Effects of Oversizing Centrifugal Pumps

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Abstract

At first sight, a centrifugal pump seems to be one of the simplest machine. In practice however, it is capable of posing an enormous spectrum of different problems. Occasionally one comes across problems that seems to defy everything, we know about centrifugal pumps.

The selection of the right pump for the right job is very important and results in minimum maintenance of pumps. But this calls for knowledge of not only what happens within the pump but also what happens behind and beyond the pump. Therefore it has to be a joint effort between the hydraulic expert and the process specialist. **Selection of the right pump itself rewards. Start up, operating problems, maintenance cost etc. are minimized.**

THE PERFORMANCE OF THE PUMP IS VERY MUCH DEPENDENT ON THE PERFORMANCE OF THE OVERALL SYSTEM.

Proper maintenance does not start with repairs of worn out spare parts, but right at the time of selection and instillation. Following certain fundamental rules will help obtain the most reliable service, the least expensive maintenance and the longest possible life from the centrifugal pumps.

Section

- Do not oversize pumps. This leads to uneconomical operation and generally narrows the safe operation range of capacities.
- Do not try to select pumps with excessively low NPSH®
- Do not falsify real available NPSH, trying to keep margin up your sleeve. This leads to selection of pumps with excessively high suction specific speed and high minimum flows.
- Do not use mechanical seal when packing is more than adequate for the intended service.

Installation :

- Do not use suction elbows in a plane parallel to shaft, place them in the plane perpendicular to the shaft.
- Do not use the casing as an anchor for the piping.
- Do provide adequate flow, pressure and temperature instrumentation for each pump.
- Pump and driver alignment must be rechecked under normal operating conditions.

Operation :

- Do not operate pumps below the recommended minimum flow.
- Do not throttle the pump suction to reduce its capacity.
- Do not run two pumps in parallel when a single pump can carry the reduced system load.
- Do not stop a pump while it is cavitating. Re-establish normal operation first and then stop the pump if you have to.
- A pump handles liquids . Keep air out.

- Do not run a pump if excessive noise or vibration occurs.
- Do run spare pumps occasionally to check their availability.
- Don't stop leakage from stuffing box completely. Some leak is necessary to lubricate and cool packing.

Maintenance :

- Do not open pumps for inspection unless factual circumstantial evidence warrants it.
- Do not over lubricate the bearings.
- Packing stuffing boxes is an art. Do not assign this task to inexperienced personnel.
- Do not tighten stuffing box glands excessively. Let enough leakage flow to cool and lubricate packing.
- Do monitor the pressure drop across suction strainer. An excessive pressure drop indicates clogging and may reduce available NPSH to a dangerous degree.
- Do keep an adequate stock of spares parts.
- Do check concentricity of all parts of the rotor before reassembly.

TERMS AND DEFINITIONS OF "HEADS"

What is "Head"?

The word "HEAD" is frequently spoken in the field of water works, pumping etc.

A column of water or any liquid in a vertical pipe exerts a certain pressure (force per unit area) on

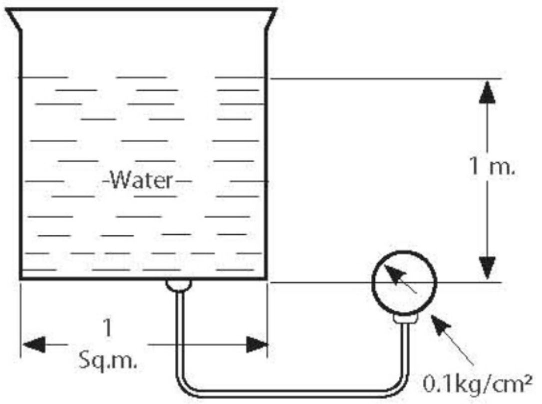
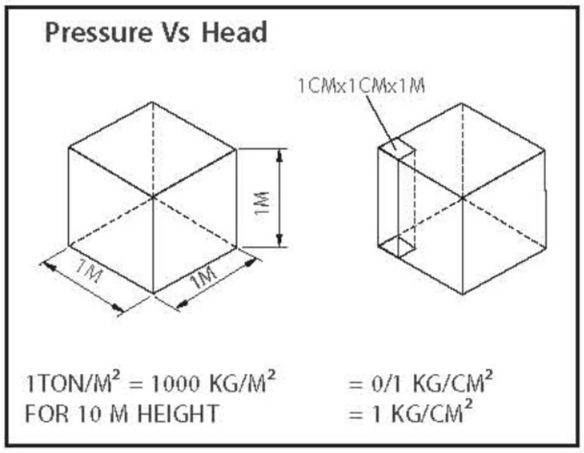


Fig. 11: Concept of Head

a horizontal surface at the bottom; this pressure is expressed in kg / cm^2 or metres of liquid column (mlc)

The height of a liquid column is known as HEAD.This is explained in Fig. 11.

A square container with 1 metre sides is filled with water to the height of 1m i.e. it contains one cubic metre of water weighing 1000 kgs. Hence at the bottom it exerts a pressure of 1000 kg / 10000 cm^2 or 0.1 kg / cm^2.



In other words a water column of 1 m will exert a pressure of 0.1 kg / cm^2 at the base. (Specific gravity of water is 1).To make the concept more clear, it can be proved that for tanks with different cross sections but the same liquid column heights, the pressure gauges at the bottom of the tanks read the same pressure.

Head and pressure :

The relation between Head in metres of liquid column and pressure in kg / cm^2 can be expressed as under:-

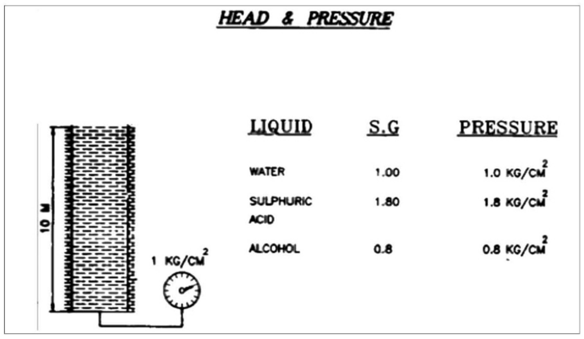
$$H \text{ in mlc} = \frac{P \times 10}{r}$$

Where, P = Pressure in kg / cm^2

r = sp.gr. of liquid. (1 kg / cm^2 = 10 m of water column)

Why is head always measured in terms of liquid column in metres when dealing with centrifugal pumps?

A centrifugal pump with a given speed in r.p.m and impeller diameter will deliver **any liquid to the same height (Head)** irrespective of its sp.gr. though pressure gauge readings will vary according to sp. Gr. This phenomenon is explained in Fig. 12



Suppose water, acid and Alcohol are pumped to the same height of 30.5 m by three similar pumps, then pressure gauges attached to each discharge pipe will read pressures differently. **This shows the pressures are directly proportional to the sp.gr. of liquids.**

That is why we must always think in terms of metres of liquid column (mlc) rather than pressure when dealing with pumps.

Effects of Over sizing pumps

The system head curve is developed by plotting total system head (static and friction loss) as the flow varies from zero to maximum. System head curve analysis helps define the operating relationship between the pump head and the system head. Efficient and trouble free operation depends on a close match of pump curve and system curve. Otherwise pumps may be picked that are improperly sized and do not run at the conditions for which they are selected/purchased.

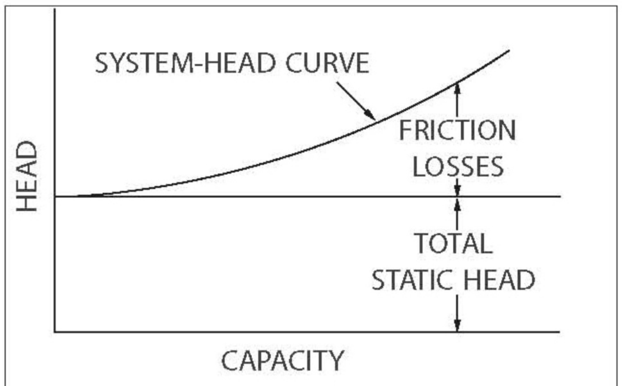
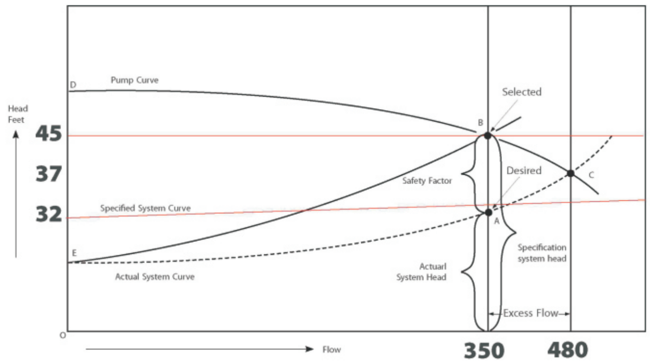


Fig 1.44 Construction of system-head curve.

At design flow 350cum/hr , the Engineer calculates the head as 32m,. Erroneously believing that using a safety factor will ensure his reaching D, he adds 12 m, to obtain total head of 45 m. Assuming the user needs a pump to operate 350cum/hr, and 45m, pump manufacturer selects a pump with curve A,B,C. The pump curve intersects the system head curve at BEP- Best Efficient Point.



However, the actual system curve is E,D,C and the pump will run at C rather than B. Because with discharge valve fully open, pump seeks equilibrium with the system and operate at the intersection of pump curve and system head curve. At point C the pump will produce a flow of 480cum/hr. Not only the user is getting different conditions than he wants, he is also operating at a less efficient point on the pump curve and spending more on energy.

To get 350 cum/hr, the valve is gradually closed , steepening the system head curve. The pump produces 350 cum/hr and 45 m. But head at 350 cum/hr is 32 m. The pump thus produces 45m and 350 cum/hr but delivers only 32 m and 350 cum/hr to the system. The additional head 12 m, is thus wasted across the valve as heat and noise.

The **effects of over sizing** the pumps are 1. operation at excess capacity requires greater NPSH® 2.High pressure drop through foot valve, 3.cavitation leading to efficiency drop and premature failure of rotor. 4.Greater power consumption 5.High initial purchase cost 6.Internal loading and hydraulic radial thrust and 7. vibration and dehydration.

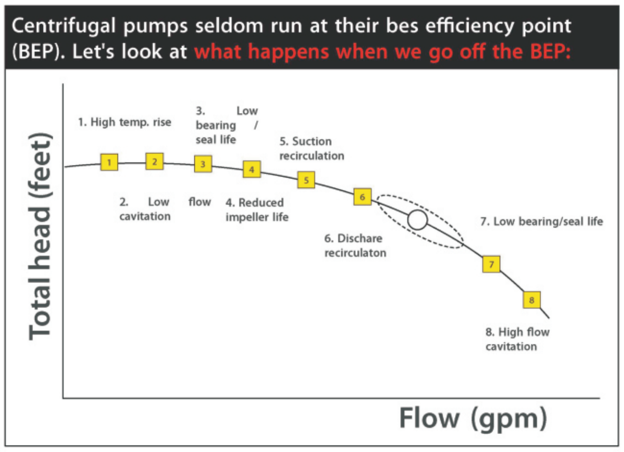
The **solutions** are 1. Reduce impeller dia 2.Reduce speed and 3.Go for new correct sized pump.

Excessive throttling pulp stock pumps leads to dehydration due to high velocity, vibrations, greater internal radial load reducing life of rotating element. Hence, the pumps are not to be operated for extended periods, less than 1/4th of BEP capacity.

Head Calculations

- You would not buy a suit without measure of your inside leg, but so many specifications call for heads based on some casually produced figures.
- The careful buyer may choose a supplier because the price is 10% lower, buy if the Engineer calculated the head, the unit is twice as dear as need be.
- Twice the head is the twice the power, 50% of which is going to be wasted. The buyer will actually be paying more. The user will be paying more in running costs.
- The maintenance man will be more fully employed because the pump is outside of its **BEP (**Best Efficiency Point).**The BEP is the cruising speed of the machine.** The loss of the efficiency on either side of the BEP represents turbulence. Turbulence causes wear. This energy is going into destroying the components it touches and stretching its effects out to non-contact parts such as bearings, seals and couplings.

Effects of Pump Running Away From BEP



One can compare man as a machine with a man made machine say pump. The performance of man can be measured by his consistent output. To have consistent output, one has to see that the man is working at or near his expected capacity, that is, he is neither overloaded or otherwise. Overloading may lead to fatigue and under expectation develops frustration. This condition is monitored by his behavior, mistakes in work and losing temper. So is the case of pump. The pump has to be selected and operated at or near its best efficiency point. Over expectation may lead to overloading of the motor, cavitations, increased vibrations. Operating the pump at part capacity may lead to increased loading on the bearings thereby increasing bearing temperatures, increased vibrations and noise. That is, the performance of the pump can be monitored by its behavior, mistakes and temperature.

HOW PUMPS GET OVERSIZED?

The most common reason pumps are over sizes is "Why take chance getting it wrong?" Design engineers are paranoid of selecting a pump unable to achieve the head required, to achieve the required system flow rate. when selecting a pump, it is prudent to include a safety margin to ensure the pump can accommodate unforeseen system changes that typically occur during the design, construction and operation of the piping system. The safety margin can be thought of as pump insurance and like any insurance , it has a premium that must be paid. The more the pump is oversized, the higher the premium. The important thing when determining the safety margin in pump selection is to choose the right amount of insurance and know what you are paying for.

Getting it right

Getting the head right is the first step to efficient and satisfactory operation. Good pipe work is real energy saver, although for the untrained observer, it is doing nothing. Selecting the BEP in curve comes easily after that. Follow these steps and energy efficiency, with all its attendant benefits could be yours.