

Pumping 101: Pumping System Optimization

Or

*How to Make Money From Your
Pumping Systems*

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Agenda

- Why care about pumping systems?
- The systems approach
- Improvement opportunities
- PSAT
- Action plan

Credits

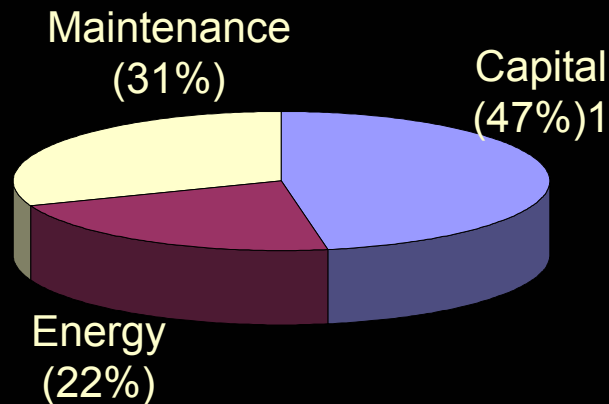
- US DOE Office of Industrial Technology (OIT)
- Lawrence Berkley National Labs

Why Care About Pumping Systems?

- Most industrial and municipal plants rely on pumping systems for their daily operation.
- Pumping system operation can be expensive.
- These systems often have significant opportunities for performance improvement.

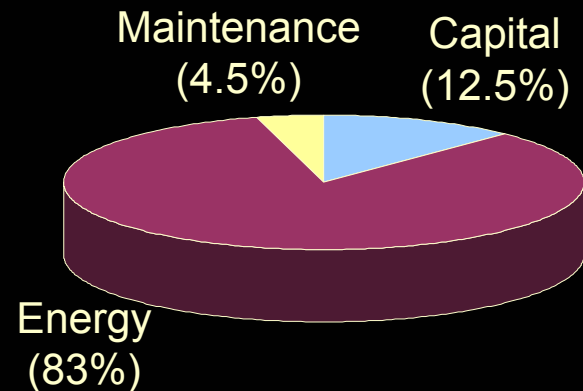
Perspective: Energy Cost with Respect to Life Cycle Cost

Delivery Van



\$25,000 capital cost
15 miles per gallon
20,000 miles per year
10 year life

Pump



\$60,000 capital cost
200 bhp pump
Operates 6,000 hrs/year
at 75 percent load factor
10 year life

Your mileage may vary

Pumping Systems are Often Energy Intensive

	Pump Energy Use as a Percentage of Total Electricity
Petroleum	50%
Forest Products	26%
Chemicals	17%
Food Processing	12%
Primary Metals	3%

A 200 hp pump operating 6,000 hours/year at 75 percent load factor uses about \$57,530 in electricity annually.

Pumping System Costs at a Large Paper Mill

Revenue (sales): \$100,000,000/yr.

Operating costs: \$95,000,000/yr. (assuming a 5% margin)

Motor system energy costs: 2.6% of operating costs

Pumping system energy costs: 31% of total motor energy costs

Improving overall pumping system efficiency by 20% results in savings of \$153,140/yr.

Affect on margin: Increase margin from 5% to 5.15%.

Without the project, revenue (production) would need to increase by \$3,062,800/yr to increase profits by \$153,140/yr.

Pumping Systems are Often Essential to Plant Operation

Common applications include:

- Cooling water supply*
- Waste water removal*
- Process heating*
- Process fluid transfer*
- Dewatering*

Pumping system failure can often bring production to a halt.

Systems Approach to Improvements

- Reduce loads – flow or pressure
- Improve the pump - efficiency, application (size), drive coupling
- Improve the motor - efficiency, sizing
- Improve the drive system - on/off and speed control

Opportunities

- $\text{power} = H \times Q \times k / (\text{eff}_1 \times \text{eff}_2 \times \text{eff}_3 \dots)$
(most systems)
 - Reduce the pressure loss (head)
 - Reduce the mass flow (volume)
 - $Q = m \times Cp \times \Delta T$
 - Increase efficiency
 - $\text{kW}_{\text{saved}} = L \times \text{hp} \times .746 \times (100/\text{EFF}_{\text{exist}} - 100/\text{EFF}_{\text{new}})$
- $\text{Energy} = \text{power} \times \text{time}$
 - Reduce the run time

Pump Affinity Laws

$$\text{Flow}_1 = \left(\frac{\text{Speed}_1}{\text{Speed}_2} \right) \text{Flow}_2$$

$$\text{Head}_1 = \left(\frac{\text{Speed}_1}{\text{Speed}_2} \right)^2 \text{Head}_2$$

$$\text{Power}_1 = \left(\frac{\text{Speed}_1}{\text{Speed}_2} \right)^3 \text{Power}_2$$

Improvement Opportunities

- How much fluid do you really need?
 - Decrease peak or design volume
 - Control volume to meet loads
- Decrease pressure losses
 - Structural losses - Improve piping configuration
 - Control losses
- Reduce pump speed or install appropriate speed control devices
- Consider alternative pump configurations
- Improve O&M practices

Reasons Why Opportunities Exist

- Lack of a systems approach during the design process
- Overly conservative or improper pump selection, resulting in poor performance
- Improper installation or operation
- Poor maintenance
- System requirements change over time

Opportunity: Reduce Flow

- Determine whether a pump can be turned off:
 - For example, the system no longer requires full flow and more pumps in a multiple pump configuration are operated than necessary.
- In some systems, the flow is higher than required:
 - Common causes: overly conservative design, change in the system demand without a change in the pump operation, lack of control valves.
 - Indications: many highly throttled flow control valves or extensive use of bypass lines, low temperature differences.

Opportunity: Match Pump to Actual Requirements

- The tendency to oversize pumps can be the result of several factors, including:
 - Overly conservative design practices
 - Anticipation of an increase in required capacity
 - Poor information on actual requirements
- Corrective actions:
 - Install a smaller impeller or trim the existing one
 - Remove stages
 - Downsize pump
 - Install a smaller and/or a more efficient pump motor
 - Replace worn impellers.

Case Study: Peabody Holding Company



Randolph Coal Preparation Facility

Case Study: Peabody Holding Company

- Action:
 - Downsized a pump. Replaced the casing and impeller with smaller components.
 - Performed basic maintenance on the V-belt drive, reducing efficiency losses.
- Results:
 - These upgrades resulted in improved reliability, lower system wear, and a 3.3 year payback in energy savings alone.

Case Study: Strohs Brewery



Strohs Brewery

Case Study: Strohs Brewery

- Action:
 - Trimmed a pump impeller, reducing pump output and the load on the pump motor.
 - Increased system efficiency by requiring less throttling of the flow control valve.
- Results:
 - Project costs of \$1,500 and annual energy savings of \$19,000 resulted in a payback of less than **one month** on energy savings alone.

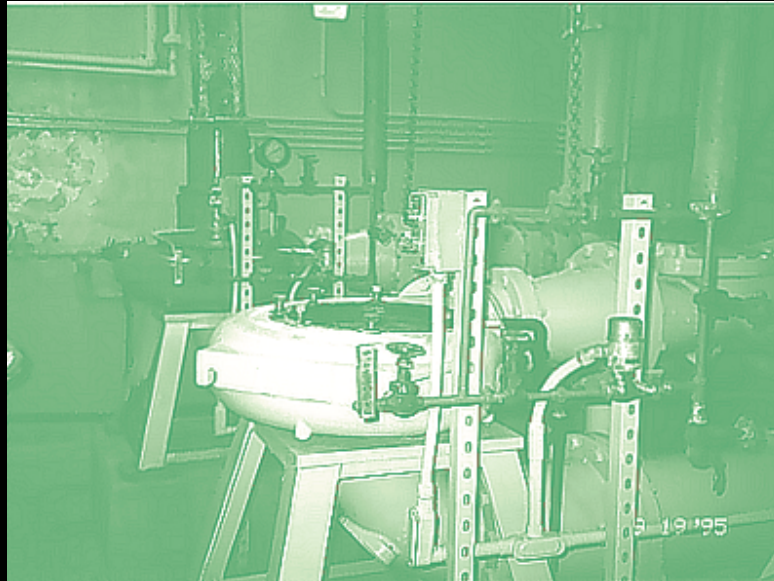
Opportunity: Reduce Pump Speed

- Consider installing a slower speed motor.
- In belt drive applications, changing sheave diameters can reduce pump speed (be cautious of increased torque on the motor).
- In applications where pumping requirements vary widely, speed control can provide attractive energy savings.

Opportunity: Alternative Pump Configurations

- Consider the use of a small pump (pony pump) in combination with a large pump. Operating the pony pump during normal conditions and the large pump during high flow conditions can increase average efficiency.
- Consider multiple pumps in parallel, energizing or de-energizing pumps as necessary allows effective load following.

Case Study: City of Milford



City of Milford Pumping Station

Case Study: City of Milford

- Action:
 - Installed a pony pump to improve the average pumping system efficiency.
 - Operating the pony pump in normal conditions and using the existing pump only in high demand conditions reduces the wear and tear of frequent pump starts.
- Results:
 - Energy and maintenance savings resulted in a 1.7 year payback.

Case Study: General Motors Automotive Plant



General Motors Pontiac Facility

Case Study: General Motors Automotive Plant

- **Action:**
 - Reconfigured the cooling water pumping system to take advantage of city water head pressure.
 - Installed adjustable speed drives to improve average system efficiency.
 - Isolated parts of the system that no longer required service.
- **Results:**
 - Increased system reliability and reduced operating costs.

Improve O&M Practices

- Establish basic system maintenance checklists and schedules.
- Predictive maintenance techniques improve reliability via early detection of equipment problems.
- In standby pump applications, the pumps should be periodically operated to lubricate bearings and to prevent damaging the wear surfaces.

How to Evaluate Improvement Opportunities

- Pumping System Assessment Tool (PSAT) 2000: Helps users identify and prioritize improvement opportunities. Contains a prescreening tool that can assist in identifying the more feasible options.
- DOE BestPractices publication, *Improving Pumping System Performance: A Sourcebook for Industry*.
- Take advantage of training seminars to increase awareness of improvement opportunities.

PSAT: Purpose and Scope

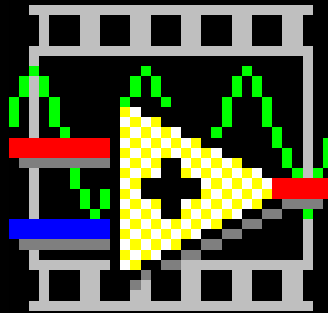
- Help end users, ranging from operators to engineers, identify systems worthy of further consideration (an extension of a pumping system prescreening process)
- Generate "What if" assessments, following the system head-capacity curve
- System loss shedding opportunity assessment
- Limitations:
 - Only 2 through 8 pole motors included in database
 - Several common pump styles are not included, for example:
 - "Plain" vertical turbine
 - Submersible
 - No explicit provision for adjustable speed drives

PSAT

General Methodology

- Uses measured fluid, electrical data
- Extracts average motor performance characteristics from the MotorMaster database
- Employs Hydraulic Institute algorithms for achievable pump efficiency
- Estimates existing, "optimal" pump and motor efficiencies and associated operating costs

PSAT Demo



Systems Approach to Manage Pumping System Operation

- Focusing solely on individual components overlooks potential cost-savings.
- Component failures are often caused by system problems.
- Use a life cycle cost approach in designing systems and evaluating repair and maintenance options.

Action Plan

1. Perform an assessment, using a systems approach:
 - Look at the end-use requirements first, then determine if the pump is efficiently sized and configured to meet these end use requirements.
2. Look for symptoms of inefficiencies:
 - High energy costs
 - Throttle valves that are generally closed
 - Bypass valves that are generally open
 - Frequent failures or repair requirements
 - High operating noise levels
 - Vibrations in the system and/or pump assembly



Action Plan (cont'd)

3. Document findings.
4. Evaluate improvement opportunities.
Remember to identify, and quantify if possible, added benefits – operability, maintenance, etc.
5. Screen and prioritize improvement opportunities.
6. Implement the most feasible projects
7. Communicate results of successful projects to increase management support.

Selling Projects to Management

- Present energy savings and operating benefits in a way that responds to corporate priorities.
- Operating priorities at most plants include:
 - High productivity
 - High utilization rates - maintaining high reliability (downtime is often prohibitively expensive)
 - Lower operating costs
- Describe projects in the financial language of management.

Ingredients for Success

- Training and workshops
- Case studies
- Discussion forums
- Increase interaction between production and management, share your experience and successes
- Begin with low-risk, quick payback improvements, build on successes

Getting Help

- A number of different resources offer services to improve pumping system performance:
 - DOE's BestPractices Program.
 - Pumping system specialists perform system assessments, troubleshoot performance problems, identify improvement opportunities, and conduct feasibility studies.
 - Pumping equipment manufacturers, manufacturer representatives, and distributors can often help with the selection of suitable components.

Where to Go

- BestPractices website:
www.oit.doe.gov/bestpractices
- OIT Clearinghouse: (800) 862-2086
- DOE BestPractices publication, *Improving Pumping System Performance: A Sourcebook for Industry*:
 - Ordering information is obtainable from the BestPractices website and the OIT Clearinghouse.
- Hydraulic Institute website: www.pumps.org
 - Includes a Life Cycle Cost guide