Pump System Energy Saving Practices

April 10, 2013

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Quiz Questions:
What do you already know about pump system energy practices?

1. Which of the following industries has the biggest potential for savings by enhancing the energy-efficiency of its pump systems?
2. What is the amount of the cash incentive provided by ActOnEnergy an eligible VFD for a motor less than or equal to 500 horsepower?
3. Which of the following is caused by excessive valve throttling?
April 10, 2013

“No Longer An Academic Theory: Pump System Energy Practices That are Saving Some Plants Millions”
Mike Pemberton
Manager, Energy Performance Services

- Former co-chair, Pumps Systems Matter education committee


- Served on the committee that developed the ASME “Energy Assessment for Pumping Systems” guidance standards
Industrial Plant Objectives

• Boost energy efficiency
• Lower maintenance costs
• Improve process control
Agenda

• Pump efficiency -- opportunity and need

• The relationship between energy, reliability and process control

• Three (3) industrial case studies
  • Paper-mill: machine save-all supply – 6 years no maintenance
  • Corn Processing - Lysine Microfiltration – VFD App w/ Wide Utility
  • Food processing: cooling tower system -- $0.5M+ Savings

• Keys to a successful energy efficiency project
Pump Electrical Energy: Savings Potential

Blue Bars: Pump Energy Savings Potential

GWhr / Year

• Average pumping efficiency at process plants: < 40 % BEP
  – Over 10 percent of pumps run < 10% BEP
  – Finnish Technical Research Center Study

• Over 13.5 million electric motors convert electricity into useful work (U.S. industries)

• Industry spend $33B annually for electricity dedicated to electric motor-driven systems
  • U.S. Department of Energy

• Improvements in motor systems and management can yield energy savings up to 42 %
  • ACEEE reference manual: Energy Efficient Motor Systems
Excess Energy is a potential Resource

Think of energy efficiency as having a large, accessible pool of low cost fuel at your finger tips and all you have to do is make the investment to tap this abundant source.”
Why Haven’t Plants Invested More in Efficiency?

• **Competition for capital**
  - Projects focused on production, like capacity expansion or modernization, are perceived to have higher value
  - Benefits of efficiency are seen as ambiguous and hard to measure

• **Lack of dedicated resources**
  - In-plant focus on short-term “firefighting” issues

• **Lack of Experience with energy efficiency projects**
  - Executives fail to see the connection between energy, equipment reliability and process efficiency

The traditional approach is, “When in doubt, don’t.” Should no longer apply to energy efficiency projects.
One Interconnected System

- Energy Usage
- Process Control
- Equipment Reliability
Pump System Impacts on Process

Excess Energy Use ≈ Lower Reliability

• Highest process equipment maintenance costs
• Major source of process leaks & fugitive emissions
• Pump and valve dimensioning degrades process control
Excessive Valve Throttling is Expensive

• Lowers pump and process reliability
• Higher energy consumption
• Sub-optimal process control
  – Increased variability
  – Manual operation

Control loops are tightly associated with pumps
Studies show that the majority of control loops actually increase process variability.

**The Effect**

**Loops**
- 20%
- 30%
- 30%
- 20%

**The Cause**
- Design
- Tuning
- Control Valve Performance

Source: Emerson™ Entech --- Results from over 300 Plant Audits in North America
Case Study #1: Paper Machine
Save-all Supply Pump
Save-all Supply Pump: Application

Moving paper stock from the supply chest to the save-all vat
Save-all Supply Pump: Issues & Specs

**Issue**: Top 5 chronic pump failure & top 5 vibration – mill-wide list

- 12x10-17 PWO AC centrifugal pump

- Design point – 7000 gpm @ 102ft & 79% efficiency, (NPSHr) = 23 ft

- Pump has a 300 Hp motor and 15.5” impeller running at 1800 rpm
Save-all Supply Pump: Interim Fixes

- Extensive Root Cause Failure Analysis (RCFA)
- Installed new/rebuilt pump rotating assemblies, suction wear plates, etc.
- Performed precision alignment on pump and motor set
- Installed new and balanced impellers (G1)
- New casing installed
- Installed new motors
## Save-all Supply Pump: Technical Improvements

A Larger (6v) pump operating at a slower speed, near the BEP

<table>
<thead>
<tr>
<th>Pump</th>
<th>Impeller Size/vanes</th>
<th>Speed (Rpm)</th>
<th>Efficiency (%)</th>
<th>BHP</th>
<th>Shaft Stiffness</th>
<th>Motor Temp</th>
<th>Thermal Misalign</th>
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</thead>
<tbody>
<tr>
<td>(12x10x1 PWO)</td>
<td>15.5 / 4</td>
<td>1800</td>
<td>79</td>
<td>254</td>
<td>39</td>
<td>190</td>
<td>0.005</td>
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<tr>
<td>14x14x2 3175L</td>
<td>18.75 / 6</td>
<td>900</td>
<td>84</td>
<td>187</td>
<td>7</td>
<td>115</td>
<td>0.001</td>
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</table>

<table>
<thead>
<tr>
<th>Pump</th>
<th>Key (lbs)</th>
<th>Vibration (in/sec)</th>
<th>Suction Specific</th>
<th>Suction Energy x10^6</th>
<th>NPSH(r)</th>
<th>Noise, db</th>
<th>Temp, F</th>
</tr>
</thead>
<tbody>
<tr>
<td>12x10x1 PWO</td>
<td>18</td>
<td>0.70</td>
<td>14086</td>
<td>274</td>
<td>23</td>
<td>67</td>
<td>155</td>
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<tr>
<td>14x14x2 3175L</td>
<td>0</td>
<td>0.08</td>
<td>12467</td>
<td>141</td>
<td>11</td>
<td>42</td>
<td>125</td>
</tr>
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</table>
Save-all Supply Pump: Economic Results

Lower Energy Costs / Reliability Improvement

Energy Improvement:

• Approximately $25,000 annual energy savings; 50% simple ROI on project

• 10 year life cycle cost savings projections (old $735K – new $497K = $238K)

Reliability Outcome:

• 26 years of poor pump reliability solved

• Cavitation was completely eliminated

• The new pump has run for 7 years with $0.00 maintenance cost:
  – Expect 7 – 10 year MTBF, possibly longer
ADM Pumps Up the Savings

• Since ADM has pumps and fans at almost every facility, they used the ActOnEnergy Staffing grant to hire the best pump experts in the field.

• In early 2012, Mike Pemberton conducted a study that identified a number of quick fixes that led to an impressive payback for ADM.

• The studies also recommended the use of two variable frequency drives (VFD) that allow ADM to slow down lysine, fructose and dextrose pumps, rather than closing their associated valves off entirely.
Ultrafiltration System for Amino Acids

- Goulds Model 3175, size 14x14-22 @ 800 HP, 1180 RPM
  - Average normal flow rate is 5000 – 5200 gpm @ 238 ft
  - Operates below the recommended minimum flow rate at 45% of BEP
- System uses 100 psi Pressure Control into UF Filters
  - As filter plugs the control valve throttles to maintain 100 psi
  - As flow reduces to 1500 gpm due to plugging a cleaning cycle is started
- Recommendations & Options
  - Trimming Impeller will lower System Head from 238’ to 188’ and save $36K/yr (112 kW)
  - Remove the 800 hp motor & control valve and install 350 HP VFD tp Implement VFD Pressure Control (≈65 psi) -- due to a 40 psi suction pressure; Operating at a lower speed (~900 rpm) will reduce energy & improve pump reliability (~25% Speed Reduction)
  - Will now use 265 hp vs. current 546 hp & save $68K/yr (212 kW)
  - Project Payback ≈21 months; Reliability Ratio MTBF =8.1
Ultrafiltration System (Trend)

- 98 - 102 PSI
- Flows Average 5000 - 5200 gpm
5100 gpm is at minimum flow.
Case Study #3:
Food Processing Plant
Cooling Tower Pump System
Cooling Tower Pump System: Application & Issues

Situation:

– Food processing facility requires 60,000 gpm in the winter and 90,000 gpm in the summer.

– This typically requires operating between 11 and 15 parallel pumps running to pump out of the cooling tower basin to meet process demand.

Challenge:

– The 400 Hp vertical pumps operated against isolation valves that were 40% open, on average, to ensure the over-sized pumps did not run too far out on the pump curve and trip the motors.
Removes Waste Heat
Cooling Tower Pump System: Analysis

Parallel Composite Pump Curves

All parallel pumps are the same size
Flow increase very small with additional pumps (in this case)
Cooling Tower Pump System: Analysis

System Curve with Parallel Pumps (B)

Flow increase much larger with additional pumps (in this case)
System Curve with Parallel Pumps (C)

Flow increase even larger with VFD Pressure Control

Flow rate

Head

One Pump
Two Pumps
Three Pumps

System Curve

VFD

Flowrate
Cooling Tower Pump System: Analysis

Fifteen (15) vertical pumps running at 68 psig (157 ft) typical for Summer months
Cooling Tower System: Results (7) Pumps Off

Eight (10) vertical pumps (min imp) running at 62 psig (143 ft) for Summer
Cooling Tower Pump System: Recommendations & Results

Recommendations:
- Trim the two-stage impellers to minimum diameter (14.5") and fully open (100%) the isolation valves to increase flow from 3500 gpm to 5500 gpm.

- The ~2000 gpm increase per pump has allowed the cooling tower system to meet summer seasonal demand with (5) seven less pumps in operation; from 15 to 10 pumps.

Results:
- Save 311 Hp x 0.746 kW/Hp x $0.038/kWhr x 8640 Hrs/Yr x 5 pumps (off) = **$380K/Yr** savings!

- The Ameren Illinois cash incentives for this project are over $100K, which brings the total first year savings to approximately **$480K/1st Yr.**

(Note: Average amp draw dropped from 440 to 405 per pump, which is an average of 35 amps less.)
Ways to Successfully Execute Energy Efficiency Projects
Prescreening Methodology

Identifying the best candidates (10% to 20% of population) to start

First: Can it be turned off?

Primary screening

1) Size and time AND 2) Load type

Secondary screening

Symptom-based Analysis-based

Focus here

Back burner stuff:

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

Properly Matched Pump:
- System Need = Supply

DOE: Pump System Assessment Training Course
Pump Symptoms that Indicate Potential Opportunity

- Throttled valve-controlled systems
- Bypass (recirculation) line normally open
- Constant pump operation in a batch process
- Frequent cycling on/off in a continuous process
- Presence of cavitation noise (at pump or valve)
- Multiple parallel pump system with all units always on

Check Repair History
Energy Efficiency Methods

- **Identifying Energy Savings Helps Justify Reliability Projects**

<table>
<thead>
<tr>
<th>Action</th>
<th>Energy Savings</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*
The Systems Approach

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

**Ultimate Goal**

**Electric Utility Feeder** → **Transformer** → **Motor Breaker/Starter** → **Adjustable Speed Drive** → **Motor** → **Coupling** → **Pump** → **Fluid System**

*DOE: Pump System Assessment Training Course*
A Good Implementation Resource from the DOE

Download the Implementation Guide

To access a copy of Guiding Principles for Successfully Implementing Industrial Energy Assessment Recommendations TODAY, go to:
http://www1.eere.energy.gov/industry/pdfs/implementaten_guidebook.pdf
1. Assign the right people
2. Make them accountable
3. Clearly assess and communicate the potential benefits of the study
4. Treat the study and implementation as one comprehensive project
Key Points About Improving Efficiency

- Wasted energy converts to heat and vibration that degrades equipment reliability

- Optimizing efficiency could save industry billions in energy and maintenance costs

- Proper sizing is important, but doesn’t guarantee efficiency

- Simple screening methods can identify top optimization targets
  - Modern VFDs are a reliable, cost effective tools

- A systems approach that integrates process and equipment data will yield best results
The Ameren Illinois ActOnEnergy® Business Program

Over $30 million in energy-efficient cash incentives
VFD Incentives Available from Ameren Illinois ActOnEnergy

For new projects that add VFDs to motors and pumps, ActOnEnergy will cover up to 75% of your project costs for a quicker payback.

<table>
<thead>
<tr>
<th>Motors less than or equal to 500 horsepower</th>
<th>$90/horsepower controlled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motors greater than 500 horsepower</td>
<td>8 cents/kWh saved</td>
</tr>
</tbody>
</table>

ActOnEnergy.com
Staffing Grant

Need a hand getting your energy efficiency project off the ground?
A Perfect \{Motor\} Match.

Now through May 31, get a 30% cash bonus for VFD projects.
Resources

- Website: ActOnEnergy.com/Business
- Phone: 1.866.800.0747
- Fax: 1.309.677.7950
- Email: ActOnEnergyBusiness@Ameren.com
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3. Which of the following is caused by excessive valve throttling?
Ameren Illinois helped my facility
SAVE $85,000 each and every year!
—John P. Pekin Hospital
2012 ActOnEnergy® Business Symposium attendee

May 21: East Peoria Embassy Suites | May 22: Collinsville Gateway Center
Questions?

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