for SIMOTION, SINAMICS and SIMATIC Systems

• Winding
• Coating and Laminating
• Cutting
• Punching
• Spooling

Advantages of Converting Toolbox
• Time saving for commissioning and service
• Transparent and tested software
• Global APC support
• Open source for simple adaptations
• Solutions for SIMOTION, SINAMICS and SIMATIC
• The applications are free

Motion Based Solutions
• SIMOTION and SINAMICS

Drive Based Solutions
• S7 PLC and SINAMICS DCC

PLC Based Solutions
• SIMATIC S7 PLC and SINAMICS
Electrode coating

Requirements

- Flexible, double-sided, intermittent strip coating at up to 50 m/min
  - Homogenous coating thickness of 150 – 300 µm
  - Tolerance for coating of 1 – 2 µm
  - Prevention of build-ups at the start and end of the coat
  - Integrated quality inspection of coating thickness, area mass, and surface structure
  - Optional integrated calendaring of the electrode (inline)
  - Fast adaptation of the process in the case of quality flaws
  - Constantly high speed of the winder drives
  - Automatic roll change
  - Integration into plant network

Customer benefits

- Flexible and fast control of the coating system with SIMATIC S7 for high precision coating
- Easily parameterized standard applications for setpoint-cascade, winder with tension control, etc.
- Fewer rejects due to automatic roll change during operation with reversing winders or goods storage
- Controllers, drives and motors scalable for all requirements and power ratings
- Simple and safe integration of quality measuring systems into the automation solution on PROFINET based on Standard Ethernet

Automation solution with Converting Toolbox

Machine

Coating system I
- Continuous
- Intermediate
- Strip

Coating system II
- Continuous
- Intermediate
- Strip
- Interim and strip

Coating system III
- Continuous
- Intermediate
- Strip
- Interim and strip
Battery Handling Toolbox allows a fast and efficient programming
The most common kinematics are available in the standard system-blocks

Battery Handling Toolbox
• **Standard** and modular Software library
• Handling with SIMOTION fulfills the OPL requirements

Standard
• The so-called standard-kinematics are already integrated on the system
• The pre-configured blocks allows a fast and efficient engineering

**Most common kinematics are available in the standard system-blocks**

- Swiveling arm
- Articulated arm
- Roller kinematics
- SCARA
- Cartesian 3D
- Cartesian 2D
- Delta 3
- Delta 2
Application for assembling

Kinematic for assembling of prismatic cell by stacking

Requirements

Cell assembling by stacking from 40 electrode and 41 separator with maximal speed
  • Material-Handling in µm-range, A4 Format
  • Accuracy in positioning of 100 µm
  • 100% check of the surface quality and layers
  • High dynamic and smooth movements
  • Time optimization of the travelling distance
  • Flexible production of different sizes of cell
  • Integration into plant network
  • Process visualization direct at the machine and management system

Customer benefits

• Simply axes coordination and zone definition
• Predefined portal kinematic and pre-simulation of the movements in 3D-Trace
• Optimal synchronization of movement speed and positioning accuracy
• Ease parametrization with standard handling library
• Simply integration of drive, panels and camera system
• Ease integration of Safety solution in drive and controller

Automation solution

SIMATIC S7 (F)

Machine automation
SIMOTION
Standard handling application

Machine

Portal

I/O: ET200 (F)
SINAMICS S/G: Traction drive
PROFIsafe
PROFINET
Machine integration in the battery manufacturing
Line integration for optimized manufacturing process – Simplify IT and plant floor integration

The three pillars for successful Integration

<table>
<thead>
<tr>
<th>IT Level</th>
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</thead>
<tbody>
<tr>
<td>Energy Data</td>
<td>Order Management</td>
<td></td>
</tr>
<tr>
<td>Quality Data</td>
<td>Maintenance</td>
<td></td>
</tr>
<tr>
<td>KPI</td>
<td>Others</td>
<td></td>
</tr>
</tbody>
</table>

Using open Communication

Line Integration – Tools and Technologies

Industry Standards – Data Definitions

Plant Floor

- Production Data
- Production Equipments

End customer

OEM
Standardized machine behavior and operations

Without standardization

- Different light stacks and different operation philosophies

<table>
<thead>
<tr>
<th>Without standardization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Produce</td>
</tr>
<tr>
<td>Machine 1</td>
</tr>
<tr>
<td>Machine 2</td>
</tr>
<tr>
<td>Machine 3</td>
</tr>
</tbody>
</table>

With standardization

- Defined signal concept
- One unified user interface
- Standardized machine operations
- Line management system

Easy to document, train and maintain
Optimized to establish line control and MES
Line integration for optimized manufacturing process

Line integration is an essential part to reduce the costs and to increase the battery product quality.
Industry services for battery industry
Overview Service Portfolio Elements @ Customer Service
Always with competent support available for you!
Extract new value from your existing Battery production data
Plant Data Services

From Data...

Data analytics and simulation
Data collection

Cloud-based analytics ecosystem

Visualization & recommendations

...to Value

Master asset uptime
Optimize energy performance
Enhance industrial cyber-security

Maximize Process Efficiency
Secure storage and data transfer

Data analytics and simulation

Cloud-based analytics ecosystem

Visualization & recommendations

...to Value

Master asset uptime
Optimize energy performance
Enhance industrial cyber-security

Maximize Process Efficiency
Secure storage and data transfer

Data analytics and simulation
Create value by connecting the real world with the virtual
From Data to Insight to Action – MindSphere – Siemens Cloud for Industry

- Optimizing plant and machinery, and energy and resource consumption
- Open standard (OPC) for connectivity of Siemens and third-party products
- Plug-and-play access for Siemens products (configuration in TIA-Portal)
- Optional cloud infrastructure – public or private cloud or location-specific solution
- MindSphere – Siemens Cloud for industry with open application interfaces for individual customer applications
- Transparent pay-per-use pricing model
- Opportunities for entirely new business models (such as offering machine-hours for sale)

Gain immediate insights throughout your whole fleet and for your assets in detail
Transform your insights into actionable results and communicate them with the request system

Configure the data to sent and the connectivity quickly and easily
Covering the whole value chain management with Siemens automation – Solutions within the battery cell production

**ZSW**
Ulm/Germany

Battery production control center for the battery research production line

**Breyer GmbH Maschinenfabrik**
Germany/Singen

Calendaring battery films

**Jonas & Redmann**
Berlin/Germany

Cell Assembly
Laser welding machine

**Trumpf Laser- und Systemtechnik**
Germany/Ditzingen

Calendaring battery films

Examples for battery machine references with Siemens Automation and Drives
Siemens is passing through the digital transformation itself and adapting its processes to the new reality

Example – Electronics facility in Amberg, Germany

- **Fast**
  - ~1 SIMATIC product per second
  - >1,200 product variants in the team center

- **Flexible**
  - 24 hours between order and arrival at customer

- **Efficient**
  - Roughly nine-fold increase in shop floor utilization since production start (1990)

- **High-quality**
  - Fewer than 11dpm, for a quality level of 99.9989%
Subject to changes and errors.

The information provided in this document contains merely general descriptions or characteristics of performance which in case of actual use do not always apply as described or which may change as a result of further development of the products. An obligation to provide the respective characteristics shall only exist if expressly agreed in the terms of contract.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens’ products and solutions only form one element of such a concept. For more information about industrial security, please visit: siemens.com/industrialsecurity

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