PEMFC Technology; Stack manufacturing processes and quality techniques

PEMFC stack and MEA manufacturing workshop, October 11th 2018, Brussels
Agenda

- ElringKlinger at a glance
- ElringKlinger PEMFC Products
- Market situation
- PEMFC manufacturing Technology at ElringKlinger
- Manufacturing and quality processes
Company profile

- 47 facilities worldwide, Turnover 2017: 1.664 billion €, 10.000 employes,
- family as strong anchor shareholder, 52 %
- Focus on mass production of parts for the automotive industry
- Supplier of virtually every OEM in the world → familiar with all quality requirements and certifications required
- Committed to play leading role in the switch to alternative drivetrains, fuel cell and battery activities

### ElringKlinger Group

<table>
<thead>
<tr>
<th>Original Equipment</th>
<th>Sales</th>
<th>Employees</th>
<th>EUR 1,382 million</th>
<th>EBIT</th>
<th>EUR 137.3 million</th>
<th>EBIT margin</th>
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</thead>
<tbody>
<tr>
<td>Sales:</td>
<td>EUR 1.664 million</td>
<td>9,611</td>
<td></td>
<td>EBIT margin 8.3 %</td>
<td></td>
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<tr>
<td>Employees:</td>
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<table>
<thead>
<tr>
<th>Aftermarket</th>
<th>Sales:</th>
<th>Employees:</th>
<th>EUR 157 million</th>
<th></th>
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<tbody>
<tr>
<td>Sales:</td>
<td>EUR 111 million</td>
<td>739</td>
<td></td>
<td></td>
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<td>Employees:</td>
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<table>
<thead>
<tr>
<th>Engineered Plastics</th>
<th>Sales:</th>
<th>Employees:</th>
<th>EUR 10 million</th>
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</thead>
<tbody>
<tr>
<td>Sales:</td>
<td>EUR 4 million</td>
<td>190</td>
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<tr>
<td>Employees:</td>
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<tr>
<th>Services</th>
<th>Sales:</th>
<th>Employees:</th>
<th>EUR 4 million</th>
<th></th>
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<tbody>
<tr>
<td>Sales:</td>
<td>EUR 4 million</td>
<td>2</td>
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<tr>
<td>Employees:</td>
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All figures refer to FY 2017
Divisions

- Cylinder-head gaskets
- Sealing systems
- Plastic housing modules
- Lightweight plastic components
- Shielding systems
- Aftermarket
- Battery technology
- Fuel cells
- Electric drive unit
- Development services with hofer powertrain
- Engineered plastics
- Engine testing services
- Tooling technology
Competences fuel cell components

Industrial production, Process-Know-how,

Technology-/ product-Know-how, simulation (fuel cell, stamping, FEM), tooling, process optimization, ...
PEM fuel fell products

Product definition:

- **Sheet metal bipolar plates**
- Elastomer sealings (optional on bipolar plate assembly)
- **Injection-molded plastic components**
  - End plate
  - Media supply unit
  - System components
- **PEM fuel cell stacks and modules**
Market situation

Game changer: legislations/requirements for emission control

→ market pull: PEMFC Stacks/Systems, mainly cv, truck and bus

Emerging activity in Europe, new suppliers:

Hannover fair 2018: faurecia, plastic omnium, ...., ElringKlinger, Proton Motor, Powercell

New focus: industrialisation, quality, cost, customer relationship

background: technology leadership
Challenges

high volume stack production

100,000 FCEV – 100,000 systems – 100,000 stacks
→ 40,000,000 cells
→ ~100,000,000 components/assembly steps
  e.g. 10 assembly lines (stack assembly):
  2 s per assembly step (sequential processes)

- Very high volumes
- Very high quality requirements, process reliability
  400 cell stack, rejected stacks < 1% requires failure rate
  ~ 1 ppm at single components
- Process stability
  homogenous, high quality production in three shift operation
Challenges

**high volume stack production**

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- → ~100,000,000 components/assembly steps
  - e.g. 10 assembly lines (stack assembly):
    - 2 s per assembly step (sequential processes)

- Product technology (components, stack)
- Manufacturability
- Production processes components and assembly cell/stack
- Processes, quality

→ **Industrialisation**
→ **Development product technology – production technology**
Approach

Development of manufacturing technology has to be in line with growing volume

→ Scalable and modular production concept

→ Parallelisation
→ Throughput optimisation
→ Continuous processing (e.g. progressive die set)

→ Eliminate/overcome bottleneck processes, e.g.
  - end of line test bipolar plate (tightness)
  - end of line test stack (incl. break in)

→ Inline control of CTQ (Critical to Quality) and SC features

→ Consistent quality processes, inhouse and along the supply chain,
  - traceability
  - supply chain management

Production concepts and equipment have to be suitable for the transition to high volume production

Brussels, 2018/10/11

PEMFC stack and MEA manufacturing workshop
Public funded projects - production technology

- **DIGIMAN**, FCH-01-1-2016: Manufacturing technologies for PEMFC stack components and stacks
- **FIT-4-AMANDA**, FCH-01-1-2016: Manufacturing technologies for PEMFC stack components and stacks
- **INLINE**, FCH-01-3-2016: PEMFC system manufacturing technologies and quality assurance
- **INN-BALANCE**, FCH-01-4-2016: Development of industrialization-ready PEMFC systems and system components
- **VolumetriQ**, FCH-01.2-2014: VOLUme Manufacturing of PEMFC Stacks for TRansportation and In-Line Quality Assurance
- **MontaBS**, Development of assembly technology and automation concepts for PEMFC stack production
- **Autostack Industrie**, Development and preparation for mass production of a high performance automotive PEMFC stack
PEMFC stack production

Flexible manufacturing line:

- MEA- and stack assembly cells, directly linked
  - Assembly of stack platforms NM 5, NM 12
- Flexibility in component size and material
  - stacks with metallic and graphitic bipolar plates
  - cell format/size, roll width
- Flexibility in component supply
  - component configurations
  - interfaces for feeding

Targets:

- Development of process/automation concept and plant-/machine technology
- Validation/revision of component design

- high volume production (5000 - 20,000 Stacks p.a.)
Automatisation cell and stack assembly

Status

- Commissioning, test operation
- Stack assembly up to 300 cell stack NM 5
- To do:
  - Optimization roll cutting CCM and
  - Stack assembly high cell count
Means for assuring homogenous quality

- Process flow according to APQP / PPAP
- Supplier management – Supplier guideline & ordering standards for each material
- Process capability study, measurement capability analysis
- Sampling and inspection process, control plan, control drawing, ...
  - e.g. Sample tests (bipolar plate), which may include:
    - Geometrical characterization (non destructive)
    - Pressure drop measurements
    - Tightness test, through-plane and along weld
    - Through-plane resistance measurements
    - Microscopy of cross-cuts (destructive)
    - Cleanliness measurements
Supplier management:

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Process Flow (Procedure APQP)

- Input
- Initial Inquiries
- Start Procurement Planning
- Definition Procurement Team
- Initial Audit
- General Supplier Approval
- Selection and Nomination Suppliers

- Risk Analysis Purchasing Project
- Release Nomination
- Definition of Packaging / Logistics
- Creation Order Norms
- Definition Basic Purchasing Data
- Preference Process
- Conclusion Contracts / Framework Orders

- Documentation of Changes
- Release Bulk Material
- APQP Planning Supplier (Parts)
- Initial Samples Order
- Initial Sample Release
- Transmission of Release to Supplier
- Disposition of Production Material
Supplier management:

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**Process Flow (Procedure APQP)**

Release of **Bulk Materials**
- Acceptance of order norm from supplier (Purchase)
- Ordering of material samples (Purchase)
- Investigation of material samples (Development)
- Audit / R@R depending on risk (Supplier Development)
  - Release for bulk material (APQP Team)
    - can be limited when
    - not all tests are done
    - documents are missing
- Documentation in Easy DMS and project list SAP ZLIEFP (Supplier Development)
- Send information about approval to the supplier (Supplier Development)
Supplier management:
Process Flow (Procedure APQP)
Supplier releasing process
Supplier management: 
Process Flow (Procedure APQP) 
Supplier releasing process
Internal documentation:

PPAP

Documentation according to VDA or PPAP is standard
Experience mobility – Drive the future.

Thank you.

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