Bosch Rexroth
Electric Drives and Controls
Energy efficiency in automation
## Bosch Rexroth
Energy efficiency in automation

<table>
<thead>
<tr>
<th>Category</th>
<th>Features</th>
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<tr>
<td>High-efficiency servo drive control</td>
<td>- Shared DC link&lt;br&gt;- Energetic recovery system&lt;br&gt;- Efficiency 97 %</td>
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<td>High-efficiency motors</td>
<td>- Optimized coil technique (pole shoe coil)&lt;br&gt;- Efficiency &gt; 95 %&lt;br&gt;- Direct drive technology</td>
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<tr>
<td>Functional integration</td>
<td>- One hybrid cable – reduced cabling requirements by up to 85 %&lt;br&gt;- Reduced control cabinet requirements by up to 70 %</td>
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<tr>
<td>Large frequency converter product range</td>
<td>- Economized speed control for more than 50 % of applications&lt;br&gt;- EFF 1 motor control&lt;br&gt;- Energetic recovery system</td>
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<td>Supporting software tools for machine optimization</td>
<td>- Control-integrated software tool for cycle time and energy-efficiency analysis</td>
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# Bosch Rexroth
Energy efficiency in automation

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<th>Energy-efficiency products in drive technology</th>
<th>Bosch Rexroth</th>
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<tr>
<td><strong>High-efficiency servo drive control</strong></td>
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<tr>
<td><img src="image1.png" alt="Image" /></td>
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<tr>
<td><img src="image2.png" alt="Image" /></td>
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<td>Functional integration</td>
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<td>Supporting software tools for machine</td>
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<tr>
<td>optimization</td>
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<tr>
<td><img src="image5.png" alt="Image" /></td>
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<tr>
<td>Mechatronic support</td>
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<tr>
<td><img src="image6.png" alt="Image" /></td>
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</table>

- **High-efficiency servo drive control**
  - Shared DC link
  - Energetic recovery system
  - Efficiency 97%

- **High-efficiency motors**
  - Optimized coil technique (pole shoe coil)
  - Efficiency > 95%
  - Direct drive technology

- **Functional integration**
  - One hybrid cable – reduced cabling requirements by up to 85%
  - Reduced control cabinet requirements by up to 70%

- **Large frequency converter product range**
  - Economized speed control for more than 50% of applications
  - EFF 1 motor control
  - Energetic recovery system

- **Supporting software tools for machine optimization**
  - Control-integrated software tool for cycle time and energy-efficiency analysis

- **Mechatronic support**
  - Mechatronic system optimization on basis of simulation models
Bosch Rexroth
IndraDrive high-efficiency drive family

- **Servo drives and frequency converters** on one single platform
- **Energy exchange** on the shared link
  - Generator-operated axis supply
    - Motor-operated axis
  - No more or reduced braking resistors
  - Reduced dissipation heat in the control cabinet
  - Elimination of cooling units
- **Supply modules with energetic recovery system** for plants with high recovery energy
- **Frequency converter and servo drive** in one link
  - Minimization of component requirements
  - Reduced control cabinet volume
- **Drive-integrated safety technology**
Bosch Rexroth
High-efficiency motors - IndraDyn

- **Broad performance range** from 100 W to 100 kW
- Servo drives in **state or the art coil technique**
  (pole shoe coil) with **efficiency > 0.95**
- **Direct drive technology**
  - Synchronous assembly motors for spindle
  - Synchronous linear motors for traversing movements
- **Optimum drive selection through IndraSize design programme**
  - Excessive drives sizes can be avoided
IndraMotion for Packaging
IndraDrive® Mi

2005
1. Platz
Automation Award

2006
1. Platz
„Product of the year in Automation“, Journal „Elektronik“,

2007
Product Innovation of the Year North American Motors & Drives
Decentralized solution and functional integration
Example IndraDrive Mi

- Realization of compact, decentralized drive technology **Primary energy savings** for:
  - Production of our products
  - Planning of other automation components
  - Manufacture in day-to-day operation
- **up to 70 % reduced control cabinet volume**
  - Reduction of dissipation heat in the control cabinet allows operation without air conditioning units or
  - allows use of smaller air conditioning units with reduced energy consumption
- **Reduced cabling requirements** by up to 85 % through shared cable harness:
  - Reduced number of cable ducts, cable passages, etc. required
  - Reduced line loss due to shorter cable distances
Conventional drive solution on the example of a packaging machine

- Conventional drives in the control cabinet
- Sensors
- Servo motors
IndraDrive Mi
application examples

Innovative drive solutions with IndraDrive Mi

- Dramatic reduction of control cabinet volume by up to 70 %
- Dramatic reduction of cabling requirements by up to 85 %
- Significant increase in machine flexibility and modularity
IndraDrive Mi
Example Homag BAZ 222

CNC
AC 3 x 380V

Control cabinet

X axis

Y1 axis
Z1 axis
C1 axis

Support 1

Y2 axis
Z2 axis
C2 axis
VT axis

Support 2

Spindle

IndraDrive Mi
Example Homag BAZ 222

CNC
AC 3 x 380V

Control cabinet

X axis

Y1 axis
Z1 axis
C1 axis

Support 1

Y2 axis
Z2 axis
C2 axis
VT axis

Support 2

Spindle
- Optimization of mechanical system through FEM model and modal analysis
  - excessive use of material can be avoided
- Optimization of machine structure and mechanical elements
  - Optimization of transfer components drive, rack/pinion..
  - Drive selection defined by drive dynamics and rigidities
- Simulation of the energy requirements of the global machine
  - Optimum supply unit design

MATLAB/Simulink

MKS Adams
Analysis and evaluation of a process (e.g. process cycle) of machine tools

Process optimization by timely synchronized recordings of signal data of the CNC, PLC and peripheral devices

East to handle data through tabular and graphic representation of the measurement results, zoom and compare functions

Process optimization to identify and avoid bottle-neck situations

Increase of productivity through shorter cycle times

Increase of plant availability through holistic view of machine behaviour and comparison to an optimized initial state
  ▪ All influences on the processing procedure are considered
  ▪ Analysis is not limited to Mechatronic analysis

Optimized process cycles regarding energy consumption
Pneumatic drive technology
Electro-pneumatic pressure control valves

Pneumatic drive optimization
- Free selection of pressure
- Adjustable force and speed
- Pressure profiles during motion possible
- Rapid buildup of force in end position
- Return stroke with reduced pressure
- Speed can also be adjusted
- Reduced compressed air requirements
  (example):
  Cylinder Ø 100 mm
  Power cycle: 6 bar
  Return stroke: 3 bar

Energy savings by approx. 20%
Reduced air consumption
Intelligent energy utilization for pneumatic drives

- Excess pressure for acceleration
- Optimization of consumption without load
- Optimization of force for motion
Pneumatic drive technology
Pneumatic valves with low power input

- Minimum power input for double relay valves of the HF valve family and only 0.35 W for MC series valves and therefore significantly below conventional pneumatic valves.
- Fully tested for leakage and consequently also for uncontrolled energy losses
- 35 years of experience in seating valve technology
Joint project for efficiency evaluation of a plant and/or machine based on end customer expectations:
- Bosch Rexroth and Homag (and if requested end customer)
- Analysis of actual situation, energy consumption, drive dimensioning…
- Deduction of approaches for optimizing energy efficiency for
  - existent machines and/or plants
  - for new machine projects

Joint projects for Energy efficiency for new developments

Cooperation in Research projects in the field of energy efficiency

Realization of requirements in new developments of Bosch Rexroth products in the areas
  - Electrical control and drive technology
  - Pneumatics
  - Linear technology
IndraMotion MTX
cta - cycle time analysis

- Analysis and evaluation of a process (e.g. process cycle) of machine tools
- Process optimization by timely synchronized recordings of signal data of the CNC, PLC and peripheral devices
- Easy to handle data through tabular and graphic representation of the measurement results, zoom and compare functions
- Process optimization to identify and avoid bottle-neck situations
- Increase of productivity through shorter cycle times
- Increase of plant availability through holistic view of machine behavior and comparison to an optimized initial state
  - All influences on the processing procedure are considered
  - Analysis is not limited to Mechatronic analysis
- Expanded of energy requirement analysis
### IndraMotion MTX
Cycle time analysis – detail analysis with all relevant data

#### Drive

<table>
<thead>
<tr>
<th>N_S1</th>
<th>Mom_X1</th>
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</thead>
<tbody>
<tr>
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#### NC

<table>
<thead>
<tr>
<th>Prog.</th>
<th>Flange XSTE</th>
<th>M6</th>
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<tbody>
<tr>
<td>CPL</td>
<td>410  420  430  440  450 460</td>
<td>610 620</td>
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<tr>
<td>NC</td>
<td>N0110</td>
<td>N0120</td>
<td>N0010</td>
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<tr>
<td>Hifu</td>
<td>440</td>
<td>M41</td>
<td>M71</td>
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<tr>
<td>Var_1</td>
<td>132 878</td>
<td>44 000</td>
<td>551 000</td>
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<tr>
<td>Var_A</td>
<td>25 1965</td>
<td>1149 8522</td>
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</table>

#### PLC

<table>
<thead>
<tr>
<th>Ch_Ena</th>
<th>t [ms]</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>243.73</td>
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</table>

<table>
<thead>
<tr>
<th>Block number read-out</th>
<th>t [ms]</th>
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</thead>
<tbody>
<tr>
<td>NC block</td>
<td></td>
</tr>
<tr>
<td>G0 X1=400 M40 M71 M38 S400</td>
<td>243.73</td>
</tr>
<tr>
<td>CPL block</td>
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</tr>
<tr>
<td>0430 REPEAT</td>
<td>0.61</td>
</tr>
</tbody>
</table>

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- **Task**
  - First overview at the machine - where are which times required?

- **Information**
  - Process times (peak, non-peak, tool changer, pallet, user times 1/2/3)
  - for used tools, defined channels, certain commands
**IndraMotion MTX**

**cycle time analysis – multi-channel block analysis**

- **Task**
  - Channel-independent analysis of NC blocks
  - Optimization of synchronization between channels
  - Optimization of production processes between the channels (shifting of tasks between the channels)

- **Information (for several channels)**
  - Interpretation (CPL)
  - Preparation (NC)
  - Realization (IPO)
  - Motion (IPO Move)
  - Programme
**Task**

- Signal analysis with NC block reference
- Detailed examination of problems, e.g.
  - Spindle start-up (spindle speed in reaction to NC blocks/production procedure)
  - Examination of axis oscillations (motor current in relation to NC blocks/production processes)

**Information**

- Oscilloscope and trace with synchronized block number display
  - Multi-channel block analysis
  - Signals of NC, of drives and the PLC
1. **Data transfer and procurement** (CAD, materials, data sheets,..)

2. **FEM model design and modal analysis**

3. **Alignment of the FE and MKS model with the measurement results.**
   - Frequency-response measurement for global axis
   - Oscillation analysis with shaker (reversing) for mechanical component
   - Pulse excitation with hammer

4. **Optimization of machine structure and mechanical elements**

5. **MKS model design** considering the own modes, rigidities and axis dynamics

6. **Mechatron optimization. System relation to co/simulation**
   - Target value analysis and optimization in the interpolating operation
   - Contour considerations and evaluation (virtual work-piece)
   - Identification and representation of non-linear System characteristics
The simulation model comprises:
- **Drive model** with simulation link
- **Mechanical model** based on the construction data with ADAMS
  - coupled mass simulation (co-Simulation)

**Simulated target values:**
- Extract from target value profile
- Positioning of X and Y axis