Efficiency and Life-Cycle-Cost Calculation

Beyond the Purchase Price

Most consumers have a good understanding of the total cost of ownership. After purchasing a car or home or appliance, they realize that with the initial purchase price come the added costs of maintenance, taxes or fees, repair parts, and energy. Pump purchases need to be viewed this way as well. They need to be installed, maintained, and sometimes repaired. They also require electricity (or other driving means such as air) to run.

Industrial pumps have a long life as well (in some cases 50 years or more). This means that a poor decision can haunt a user for many years. For this reason, it's critical to consider a pump's total Life-Cycle-Cost before making this decision.

Calculating the Total Life-Cycle-Cost (LCC)

According to the Hydraullic Institute (www.pumps.org), life-cycle-costing for pumps is calculated as following:

$$LCC = C_{ic} + C_{in} + C_e + C_o + C_m + C_s + C_{env} + C_d$$

Whereas C_{ic} = initial costs, purchase price (pump, system, pipe, auxillary services)

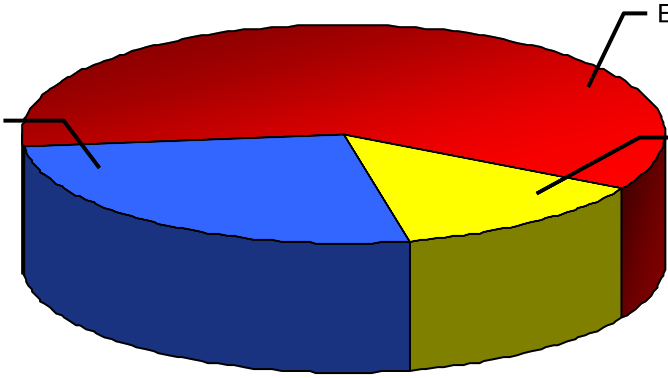
- C_{in} = installation and commissioning cost (including training)
- C_e = energy costs (predicted cost for system operation, including pump driver, controls, and any auxillary services)
- C_o = operation costs (labor cost of normal system supervision)
- C_m = maintenance and repair costs (routine and predicted repairs)
- C_s = downtime costs (loss of production)
- C_{env} = environmental costs (contamination from pumped liquid and auxillary equipment)
- C_d = decommissioning / disposal costs (including restoration of the local environment and disposal of auxillary services)

Each of these values will vary widely in significance from application to application. In industries such as petrochemical or pharmaceutical, downtime costs are substantial which would rule out pumps that require frequent maintenance or which are prone to catestrphic failure. In other cases, perhaps the local code requires special fees for the disposal of certain materials. In that case, added costs would be applied for environmental and/or decomminssioning.

Unfortunately, many pump users lack the knowledge or the foresight to recognize the significance of LCC calculations. All too often, the final decision is dictated by one of the more insignificant costs of the total LCC…purchase price.

The Insignificance of the Initial Purchase Price

At the date of purchase, the quoted price for a pump may seem like the most important matter at hand. In actuallity, the initial purchase price is only a fraction of the pump's total life-cycle-cost (LCC). The chart below represents a pump's total life-cycle-cost over a period of 7 years.



This chart is based on an internal gear pump operating continuously for a period of 7 years and does not account for raises in electricity prices over that period, which would further decrease the significance of the initial purchase price.

Obviously these percentages vary from pump to pump and application to application, but energy costs typically remain the highest single source of cost over a pump's life.

Reducing Energy Costs

Lengthy papers have been written specific to savings from maintenance and parts. And while each should be included in LCC calculations, energy costs remain the largest contributor and yet are often overlooked.

Energy savings can be obtained many different ways. Specific to pumps, the three most common means are to alter the system to decrease the input power requirement, to implement controls to maximize pump efficiency, or to replace inefficient pumps with more efficient models for the application.

System Changes

Unfortunately for system designers, too often a tight budget can trump good foresight. Narrow pipes running through a maze of twists and turns increase the system head required and in turn, the pump power required. Add to that any changes in viscosity, product buildup, or corrosion on the pipe walls, and the power requirement can climb further. Too often, this is only taken into consideration when looking at the size and initial purchase price of a motor. Motors, like pumps, carry the bulk of their price in energy costs over the life of the motor.

For new installations, a bit of foresight can save thousands, but for existing installations this may not be an option.

Energy Savings through Pump Control

Advancements in control technology, decreases in controller prices, and increases in electricity rates have made pump control a popular means of obtaining energy savings. Examples include:

- Use of variable speed drives (i.e. VFD) to control pump flow rate or maintain pressure. VFD use is becoming more and more common for use with centrifugal pumps to keep them running at their best efficiency point (BEP).
- Use of power monitors to track motor power usage and/or shut them down if power deviates. They can be used to keep pumps from running dry or to keep them from running at high pressure.
- Use of PLC or similar logic controls to monitor flows, pressures, power consumption, temperature, etc. These are the most complex and costly, but allow just a few operators to monitor multiple pumps and systems.

Unlike piping and system design, controls are often easy to implement on established pumps. For example: While it may seem like a simple enough concept, many users of unloading pumps leave the pumps running well after the rail car or tanker is empty. This is an obvious waste of energy, not to mention hard on pump. Installation of a power monitor *(figure 1)* takes less than an hour and often pays for itself in energy savings within the first year (and don't forget the added insurance against a pump failure).

Figure 1
Power Load Monitor
(Photo courtesy of Viking Pump, Inc.)

Maximize Pump Efficiency

When selecting a pump it's critical that all the service conditions are known. Changes such as pressure or viscosity variations can dramatically affect a pump's performance and efficiency. Centrifugals for example are designed to run on thin liquids at a set operating point. With different impellers and auxiliary controls they can be configured to operate on moderate viscosity liquids at varying conditions, but are highly inefficient. They also become inefficient at higher viscosities and low flow / high head conditions. See "When to Use a Positive Displacement Pump" for more details.

While rotary PD pumps efficiencies are fairly constant at varying flows and moderate viscosity changes, there still can be differences from application to application and principle to principle.

Pump efficiency is calculated as following:

$$MechanicalEfficiency = \frac{Differential\,Pressure[PSI]\,x\,Capacity[GPM]\,x100}{Horsepower[BHP]\,x1715} \quad \text{(U.S. units)}$$

$$MechanicalEfficiency = \frac{Differential\,Pressure[BAR]\,x\,Capacity[m^3/hr]\,x100}{Horsepower[kW]\,x36} \quad \text{(metric units)}$$

The following tables compare pumps for two applications. The first is for #2 fuel oil at 100 GPM and 100 feet. The second is for the same fuel oil, but at higher pressure. The third is for a thicker liquid, in this case lube oil.

Conditions: #2 Fuel Oil (3 cP), 100 GPM, 100 feet

Pump	BHP Required	Efficiency	Yearly Energy Cost* [$US]
End Suction Centrifugal	3.5 HP	63%	$1,418
Rotary PD - Internal Gear	3.0 HP	72%	$1,215

Conditions: #2 Fuel Oil (3 cP), 100 GPM, 200 feet

Pump	BHP Required	Efficiency	Yearly Energy Cost* [$US]
End Suction Centrifugal	7.8 HP	65%	$3,159
Rotary PD - Internal Gear	6.5 HP	79%	$2,633

Conditions: 80W Gear Oil (150 cP), 100 GPM, 200 feet

Pump	BHP Required	Efficiency	Yearly Energy Cost* [$US]
End Suction Centrifugal	13.8 HP	37%	$5,589
Rotary PD - Internal Gear	7.0 HP	72%	$2,835

** Based on 2007 average of $.062/kWh for US industrial customers*
Average prices vary from approx. $.043 to $.135/kWh worldwide

As viscosity, flow, and pressure vary, so will power and efficiency. The above tables merely illustrate the importance of selecting the appropriate pump for the application and to make sure that energy savings is included in the selection process. The scariest part is that application examples like these are all too commonplace and in a plant with hundreds of pumps, this equates to hundreds of thousands of dollars lost each year due to ignorance or nearsightedness at the date of initial purchase.

The Educated Pump User

This document is not an endorsement of one pumping technology over another. In all examples above, each pump can adequately handle the application. In fact, the educated user may have selected the centrifugal in the first example example based on factors other than energy costs in their LCC calculations.

It's a pretty safe assumption though that energy costs will not be coming down in the foreseeable future. Add to that, local, government, or corporate restrictions on energy usage and this becomes even more critical. Here are some steps to take towards reducing pump energy consumption:

- Run LCC calculations for all new pump installations. Existing pumps should be examined as well.
- "Right size" pumps for the application. Avoid running centrifugals off of their "best efficiency point" and don't misapply them (see charts above).
- Install power monitors to track electricty usage and identify poor performing units. This also helps to avoid running pumps dry or against "dead head" conditions.

An experienced pump representative can assist with this and help perform a pump survey to help identify problems and suggest potential solutions.