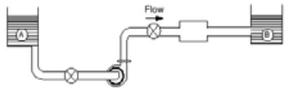
Chapter4.7: Water Pumps

Short type questions

Long type



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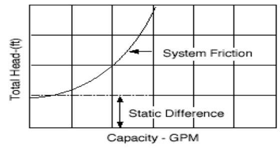
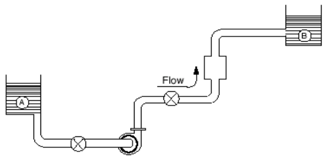


1. What … thods available fo… …ite briefly about any tw…

Ans Some of the measurement methods for large…



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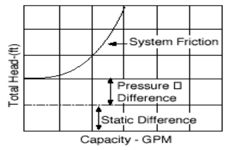
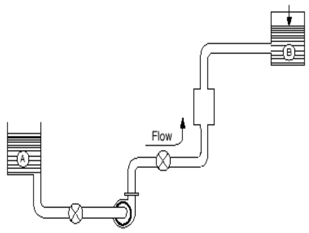


…e flowmeter

Tra…



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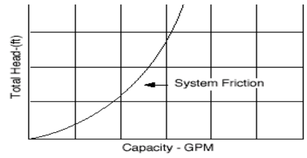


Trac… suitable for cooli… …cause of their sens… permanent head…

The … a tracer into the c… …t an accurately mea… of samples is extracted from the system at a point where the trac… …d with the cooling water. The mass flow rate is calculated from :

where, q_{cw} = cooling water mass flow rate, kg/s

q_1 = mass flow rate of injected tracer, kg/s

C_1 = concentration of injected tracer, kg/kg

C2= concentration of tracer at downstream position during the 'plateau' period of constant concentration, kg/kg

The tracer normally used is sodium chloride.

Ultrasonic Flow meter

Operating under Doppler effect principle these meters are non-invasive type of measurements which can be taken without disturbing the system. Scales and rust in the pipes are likely to impact the accuracy.

- For better accuracy, a section of the pipe can be replaced with new pipe for flow measurements.

Tank filing method

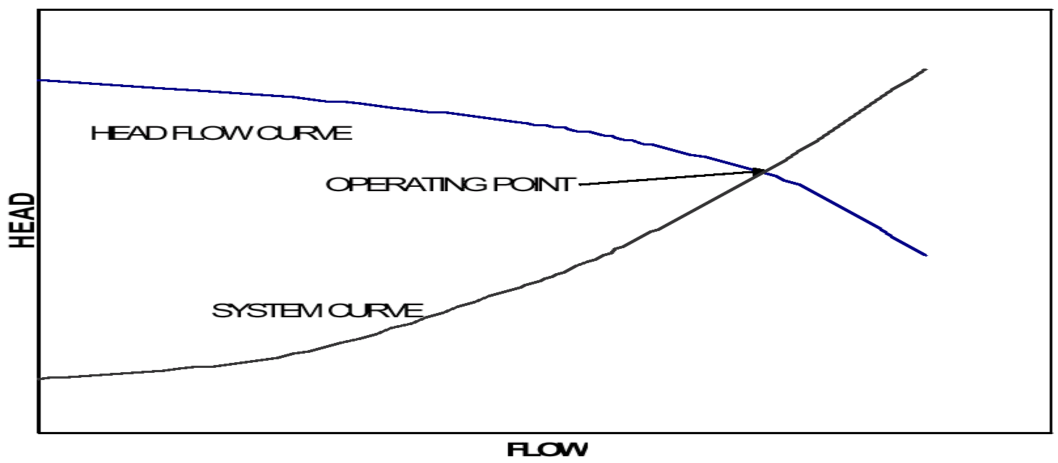
In open flow systems such as water getting pumped to an overhead tank or a sump, the flow can be measured by noting the difference in tank levels for a specified period during which the outlet flow is stopped.

Installation of an on-line flow meter

If the application to be measured is going to be critical and periodic then the best option would be to install an on-line flowmeter which can rid of the major problems encountered with other types.

2. Explain the Pump operating point with a diagram?

Ans When a pump is installed in a system the effect can be illustrated graphically by superimposing pump and system curves. The operating point will always be where the two curves intersect.



If the actual system curve is different in reality to that calculated, the pump will operate at a flow and head different to that expected.

Numerical type questions

1. The following table gives the centrifugal water pump details:

Rated flow	:	90 m^3/h
Rated head	:	4.5 kg/cm^2(g)
Motor Rating pump	:	37 kW

Considering 65% pump efficiency and 85% motor efficiency, (a) find out whether the sizing of the drive correct? If not what should be the size of motor?

(b) If the above pump is drawing 18.5 kW and the required head is 30m, the rated flow rate is 90 m^3/h, what should be the size of the new pump? And what would be the savings considering 70% pump efficiency and 89% motor efficiency?

(a) The liquid horse power of the pump is

Hydraulic power P_h = Q (m^3/s) x Total head, $h_d - h_s$ (m) x ρ (kg/m^3) x g (m/s^2) / 1000

$$= \frac{90 \times 4.5 \times 10 \times 9.81}{3600} = 11.04 \text{ kW}$$

Considering 65% pump efficiency and 85% motor efficiency

$$\text{The required power} = \frac{11.04}{0.65 \times 0.85} = 19.98 \text{ kW}$$

Higher size motor has been chosen, which is incorrect. The reduced standard size motor for this pump would be 22 kW.

(b) The measured parameters are:

Flow	=	90 m^3/h
Head	=	3.0 kg/cm^2
Power	=	18.5 kW

The operating efficiency of the pump is (considering 85% motor efficiency)

$$\text{Pump output power} = \frac{90 \times 3.0 \times 10 \times 9.81}{3600 \times 0.85} = 8.65 \text{ kW}$$

$$\therefore \text{Pump efficiency} = \frac{8.65}{18.5} = 46.8\%$$

The new sizing of the pump should be 90 m^3/h, 30m head. Considering a pump efficiency of 70% and the motor efficiency of 89%, the power consumption should be:

$$= \frac{90 \times 30 \times 9.81}{3600 \times 101.9 \times 0.7 \times 0.89} = 11.8\ kW$$

Existing power consumption	=	18.5 kW
Proposed power consumption	=	11.8 kW
∴ Net savings	=	6.7 kW

2. In a large paper plant, the following are the designed and measured parameters for a clear water pump.

Particulars	Design	Operating
Flow, m^3/h	800	576
Head, m of WC	55	24 (after control valve)
Power, kW	160	124
Speed, rpm	1485	1485

The pump delivery has been throttled to about 30% (closed) manually to get the required flow rate. Normal required water flow rate is 500 m^3/h to 700 m^3/h. Calculate the present operating efficiency and in your opinion what should be the optimum solution to get the required flow rate variation? And what would be the savings if the pump is delivering the flow rate of 550 m^3/h. (Consider efficiency of motor as 93%).

Ans. Present pump output $= \dfrac{Q \times H \times g}{3600 \times \eta_p \times \eta_m}$

$$= \frac{576 \times 24 \times 9.81}{3600 \times 0.93} = 40.5 \text{ kW}$$

Pump input power = 124 kW

$\therefore$ pump operating efficiency $= \dfrac{40.52}{124} \times 100 = 32.67\%$

The pump is operating at a poor efficiency of 32.67% due to throttling of the flow.

Since the pump discharge requirement varies from 500 m^3/h to 700 m^3/h, the ideal option would be to operate with a VSD. According to affinity laws:

$$\frac{Q_1}{Q_2} = \frac{N_1}{N_2}$$

$$\frac{H_1}{H_2} = \left(\frac{N_1}{N_2}\right)^2$$

$$\frac{P_1}{P_2} = \left(\frac{N_1}{N_2}\right)^3$$

For a flow rate 550 m^3/h, the reduced speed of pump would be:

$$= \frac{550}{800} = \frac{N_1}{1485}$$

$\therefore$ N_1 = 1021 rpm

With the reduction in speed the reduction in terms of head would be:

$$= \left(\frac{1021}{1485}\right)^2 \times 5.5 = 2.6 \text{kg/cm}^2$$

The reduction in power would be:

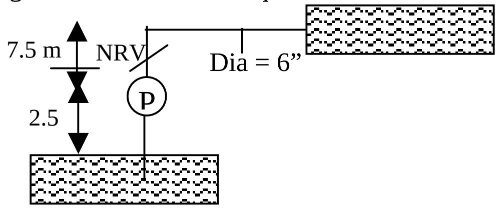
$$= \left(\frac{1021}{1485}\right)^3 \text{ x } 124 = 40.3 \text{ kW}$$

$\simeq$ 40.3 kW

$\therefore$ the reduction in power = 124 – 40.3

= 83.7 kW

3\. Analyze the following figure and answer the questions.



Pump rated parameters

Q	30 lps
H	18 m
P	9.3 kW
η_P	65%

a In normal operation what would be the flow rate from pump compared to rated value?

b Is the pump operating at its design efficiency

Ans. **a**. In the present case, flow rate from the pump will be higher than rated flow rate. It is mainly due to lower operating head (around 10 m) as against rated head (18 m).

b. Pump operating efficiency will be less than design efficiency. It is due to higher flow rate and lower operating head.

4\. In one of the chlor Alkali plant, analysis of one of the operating parameter of a titanus impeller pump for flow of brine were as follows:

	m^3/hr	Head	kW
Rated	310	45	90
Actual	210	40	67

On detailed examination of the flow/head requirement (maximum) was assessed to be 260 m^3/h and 30 m. Though change of pump was one of the option, considering cost of special pumps impeller ‘impeller cutting’ was one of the options suggested which involves Rs 3.0 lakh as cost. Calculate likely annual saving after impeller cutting with pump efficiency at 65% and motor efficiency at 85%, fluid density 1160 kg/m^3 operating hours: 8000, unit rate: Rs 5/-

Ans.

Hydraulic power P_h = Q(m^3/s)xTotal head, h_d-h_s(m)xρ (kg/m^3) x g (m/s^2) / 1000

After trimming impeller power consumption $= \frac{(260/3600) \text{ x } 30 \text{ x}1160 \text{ x } 9.81}{1000 \text{ x } 0.65 \times 0.85} = 44.6$ kW

Estimated power savings = 67 - 44.6 = 22.4 kW

Annual savings (Rs) = 22.4 x 8000 x 5 = Rs 8.96 lakh

Simple pay back period $= \frac{3.0}{8.96}$: 4 months