4EE – High Performance Energy Efficiency for Hydraulic Machine Drive

Wagner Mattos, Bosch Rexroth Brazil
Electricity Generation by Region

- USA: +21%
  - 2010: 1,069 TWh
  - 2035: 1,968 TWh

- Europe: +19%
  - 2010: 3,662 TWh
  - 2035: 4,357 TWh

- Middle East: +111%
  - 2010: 824 TWh
  - 2035: 1,740 TWh

- India: +244%
  - 2010: 960 TWh
  - 2035: 3,298 TWh

- China: +134%
  - 2010: 4,247 TWh
  - 2035: 9,945 TWh

- Latin America: +75%
  - 2010: 1,069 TWh
  - 2035: 1,968 TWh

- World: +71%
  - 2010: 21,408 TWh
  - 2035: 35,637 TWh

Current Situation / Trends / Motivation

Energy Prices for Industrial End-User

Average price electrical energy
European Union (EU 15)
Source: Eurostat

€/kWh

+ 50 %
Energy Consumption – Brazil

Almost 70% of the industrial energy consumption is drives and motors.

* European Union (Total 3134 TWh, 37% Industry 1159 TWh, Drives & Motors 800 TWh)
Current Situation / Trends / Motivation

Life Cycle Cost / Total Cost of Ownership (TCO)

80..95 %
- Commissioning
- Training
- Spare Parts
- Maintenance
- Personnel Cost
- Tax
- Insurances

5..20 %
- Machines & Equipment
- Energy
  - Modernization
  - Disposal
  - ...

Energy Cost
Approx. 5,950 € (96%)

Purchase price
Approx. 250 € (4%)

AC motor 1 kW
5 years power-on time
Saving Energy and Increasing Productivity with Rexroth:

Efficient Components
- Products and systems with optimized efficiency

Energy Recovery
- Recovery and storage of excess energy

Energy on Demand
- Energy usage on demand, stand-by mode

Energy System Design
- Systemic overall view, design, simulation, consulting

Implementation across Complete Machine Life Cycle
- Concept
- Design
- Engineering
- Commissioning
- Production/Operation
- Modernization
Important Approaches to Energy Savings

Design Options

- Concept
- Mechanical Engineering Software Engineering Commissioning
- Production
- Retrofit

- System Design
- Efficient Components
- Recovery
- On Demand

Design Options vs. Machine Life Cycle
Current Situation / Trends / Motivation

MPA01
MSK synchronous motor
MAD
asynchronous motor
motor with encoder

SvP 7010
SvP 5010

FcP 7010
FcP 5010

IndraDrive
Rexroth FV

Internal gear pump
PGH/PGM

variable and fixed pump
A10/A4 and PGx

standard asynchronous motor (1,5...90kW) (encoderless)
Current Situation / Trends / Motivation

Components
- DC-MA
- DC-IA/TE3
- DC-IA/TE3

Kit
- DC-IA/TE3
  Development & production of Drive-Toolbox (incl. intelligent Drive control)

System
- DC-IA/TE2
  Development IS-specific HPU
- DC-IA/TE1
  Development IS-specific System solutions

Sales
- DC-IA/SET
  Sales HPU to OEM
  Sales Compact axis to OEM
  Sales Sytronix kit to OEM

Application
- OEM

* Approval of pump in collaboration with TE2
**Sytronix – System variants**

## Focus Applications

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<td>Sytronix SvP</td>
<td>Sytronix DFE</td>
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# Current Situation / Trends / Motivation

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<th></th>
<th>Efficiency</th>
<th>Dynamics</th>
<th>Costs</th>
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<tr>
<td>AC motor + fixed pump</td>
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<td>AC motor + variable pump</td>
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Energy balance

Classical solution
Constant rotation speed – fixed displacement pump – control via proportional valve

Diagram:
- Motor heating
- Pump losses
- Throttling losses across the valve
- Useful energy

Total energy

50/60 Hz

Prop. valve

Actuator
Sytronix – Motivation

Energy balance

**Mechanical p/Q-Displacement**
Constant rotation speed – fixed displacement
pump – control via p/Q-valve

Useful energy
- Motor heating
- Pump losses
- Throttling losses across the valve

Total energy

Energy savings p/Q

50/60 Hz

Actuator
Sytronix – Motivation

Energy balance

SYDFE - solution
constant rotation speed – variable
displacement pump – control via electronic adjustment

Energy balance diagram:
- 100% Energy Savings p/Q
- 100% Energy Savings SYDFE
- 50/60 Hz
- M
- SYDFE
- Energy savings by preventing throttling losses
- Motor heating
- Pump losses
- Useful energy
- Total energy
- Actuator

Energy Savings
50/60 Hz
SYDFE

Motor heating
Pump losses
Useful energy
Total energy
Energy Savings
Energy Savings SYDFE
Energy Savings p/Q
50/60 Hz
M
SYDFE

Energy balance diagram:
- 100% Energy Savings p/Q
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- SYDFE
- Energy savings by preventing throttling losses
- Motor heating
- Pump losses
- Useful energy
- Total energy
Energy balance

Sytronix FcP
Variable speed – constant or displacement pump – speed control

Sytronix – Motivation

Energy savings

Sytronix FcP
Energy savings

Energy savings FcP

Total energy

Useful energy

Converter losses
Motor heating
Pump losses

Futher energy savings due to speed reduction during part-load operation

Actuator

80%
Energy balance

Sytronix SvP
Servo-variable speed – constant pump – axis control

40-80% Energy savings due to speed reduction during part-load operation

Energy savings SvP
Total energy
Useful energy
Converter losses
Motor heating
Pump losses
Actuator

4EE – High Performance Energy Efficiency for Hydraulic Machine Drive
**Sytronix – Motivation**

**Energy balance**

**Sytronix DFE**
Variable speed – variable displacement – speed- and swivel angle control

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**Energy Savings DFE**
Further energy savings due to reduced rotation speed during part load operation.

- 80% Energy savings displacement pump
- 20% Energy Savings DFE
- 0% Total energy

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**Useful energy**
- Converter losses
- Motor heating
- Pump losses

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**Actuator**

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**4EE – High Performance Energy Efficiency for Hydraulic Machine Drive**
Advantages

**Reduced energy consumption**
Energy savings up to 80% to decrease operating costs and reduce CO$_2$ and thus reducing the „Carbon Footprint“

**Lower noise emission**
Sytronix drives can reduce the noise emission of the hydraulic power unit up to 20 dB(A). Meeting stringent noise specifications in certain market areas is easier and may be accomplished with noise control measures.

**Easier installation and commissioning**
Pre-configured Sytronix hydraulic pump drives and assemblies utilize matched components to provide complete pump drive systems. This results in short installation and commissioning times. Rexroth offers more than 100 drive configurations in three different performance classes.
Advantages

Easier cooling
By lowering the average pump drive speed, variable-speed pump drives can significantly reduce generated heat, minimizing the cost and energy required to cool the hydraulic system.

Lower space requirements
Using Sytronix drives can lower space requirements for the hydraulic system:
→ Compact design
→ Simpler valve technology and reduced requirements for control electronics
→ Reduced hydraulic fluid volume resulting in smaller reservoir requirements
→ Reduction in space for cooling due to reduced heat loads and elimination of most noise containment hardware

More reliable operation
→ Integrated system design using proven hydraulic and electrical components
→ Condition monitoring and diagnosis available in the drive control electronics
Advantages

**Retrofit design assistance**

Rexroth can provide customers with support throughout the retrofitting process, from planning to assembly to on-site commissioning.

**Compliance with regulatory requirements**

Sytronix variable-speed pump drives can assist with compliance for noise control (EU Directive 2003/10/EC) and electric motor energy efficiency (EU Regulation (EC) no. 640/2009).
Optimizing a Milling Machine

**Former drive solution**
Series production with constant rotation speed (2.2 kW motor) with variable displacement pump and 6 min. cycle time

- Energy consumption: 1.04 kW

**Rexroth 4EE solution**
- Variable speed pump
- No hydraulic cooling

- Energy consumption: 0.66 kW

**Energy savings**
- 2,280 kWh/a
- 228 €/a **

**CO₂ reduction**
- 0.5 t/a *

- 36 %

* CO₂ Emission: 0.24 kg CO₂/kWh
** Current price: 0.10 €/KWh
Optimizing a Lathe Machine

**Former drive solution**
Series production with constant rotation speed (5.5 kW motor)  
With variable displacement pump and 45 sec cycle time

Energy consumption 3.7 kW

**Rexroth 4EE solution**
- Variable speed pump

Energy consumption 2.2 kW

Energy savings 6,750 kWh/a  
675 €/a **

CO₂ reduction 1.6 t/a *

Noise level  
(Peak / Ø) 82 / 72 dB(A)  (former solution)  
72 / 62 dB(A)  (4EE solution)

- 40 %  
- 10 db

* CO₂ Emission: 0.24 kg CO₂/kWh  
** Current price: 0.10 €/KWh
Optimizing Press Brake Machine

**Original drive solution**
- One center aggregate with constant pump
- Two open loop control blocks with control valves

Energy consumption 57,300 kWh/a

**Rexroth 4EE Automation solution**
- Two Sytronix SvP 7000 Axial drives
- Axial control without valve (in the drive)
- High efficient synchronous motors

Energy consumption 32,700 kWh/a

Energy savings 24,600 kWh/a
2,460 €/a **

CO₂ reduction 5.9 tCO₂/a *

Noise level 87.6 / 74.6 dB(A) (Original solution)
76.3 / 67.6 dB(A) (Rexroth solution)

£ 43 %

£ 11 db

* CO2 Emission: 0,24 kg CO₂/kWh
** Current price: 0,10 €/KWh
Die Casting Machine

Original drive solution
Displacement pump system with DFEE-Pump
Clamping force: 50t
Cycle time: 30s

Energy consumption: 16,280 kWh/a

Rexroth Sytronix solution
- Servo-variable pump drive SvP
- Smaller cooling system
- Reduced noise level

Energy consumption: 9,620 kWh/a

Energy savings: 6,660 kWh/a
666 €/a **

CO₂ reduction: 1.6 t/a *

Energy system Design
Efficient Components
Energy Recovery
Energy on Demand

* CO₂ Emission: 0,24 kg CO₂/kWh
** Current price: 0,10 €/KWh
Sytronix DFE

Injection Molding machine

Former solution
Hydraulic – DFEC-variable pump, asynchronous motor, constant speed
Installed power: 11 kW bis 75 kW
Operation: 24h/240days

Energy consumption: 28,000 kWh/a

Rexroth Sytronix solution
- Double pump combination
- DFEn – variable pump, variable speed
- Smaller cooling system
- Reduced noise emission

Energy consumption: 18,000 kWh/a

Energy savings: 10,000 kWh/a
1,000 €/a **

CO₂ reduction: 2.4 tCO₂/a *

- 34 %

* CO₂ Emission: 0,24 kg CO₂/kWh
** Current price: 0,10 €/KWh
Thank you!!!