Pump System Energy Efficiency and Smart Pump Demonstrator

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Top10
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Profile

- **Researcher**
  - Motor system energy efficiency
  - Appliance energy efficiency standards and labels
  - Cooling efficiency
  - Industrial IoT standardization

- **Programmer**
  - Embedded device and system
  - IoT cloud OPC UA server
  - Web application
  - Web crawling

- **Coordinator**
  - International cooperation
  - Technology transfer
Table of content

• Motor system efficiency is the key approach
• Training is the most cost-benefit method
• Smart pump demonstrator – from Switzerland to China
• Smart pump demonstrator platform
• Pump system efficiency cases
• Innovative international cooperation pattern
Fluid systems consume major industrial electricity

- Key motor systems in industries
  - Pump systems
  - Fan systems
  - Air compressor system
- It is not only a problem for motor, but also for fluid systems.

*China industrial motor system energy consumption
System efficiency and saving are the key factor

- System efficiency is the multiplicative results of all component efficiency
- The lowest efficiency component decides the whole system efficiency: Barrel effect
- Replacing high efficient motor has limited improvement of system efficiency
IEC motor efficiency classification

![Graph showing efficiency vs. motor rated power for different IE classes.](image-url)
Motor system optimization can gain the biggest saving potential.

Considerable energy saving can be achieved by low or even no cost!!!
Effective training is the key factor of success
Swiss Pump Demonstrator
Pump Demonstrator China Version

- 1 big pump and 4 small pumps to simulate operation load
- Operable and adjustable
- Remotely controlled
- Instant data sampling
- Cloud data receive and publish service
- Web and professional client software
- Apply to other industrial devices and systems
Pump demonstrator 3D
Innovation: Digitalization and standardization

Smart sensors and meters

VFD

Flow

Pressure

Power

Data gateway

OPC Cloud Server

Graphical, dynamical clients

OPC UA Protocol
Global accessible web portal

https://pd.scinergyiot.com:7006/
Please register and experience
Web training client – virtual control panel

Everyone has a set of digital and dynamic data display panels!!!
Remote training
Five most important points for efficient pump system

• **Design**: design the system for effective and proper application conditions (water requirement, heat requirement)

• **Losses**: investment on minimum energy losses layout (short lines with large cross section, no unnecessary throttles and bends of the network)

• **Variable operation**: adjust amount of water and pressure under on-demand control

• **Frequency converter**: control the speed of the driving motor (instead of throttle or step switching)

• **Efficient motor**: high efficient motor adapted to pump for needs and speed
Practice 1: how rotating speed affects system flow, pressure and power?

Motor rotating speed:  \( \text{RPM} = \frac{60 \times \text{Frequency} \times 2}{\text{Poles}} \)

Nominal rotating speed under 50 HZ
- 2 poles: 3000 RPM
- 4 poles: 1500 RPM
- 6 poles: 1000 RPM
- 8 poles: 750 RPM
Practice 1: how rotating speed affects system flow, pressure and power?

\[
Q_2 = Q_1 \cdot \left(\frac{V_1}{V_2}\right)^4
\]

\[
H_2 = H_1 \cdot \left(\frac{V_1}{V_2}\right)^2
\]

\[
P_2 = P_1 \cdot \left(\frac{V_1}{V_2}\right)^3
\]

V: Frequency
Q: Flow
H: Pressure
P: Power
Practice 2: replacing in-efficient motor with efficient motor can save expected energy?
Replacing in-efficient motor with efficient motor can save expected energy? – not for pump system

<table>
<thead>
<tr>
<th>Increase number of revolutions</th>
<th>Increase input and output power of pump</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td>3%</td>
</tr>
<tr>
<td>2%</td>
<td>6%</td>
</tr>
<tr>
<td>3%</td>
<td>9%</td>
</tr>
<tr>
<td>4%</td>
<td>12%</td>
</tr>
<tr>
<td>5%</td>
<td>16%</td>
</tr>
</tbody>
</table>
Practice 3: how valve control affect flow, pressure and power?
Practice 4: why VFD can save energy? - Theoretic figure
Practice 4: why VFD can save energy? - practical
Practice 4: why VFD can save energy? - practical
Practice 5: how VFD can automatic control system? - PID control
Practice 6: how to combine fixed + variable speed pump systems?
Practice 7: will partial load reduce efficiency?

- System base power: 290W

<table>
<thead>
<tr>
<th>System power (W)</th>
<th>VFD Frequency (HZ)</th>
<th>VFD Input Power (W)</th>
<th>VFD Load (%)</th>
<th>VFD Output Power(W)</th>
<th>VFD Power Loss(W)</th>
<th>VFD Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>475</td>
<td>15</td>
<td>185</td>
<td>2.7</td>
<td>75</td>
<td>105</td>
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<tr>
<td>640</td>
<td>20</td>
<td>350</td>
<td>6.4</td>
<td>140</td>
<td>210</td>
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<td>595</td>
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<td>390</td>
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<td>940</td>
<td>21.6</td>
<td>350</td>
<td>590</td>
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</tr>
</tbody>
</table>
Practice 8: how IoT technology can support efficiency improvement?

• Device communication protocol: analog, Modbus, I2C, etc
• Cloud communication protocol: OPC UA
• System status monitoring
• System remote control
• System data persistent and storage
• System data analysis and optimization plan
• Energy efficiency AI or expert system
Swiss Pump Demonstrator
International cooperation pattern

HEIG
Swiss
Original Design
Intellectual Property Owner

Impact Energy
Swiss Promoter and Coordinator

IP authorization

Scinergy Zhenjiang
China Technology Transferee

IP authorization

Pump
Demonstrator
China

Develop

Topmotors
Training material

Develop

R&D Funds

Zhenjiang Bureau of Science and Technology

R&D Funds

Swiss SDC
Thank You!

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