Life Cycle Cost Of Centrifugal Pumps In Paper & Pulp Industries For Maximising Profits

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ABSTRACT

This paper deals with the Life Cycle Cost (LCC), of any piece of Equipment is the total "Lifetime" cost - which starts from purchase, install, operate, maintain and dispose of that equipment.

Introduction

Generally, in today's work culture, people only consider the procurement cost neglecting other important costs. Here the procurement cost of an equipment is like a tip of iceberg which does not show the underlying hidden cost. The consideration of only the tip of iceberg is hazardous as the difficulties and hazards generally are hidden in the inside as depicted in Fig.1.

It is clearly seen that consideration of life cycle cost is highly rewarding, after removing all the hidden costs that are being left unattended.

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 similarly. They need to be installed, maintained, and sometimes repaired. They also require electricity (or other driving means such as air) to run.

Fig. 1. Purchase cost - Tip of the iceberg

C.R.I. Pumps Pvt Ltd., Unit : Tuff Pumps, Coimbatore

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 (LCC) before making this decision (1).

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, namely, the purchase price.

Literature Survey

A LCC analysis does not provide an exact number of the costs; it merely gives an insight in the major cost factors and an insight into the magnitude of the costs. The LCC estimate is only an estimate. Estimates can never be more accurate than the inputs and the inputs are often estimates themselves or expert opinions.

Pumping systems account for nearly 20% of the world's electrical energy demand and range from 25-50% of the energy usage in certain industrial plant operations.(1)

Why should an organization care about LCC?

- Most organisations only consider the Initial purchase and installation cost of the equipment.
- It is in the fundamental interest of the plant designer and

manager to evaluate the LCC of different solutions before installation of new plant or major over haul.

- In today's competitive market, organizations must continuously seek cost saving methods, which will improve their profitability.

Fig.2. LCC Analysis for Pumping Systems in Paper & Pulp Industry

- Along with economic reasons, LCC helps in developing awareness about environmental impact of their business and conserving energy as one way to reduce emission, preserve natural resources and reduce carbon foot print. This will also help in reducing emission of Green House gases (CO_2. methane, Nitrous oxide etc.,) (1).

Calculating the Total Life Cycle- Cost (LCC)

- According to the Hydraulic Institute life-cycle-costing for pumps is calculated as following **:**
- **LCC = Cip + Ce + Cm + Co + Cs + Cenv + Cin wherein,**

Cip = Initial purchase price (pump, system, pipe, auxillary services)
Ce = Energy costs (predicted cost for system operation, including pump driver, controls, and any auxillary services)
Cm = Maintenance and repair costs (routine and predicted repairs)
Co = Operation costs (labor cost of normal system supervision)
Cs = Downtime costs (loss of production)
Cenv = Environmental costs & disposal costs (contamination from pumped liquid and auxiliary equipment)
Cin = Installation and commissioning cost (including training)

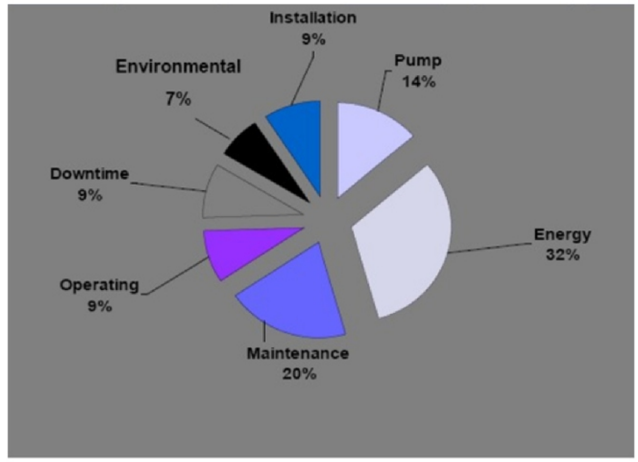

Fig.3. Pie Chart depicting the Total LCC.

Each of these values vary widely in significance from application to application, in Process Industries such as Paper & Pulp, Petrochemical (or) Pharmaceutical - but the Energy costs typically remain the highest single source of cost over a pump's life, followed by Maintenance costs.

Fig. 3, Shows a pie-chart depicting the various costs that make-up the total life cycle cost. It is noticed that the Initial capital costs represent only a small fraction of the total LCC for process equipment. Energy and Maintenance costs contribute more heavily to the total cost.(1)

Results And Discussion

Since, the Energy & Maintenance Costs are the major contributors to the LCC of the Pump, these 2 parameters are discussed below.

I) Ce - Energy Costs :

Energy consumption is often one of the larger cost elements and may dominate the LCC, especially if pumps run more than 5000 hours, per year (1).

The input power is given by the following equation

$$P = \frac{Q \times H \times s.g.}{367 \times \eta p} \ [kW]$$

where P = power, Q = rate of flow (m^3/hr), H = head (m) or (ft),

ηp = pump efficiency and s.g. = specific gravity of liquid

I (a) 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 through 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, and to replace inefficient pumps with more efficient models for the application (3). Hence the major reasons for high power consumption are Improper Selection of the pump and Old Inefficient Pumps.

Improper selection of the pump :

Fig.4 shows a typical Pump Performance curve.

Generally, the pump selection has to always be close to and on the left hand side of the Best Efficiency Point (BEP). The BEP is the point at which the pump operates most cost-effectively in terms of both energy efficiency and maintenance considerations. For example, operating at a flow rate above the BEP could lead to excessive vibration, noise, and erosion. Operating at reduced flow rates could result in liquid temperature buildup, excessive radial thrust, and recirculation at the impeller suction or discharge (Hydraulic Institute 1994). Thus, operation near the BEP minimizes wear to seals, bearings and other parts. In practice, operators are not able to control a pump consistently at its BEP due to changing demands, but

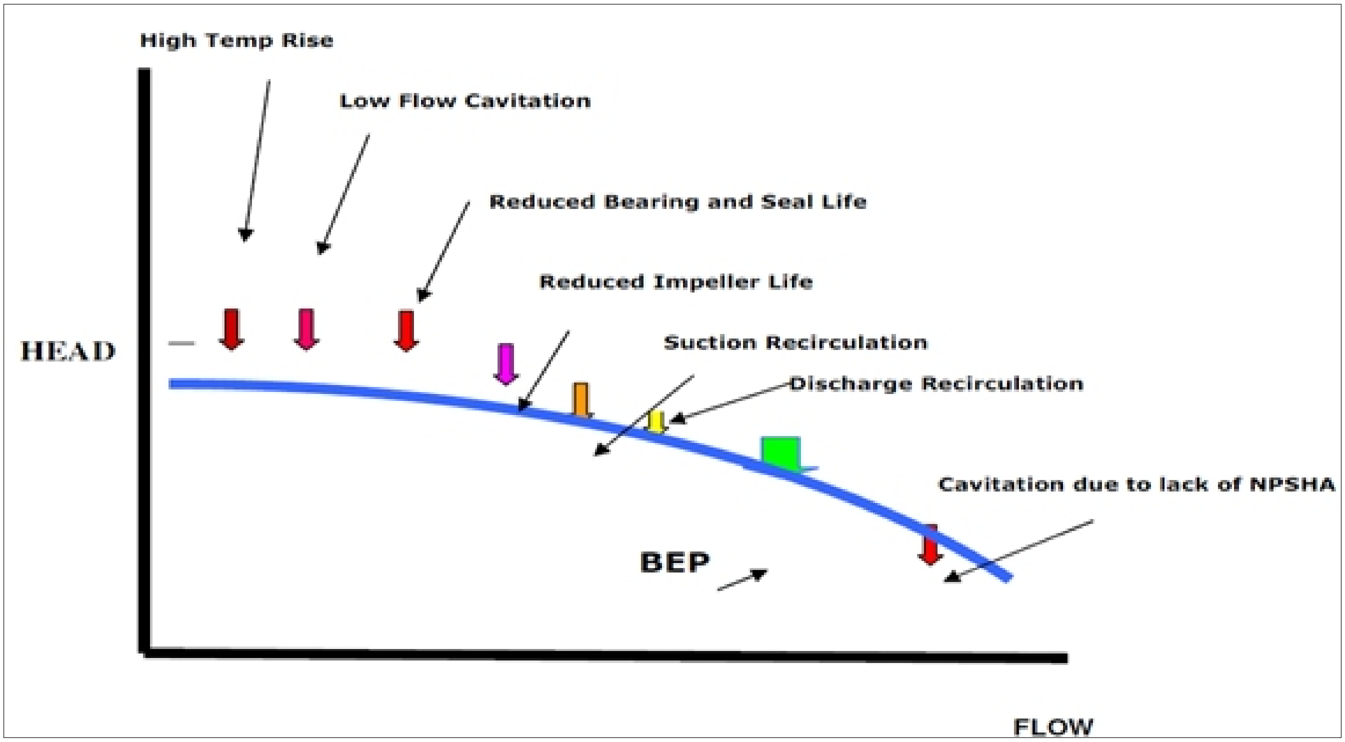

Fig: 4. Typical Pump Performance curve

Table1: Comparison between the existing and the proposed Pump

Application : Unbleached Pulp	Existing Pump	Proposed CRI Pump
Duty Parameters :		
Flow	*440 m³/hr*	*440 m³/hr*
Head	*14 Mtrs*	*14 Mtrs*
SG of liquid	*1.03*	*1.03*
Model	**APP-C-31-150**	**ECC - 8 x 6 x17**
Efficiency %	**62 %**	**70%**
BKW (Difference in Bkw - 3.1 Kw)	*27.8 (Approx.)*	*24.7*
Motor Rating	**37 KW**	**30 KW**
Speed	*1450 RPM*	*1450 RPM*
MOC	*CI / SS 316*	*CI / SS 316*

maintaining operation within a reasonable range of the BEP will lower overall system operating costs.(2)

Replace Old Inefficient Pumps by New Efficient Pumps:

Replacing a pump with a new efficient one reduces energy use by 5% to 10%. Higher efficiency of motors also, has been shown to increase the efficiency of the pump system by 2% to 5%. Table 1 shows a comparison between the existing pump and the one proposed by CRI Pumps.

It is estimated that the savings per annum will be approximately Rs. 1,35,780/- per Pump and ROI will be approximately 9 months !!

I (b) Energy Savings through Pump Control

i) Use of Variable Speed Drives (VFD) to control pump flow rate or maintain pressure. VFD use is becoming more and more common for centrifugal pumps to keep them running at BEP.

ii) 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.

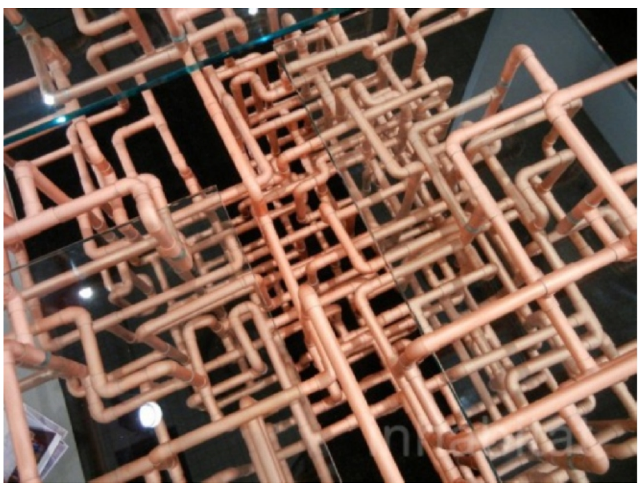

Fig.5. Narrow pipes running through a maze of twists and turns

iii) Use of PLC or similar logic controls to monitor flows, pressures, power consumption, temperature, etc. These are a bit complex and costly, but allow just a few operators to monitor multiple pumps and systems (3).

I (c) 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 as shown in Fig.5, increases the System Head required and in turn, the pump power. 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 (3).

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 their BEP.
- Install power monitors to track electricity usage and identify poor performing units. This also helps to avoid running pumps dry or against "shut-off head" conditions (3).

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

II) Cm = Reducing Maintenance costs

Maintenance:

Obtaining optimum working life from a pump requires regular and efficient servicing. Inadequate maintenance lowers pump system efficiency, causes pumps to wear out more quickly and increases costs. Better maintenance will reduce these problems and the most important to save energy. (2)

Proper maintenance includes the following:

- Replacement of worn impellers, especially in caustic or semi-solid applications.
- Trimming of Pump impellers
- Bearing lubrication replacement, once annually or semi-annually.
- Inspection and replacement of Gland packing seals
- Inspection and replacement of mechanical seals
- Wear ring and impeller replacement.
- Pump/motor alignment check.

Pump Impeller Trimming

Oversized and throttled pumps that produce excess pressure are excellent candidates for impeller replacement or "trimming," to save energy and reduce costs. Correcting pump oversizing can save 15% to 25% of electricity consumption for pumping.Trimming reduces the impeller's tip speed, which in turn reduces the amount of energy imparted to the pumped fluid; as a result, the pump's flow rate and pressure both decrease. A smaller or trimmed impeller can thus be used efficiently in applications in which the current impeller is producing excessive heat. In the food processing, Paper and petrochemical industries, trimming impellers (or) lowering gear ratios is estimated to save as much as 75% of the electricity consumption for specific pump applications. (4)

Inspection and replacement of mechanical seals

Mechanical seal failures accounts for up to 70% of pump failures in many applications. The sealing arrangements on pumps contribute to the power absorbed. Often the use of balanced seals and no-contacting labyrinth /cartridge type seals, help to optimize pump efficiency. Most of the above mitigate towards "good mechanical seal life". However the most important factor contributing to adequate seal life is without doubt the use of appropriate STUFFING BOX design. Modern pump stuffing box designs for use in fibre plants are generally based upon the "Taper or big bore concept".

Double seals will always out perform a single type mechanical seal when used in conjunction with a pressurized (water) barrier fluid. This is because the internal seal faces are sealing water not product. Double seals are additionally used in the most arduous duties i.e., where the pump is run outside its design duty parameters, where there is high levels of air entrainment & prolonged dry running, On pumping applications double seals should be specified where concentrations exceed 6% .(5)

Conclusion

Thus Procurement strategies focused on lowest initial costs are more likely to lead to higher long term costs. It is often directed to reduce costs and work within budgets. In the short run, this approach can make us and the department appear efficient, but the lower capital costs may come with maintenance or other problems that eventually will be realized by the company shareholders in the coming years and decades. Life Cycle Cost can help avoid unnecessary downtime and help make a process more competitive and profitable. At the very least, an LCC analysis may prompt engineers to consider a wider range of possibilities.

References

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