OUR VERTICAL SEWAGE PUMP

1. Maximum eff

Pumpsense Fluid Engineering Pvt. Ltd.

Power Evaluation & Life Cycle Cost

SEA WATER LIFT PUMP FROM HS RANGE

A petroleum refinery has finalized the following specifications for eight cooling tower pumps (6 working & 2 stand-by)

Q = 3600 m3/hr.
H = 45 m
N = 990 r.p.m
$NPSH_a$ *= 13 m*

The company is considering a minimum acceptable efficiency for inclusion in the bid documents. We need to find the minimum acceptable efficiency from the data given to us.

Description

To establish achievable level of pump efficiency, the refinery can use the guidelines of **HIS (Hydraulic Institute Standard)**.
The process will be as follows:-

Calculate pump specific speed: We assume that a split-case pump will be selected at B.E.P (Design point) & this will correspond to the duty point specified.

$$\textbf{Specific Speed}\ (N_s) = \frac{N \times \sqrt{Q}}{H^{3/4}}$$

So, $\left(\frac{990\sqrt{3600}}{45^{\frac{3}{4}}}\right) = 3418\ \textit{(Metric)}$

$\quad or\ \ 2943\ \textit{(US units)}$

For 3600 m3/hr. (or 15,850 US gpm) & specific speed of 3418 metric units (or 2943 US units), **HIS** suggests : **Peak efficiency** of **92%** & **variance** of **± 2%.**
Accordingly, the refinery may decide to impose the following ceiling.

Minimum acceptable efficiency = 91-2 = 89%
Maximum efficiency for evaluation = 91+2 = 93% (No credit over 93%)

2. Power Loading & efficiency

Considering again the previous example, the refinery can arrive at the energy loading figure and thus the Life Cycle Cost on the following basis:

Assuming,	No. of hours of operation	-	20 hrs/day
	No. of days of operation	-	300 days/year
	Life of the project	-	30 years
	Cost of capital (interest rate)	-	9 %
	Cost of power	-	US$ 0.08/ Kw-hr.
	specific gravity of the pumped fluid	-	1.0

Pump duty = 3600 m3/hr @ 45 m head

$$Base\ \ power\ = \frac{Q\times H\times S.G}{3.67\times\ \eta} = \frac{3600\times 45\times 1.0}{89\times 3.67}\ \ =\ \ 496\ kW$$

$$Power\ with\ 90\%\ efficiency\ = \frac{3600\times 45\times 1.0}{3.67\times 90}\ = 490.5\ kW$$

Thus, power saving for 1 unit higher efficiency over the base = 5.5 kW

$$Cost\ of\ power\ per\ kW = 1\ kW\times 20\ hrs\ /day\times 300\ days\ /yr\times 0.08\ US\$\ /KW - hr.$$
$$=\ \ US\$\ 480\ per\ year$$

Present Worth Factor

We are intersted in finding the cost of pump operation for the entire duration of 30 years. The present value of a series of identical annuities (x) for **n years** & at a **rate of interest i %** (cost of money) can be found from the following mathematical series:

$$Net\ present\ value\ of\ annuities$$
$$=\ x\ +\ x/(1+\ i)\ \ +\ \ x/(1+\ i)^2\ +\ \ldots\ldots\ldots\ldots + x/(1+\ i)^n$$
$$=\ (x\ /\ i)\ [1-\ (1+i)^{-n}]$$

Where $\left(\frac{1}{i}\right)[\mathbf{1} - (\mathbf{1}+\boldsymbol{i})^{-\boldsymbol{n}}]$ is called **Present Worth Factor (PWF)**

Hence, $$PWF\ =\ \left(\frac{1}{0.09}\right)\times[1-\ (1+0.09)^{-30}] =\ \ 10.273$$

$$Energy\ loading\ =\ \ Cost\ of\ Energy\ per\ kW\ per\ year\times PWF$$
$$=\ \ US\$\ 480\times 10.273\ =\ \ US\$\ \ 4931$$ *, or approximately US$ 5000 per kW*

This means that a pump with efficiency of 90% will receive energy loading advantage of

$$=\ \ \ 5.5\ kW\times US\$\ 5000\ =\ \ US\$\ 27{,}500$$

The price of a circulating water pump of the above specification is likely to be around US$ 30,000.

We can therefore conclude that the following statement is largely true:

<u>Capitalized Cost of One Unit Difference in Efficiency is Equal to the Cost of the Pump</u>

3. Life Cycle Cost (LCC) evaluation

- LCC is utilized as a powerful management tool that helps in maximizing efficiency, while minimizing wastage of Industrial Process Systems.
- LCC deals with the optimization of :-
    - Design
    - Operation
    - Maintenance
    - Energy
    - Fluid Dynamics
    - Driver System
    - Site Interface
    - Piping Accessories
    - Control Instrumentation
- LCC is total lifetime cost to purchase, install, operate, maintain, & dispose.

$$LCC = C_{IC} + C_{IN} + C_E + C_O + C_M + C_S + C_{ENV} + C_D$$

Where, C_{IC} *= Initial Cost*

C_{IN} *= Installation & Commissioning Cost*

C_E *= Energy Cost*

C_O *= Operating Cost*

C_m *= Maintenance & Repair Cost*

C_S *= Downtime Cost*

C_{ENV} *= Environmental Cost*

C_D *= Disposal/Decommissioning Cost*

Specific Issue

A pump user has received two offers from pump manufacturers for his requirement of centrifugal pump. Each Pump has a different quoted price of purchase and works at different efficiencies. The duty details of pumps offered are as follows:

Capacity	720 m3 / hr.
Head	130 m
Speed	1480 rpm
Specific Gravity	1.0 (water)

Reminders:

Pump efficiency depends on pump size, type and on specific speed. Given the pump duty **(Q, H, N and pump type)** – optimum efficiency can be estimated from the efficiency chart provided in the Hydraulic Institute Standards. From chart:

Manufacturer A has **efficiency 75%**

Manufacturer B has **efficiency 80%**

Life of the project (years)	**25**
Hrs. of operation per day	20
No of days of operation/ year	300
Cost of power(US$/kW-hr)	0.08
Interest rate (%)	9

Also, Manufacturer A has quoted a price of **$10,000**.

& Manufacturer B has quoted a price of **$13,000.**

Description: First, we calculate power consumption by each pump

$$Power\ consumed\ by\ pump\ A\ (KW) = \frac{Q\ \left(\frac{m3}{hr}.\right) \times H\ (m) \times specific\ gravity}{3.67 \times\ \eta\ (\%)}$$

$$= \frac{720 \times 130 \times 1.0}{3.67 \times 75} = 340.05\ kW$$

Similarly, $Power\ consumed\ by\ pump\ B\ = \frac{720 \times 130 \times 1.0}{3.67 \times 80}\ =\ 318.80\ kW$

Therefore, additional power consumption by pump A is 21.25 kW.

$$The\ additional\ annual\ power\ cost\ due\ to\ lower\ efficiency$$
$$=\ additional\ power \times cost\ of\ power \times No.of\ hours\ of\ operation/yr.$$

In this case, $21.25\ kW \times US\$\ 0.08 \times (300 \times 20)\ =\ US\$\ 10{,}200\ per\ year.$

PWF: Here, i = 9 % & n = 25 years.

Hence, we get $PWF = (1/0.09)\,[1 - (1.09)^{-25}] = 9.822$

$$The\ present\ value\ of\ annual\ additional\ energy\ cost$$
$$= PWF \times additional\ energy\ cost\ /\ yr.$$

$Or,\ \ 9.822 \times US\$\ 10{,}200 = US\$\ 100{,}190.$

$$So, total\ saving\ using\ pump\ B$$
$$= cost\ of\ energy\ saved - the\ difference\ in\ initial\ purchase\ price$$

$$= US\$\ 100{,}190 - (13{,}000 - 10{,}000)$$
$$= \boldsymbol{US\$\ 97,190}$$

Hence, the user should buy Pump B which has a lower Life Cycle Cost.