Smart Adaptive Systems

Ad Scheepers
Bosch Rexroth
## Industry 4.0 @ Bosch Rexroth

### Bosch Rexroth: Part of Bosch-Group

<table>
<thead>
<tr>
<th>Bosch-Group</th>
<th>70.6 billion euros in sales</th>
<th>374,778 associates</th>
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**Mobility Solutions**
- One of the world’s largest suppliers of automotive technology
  - 59% share of sales

**Industrial Technology**
- Leading in drive and control technology, packaging, and process technology

**Energy and Building Technology**
- Leading manufacturer of security technology
- Global market leader of energy-efficient heating products and hot-water solutions
  - 41% share of sales

**Consumer Goods**
- Leading supplier of power tools and accessories
- Leading supplier of household appliances

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Original excerpt Presentation of the Bosch Group | C/CCB, C/CCD | April 2016
Every industry has specific needs

- Reflect specific needs and requirements of markets and industries
- Bundle relevant technologies, application expertise and services
- Global presence combined with local know-how
- Proximity to customer

We have deep industry knowledge
## Industry 4.0 @ Bosch Rexroth

### Every industry has specific needs

<table>
<thead>
<tr>
<th>Mobile Applications</th>
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<tbody>
<tr>
<td>Construction Machinery</td>
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<tr>
<td>Material Handling</td>
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<tr>
<td>Agricultural and Forestry Machinery</td>
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<td>On-Highway and Commercial Vehicles</td>
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<th>Machinery Applications and Engineering</th>
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<tr>
<td>Marine and Offshore</td>
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<td>Motion Simulation</td>
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<tr>
<td>Mining and Material Handling</td>
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<td>Material Processing and Onshore Drilling</td>
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<td>Metallurgy</td>
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<td>Civil Engineering</td>
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<td>Stage Technology</td>
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<td>Energy Technology</td>
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<td>Testing Technology</td>
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<td>Transportation and Large Engines</td>
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<td>Presses</td>
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<th>Factory Automation</th>
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<tr>
<td>Electronics and Manufacturing Technologies</td>
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<td>Processing and Packaging</td>
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<td>Printing and Paper</td>
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<td>Automotive</td>
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<td>Machine Tools</td>
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<td>Plastic Machines</td>
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We have deep industry knowledge
Many technologies. One right solution

- Components, modules, systems and services – leading-edge innovation
- Multi-technology options
- Engineered for perfect integration
- Adapted to regional requirements
- Maximizes performance, reliability and productivity
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Financially strong and future-oriented

Total sales: € 5.4 billion

Germany: € 1.3 bn
Europe without Germany: € 1.9 bn
Asia / Pacific / Africa: € 1.2 bn
Americas: € 1 bn

Total staff: 31,100

Germany: 15,100
Europe without Germany: 7,800
Asia / Pacific / Africa: 5,200
Americas: 3,000

Total research and development: € 325 million

Expenditure as a percentage of sales: 6.0 %
Investments: € 121 million
Expenditure as a percentage of sales: 2.2 %

55 manufacturing locations and customization sites in 22 countries
Present on location in more than 80 countries
Industry 4.0 @ Bosch Rexroth

Bosch dual strategy i 4.0

Lead Provider
System manufacturer/
Production resource view

<table>
<thead>
<tr>
<th>Lead Operator</th>
<th>Product manufacturer/</th>
<th>Product view</th>
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<tbody>
<tr>
<td>Bosch Rexroth</td>
<td>Product manufacturer/</td>
<td>Product view</td>
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<td>Bosch Group</td>
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<td>Drive and Control</td>
<td>Bosch Software</td>
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<td>Technology</td>
<td>Innovations</td>
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<td>Bosch Sensor</td>
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<td>Bosch Connected Devices &amp; Solutions</td>
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285 Bosch plants world wide

- Manufacturer of products
- Machine operator
- Plant operator
- Interface to customers/suppliers

More than 100 pilot applications are bundled within the Innovation Cluster CI
Industry 4.0: Features

- Distributed intelligence
- People as key players
- Fast integration and flexible configuration
- Open standards
- Virtual representation in real time
- Virtual representation in real time
- Digital life-cycle management
- Secure value creation network
- Open standards
- Virtual representation in real time
Continuously adaptable i 4.0 assembly line
Industry 4.0 – assembly line: products and customers

**products**

hydraulic valve slices with On Board Electronic (OBE)

6 product families, 200 valve slice variations, > 2,000 components

**customers**

AGCO, CNH, John Deere, Same, Claas, Fendt
Manufacturing of valve slices for mobiles

Classical invest in high runner line – Are there alternatives?
Industry 4.0 @ Bosch Rexroth

Initial situation

- several assembly lines for 11 product families
- high stock for block assembly
- low agility → high setup time
- high effort for shop-floor management
- high effort for qualification expenses

Challenge

- volatile markets
- individual customer requirements
- reduced delivery time
- reduced product life cycle
- social behavior, demography

Target situation

- multi product line for 6 product families
- batch size 1 for block assembly
- flexible, autarchic work stations
- low effort for shop-floor management
- on-the-job training due to operator oriented HMI

Target: convertible, intelligent and flexible assembly line
Industry 4.0 – assembly line

- Project duration: 1 year (June 2013 – June 2014)
- I4.0 specification at the start – some visionary descriptions
Industry 4.0 – connected assembly line

- Digital connection between operator, product and work station
- Integration in virtual world of order planning and production control systems
Industry 4.0 – digital work plan

**benefit:**
online configuration of work task possible

**identify product (RFID) in the machines**
matching of necessary and provided services

**benefit:**
work task is executed directly by the machine
Industry 4.0 – connected work station

**Features**

- Autonomous, intelligent, ad-hoc connected system = Cyber Physical System
- Virtual image represents the services of the work station, offers services to the product
- Online check if station services fitting to the work plan of the product
- Context based, intuitive user interface for operator
- Modular station with unified interfaces (m, e, p)

**Benefits**

- Online configurability ensures
  1. Quick adaptation to new requirements, e.g.
     - new products with new operations
     - changing quantities of products
  2. Transparent overview for the production planer about the capabilities of lines
  3. Easy to handle changes of user interface for the operator
Operator recognition and adaptation

- User Interface
- Adjust light intensity
- Pick to light system
- Operator recognition with Bluetooth tag
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Smart Automation Line: Conclusion

Use Case
- Flexible and adaptable production facility
- Production with batch size 1

i4.0 Approach
- Precise product identification via RFID, Work instruction synchronization, individual assembly steps
- Flexible autonomous work stations, virtual work space configuration
- Line/product status via “Active Cockpit”

Result/Targets
- Inventory reduction, no set up time
- Output increase
Process Quality Management
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NEXO – Industry 4.0 Tightening System

Process Quality Manager – Software Application

NEXO Productivity 0-defect

- Continuous Improvement process
- Process control
- Multiplication of expert knowledge

Multiple production sites

Fast production ramp-up

Large scale production environment

Process Quality Manager
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Enhancement of transparency and enables scalability
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Enabling of effective monitoring

Field of nine ESA030G SWT3

Last 100 tightenings:

Additional values

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Possibility of comparing different tightening curves

Tightening curve ESA030G SWT3

X-Axis: Angle (°)
Y-Axis: Torque (Nm)

Standardization: Do not standardize

Last 100 tightenings:
Remote control, analyses & global deployment
Deploy expert knowledge via intelligent rules management
**Process Quality Manager for Tightening Systems**

**Proven:**
- 1st installation at Automotive Company
- >300 tightening systems connected

**Know how built-in:**
Joint solution by Rexroth & Bosch Software Innovations

**Scalable platform – open architecture:**
server-based; simplified process data format; browser based software

**Minimized failure costs and downtime**