Holistic Pump System Designs:

Optimizing Pump & Process Efficiency
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# Pumping Systems Are Energy Intensive

<table>
<thead>
<tr>
<th>Industry Type</th>
<th>Pump Energy (% Total Motor Energy Usage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petroleum</td>
<td>60%</td>
</tr>
<tr>
<td>Forest Products</td>
<td>30%</td>
</tr>
<tr>
<td>Chemicals</td>
<td>25%</td>
</tr>
<tr>
<td>Food Processing</td>
<td>20%</td>
</tr>
<tr>
<td>Primary Metals</td>
<td>10%</td>
</tr>
</tbody>
</table>

A 200 Hp Pump uses ≈ $50,000 / Yr in Electricity

- MECS 1994, Bureau of Economic Analysis 1997
- Census of Manufacturers, 1993
Pump Energy Savings Potential

50 – 500 Hp Pumps use 60% of total Pump Energy

Energy savings help justify reliability projects!
Finnish Technical Research Center Report:
"Expert Systems for Diagnosis of the Condition and Performance of Centrifugal Pumps"

Evaluation of 1690 pumps at 20 process plants:
  • Average pumping efficiency is below 40%
  • Over 10% of pumps run below 10% efficiency
  • Major factors affecting pump efficiency:
    • throttled valves
    • pump over-sizing
  • Seal leakage causes highest downtime and cost
Excessive Valve Throttling is Expensive

- Higher energy consumption
- Lower process reliability
- Poor process control
  - increased variability
  - manual operation

Control engineers need to consider the pumping system as an integral part of the automation architecture.
Processes Often Are Not Well Controlled

...process variability exists, in many cases, not because of the raw materials or variations due to natural causes, but because process variability has been introduced into the process through design selection or the adjustment of process and control equipment.”

Source: EnTech Report V11.2
www.emersonprocess.com/entechcontrol/download/
Processes Often Are Not Well Controlled

“Unfortunately, the tendency to oversize control valves has not changed significantly. With each design engineer applying an extra safety margin to avoid the possibility of undersizing

….. most valves end up being too big and operate as low as 15% open on startup…usually makes good process control nearly impossible.”

Source: EnTech Report V11.2

www.emersonprocess.com/entechcontrol/download/
Some Fundamentals

Fixed vs. Variable Speed Pumping
Basic Pump Curves

Pump Curve:
- Motor Speed
- Impeller Diam.

System Curve:
- Static Head
- Friction Head

The operating point is at the intersection of the pump and system curves.

H = Head
Q = Flow

= operating point
• Valve throttling results in excess power consumption
• Excess energy noted in blue area.
• Bypass lines consume excess power consumption.
• Excess energy noted in blue area.
Thrust Brg. Horz.
Overall Vibration Vs. Flow
Fixed Speed with Control Valve vs Variable Speed

Stock Pump

- Test 11 Variable Speed Test 17.5" Dia
- Test 1 1785 Rpm 17.5" Dia

BEP = 1500 GPM
Reliability Issues Relative to BEP
Pump Performance Curve
Variable Speed: *Maximizes HQ Flexibility*

N = Speed
• Variable speed control meets the exact flow and head requirements
• No excess energy is consumed!
Energy savings are possible because of affinity laws.

Speed reduction provides significant energy savings at partial load.

The reduction of the speed provides:

- Flow reduction according to the linear function
- Head reduction according to a square function
- Power reduction according to a cubic function!

\[ P = \text{Power} \]
Variable Speed Control

Opportunities and Benefits
U.S. Motor Systems
Market Opportunity Assessment

“Motor systems equipped with VSD’s account for only 4% of motor energy usage, compared to the potential for application on 18 - 25% of the total energy used…”

Source: DOE-Office of Industrial Technology
Pumping System Elements

Traditional Pumping System
(Fixed speed pump, control valve, transmitter)

Variable Speed Drive Pumping System

Control loops are tightly associated with pumping systems

“Impacted by process changes”

“Adapts to process changes”
Paper Machine Rebuild
VFD Savings Potential for 30 Pump Systems

**LCC Analysis of 30 pumps w/VFD:**
- **Capital Cost Savings:** $230K U.S.
- **LCC Savings (15 yrs):** $5.6M
- **NPV (15 Yr):** $2.7M
- **Ave. Payback Period:** 2 months

“Motor and Valve Performance Can Make or Break Your Bottom Line”
<table>
<thead>
<tr>
<th>Service</th>
<th>Initial Capital Savings</th>
<th>Installation Savings</th>
<th>Total Installed Cost Savings</th>
<th>(15 yr) Energy Savings</th>
<th>(15 yr) Maintenance Savings</th>
<th>(15 yr) Total Savings</th>
<th>Payback (months)</th>
<th>Net Present Value (NPV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dilution Pump From No 3 PM</td>
<td>$1,206</td>
<td>$14,006</td>
<td>$15,212</td>
<td>$57,169</td>
<td>$31,748</td>
<td>$88,917</td>
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<td>$53,956</td>
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<td>Uncoated Broke Storage</td>
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<td>$10,116</td>
<td>$11,432</td>
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<td>$14,559</td>
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<td>$696</td>
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<td>Cleaner Final Stage Feed</td>
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<td>$4,582</td>
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<td>GW Storage Diluted</td>
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<td>Saveall Chest pump</td>
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<td>$8,582</td>
<td>$63,536</td>
<td>$30,045</td>
<td>$93,581</td>
<td>Immediate</td>
<td>$27,451</td>
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<td>Saveall Filtrate Pump</td>
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<td>GWHD Storage</td>
<td>($3,304)</td>
<td>$5,496</td>
<td>$2,192</td>
<td>$124,475</td>
<td>$31,699</td>
<td>$156,174</td>
<td>3.6</td>
<td>$72,869</td>
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<tr>
<td>Totals Installation Cost Savings</td>
<td>($98,911)</td>
<td>$328,146</td>
<td>$229,235</td>
<td>$4,685,803</td>
<td>$913,550</td>
<td>$5,599,353</td>
<td>1.7</td>
<td>$2,742,615</td>
</tr>
</tbody>
</table>

- Mean Payback Period: 1.7
- Total Net Present Value (NPV): $2,742,615
- Mean Net Present Value (NPV): $94,572
Asset Management

utilizing

Pump Intelligence
Asset Management Software
Operations, Maintenance and Engineering Support
RCM Reduced Pump Bearing and Motor Failures

The mill was applying VFDs on pumps during the years included in this study.

TAPPI Solutions! Magazine: GP Old Town
September 01, 2001 Vol. 01, No. 01
RCM Steadily Increased Plant Availability

The mill was applying VFDs on pumps during the years included in this study.
Optimizing Pump System Performance
A Systems Design Approach
The Systems Approach

- Focusing on individual components often overlooks potential design and operating cost-savings.
- Future component failures are frequently caused by initial system design.
- Use a LCC approach in designing systems and evaluating equipment options.

Diagram:

1. Electric utility feeder
   - Transformer
   - Motor breaker/starter
     - Adjustable speed drive

2. Motor
   - Coupling
   - Pump

3. Fluid System

Ultimate Goal
Prescreening Methodology

First: Can it be turned off?

Primary screening

1) Size and time
AND
2) Load type

Back burner stuff:

Small Loads:
- Low Run Hours,
- Non-centrifugal loads

Secondary screening

Symptom-based

Analysis-based

Focus here

Properly Matched Pump:
- System Need = Supply

Source: DOE - OIT
Pump Symptoms that Indicate Potential Opportunity

- Throttled valve-controlled systems
- Bypass (recirculation) line normally open
- Multiple parallel pump system with same number of pumps always operating
- Constant pump operation in a batch process or frequent cycle operation in a continuous process
- Presence of cavitation noise (at pump or elsewhere in the system)
**Energy Savings Methods**

<table>
<thead>
<tr>
<th>Action</th>
<th>Saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replace throttling valves with speed controls</td>
<td>10 - 60%</td>
</tr>
<tr>
<td>Reduce speed for fixed load</td>
<td>5 - 40%</td>
</tr>
<tr>
<td>Install parallel system for highly variable loads</td>
<td>10 - 30%</td>
</tr>
<tr>
<td>Equalize flow over product cycle using surge vessels</td>
<td>10 - 20%</td>
</tr>
<tr>
<td>Replace motor with more efficient model</td>
<td>1 - 3%</td>
</tr>
<tr>
<td>Replace pump with more efficient model</td>
<td>1 - 2%</td>
</tr>
</tbody>
</table>

*Source: DOE - Office of Industrial Technology*
Pump Optimization Benefits Summary

- Reduce Energy and Maintenance Cost
- Improve Pump and Process Reliability
- Increase Process Uptime and Throughput
- Improve Process Control & Quality
  - less variability
  - higher % of loops in automatic
- Reduce Fugitive Emissions
High Reliability Impact VFD Applications

• Mill Water Supply
  - Pressure control
• Seal Water Supply
  - Pressure control
  - Reduce process downtime
• Stock Blending
  - Consistency control
  - Improve product quality
• WW Dilution
  - Consistency control
• Machine Chest
  - Basis Weight MD control
  - Improve PM performance
• Broke Chest
  - Reduce Energy & Maintenance
• Repulper Chest
  - Reduce Energy & Maintenance

“There are many high impact applications that improve bottom line performance”
Holistic Pump System Designs

Thank You!

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