Effect of Oversizing Pulp Stock Pumps

M. Maria Francis**

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.

Introduction

M. Maria Francis

The performance of the pump is very much dependent on the performance of the overall system. 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 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. 1.

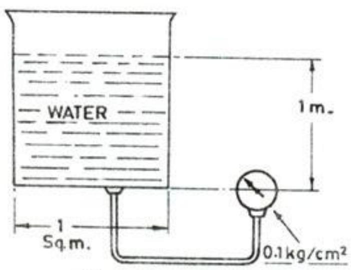

Fig. 1: Concept of Head

A square container with 1 metre sides is filled with water to the height of 1 m 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 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 / cm2 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 / cm2 = 10 m of water column)

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.2

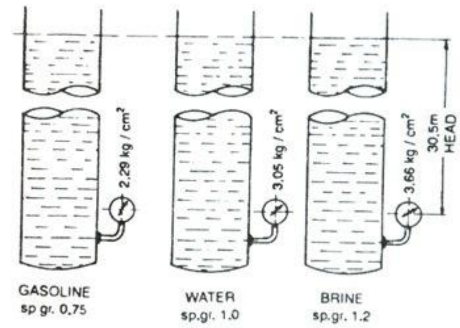

Fig. 2: Gauge readings relate to liquid specific gravity

Suppose gasoline, water and brine 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.

Affinity Laws

The affinity laws express the mathematical relationship between several variables involved. In pump performance they are as under-

1) With impeller diameter 'D' held constant and speed

I) $\frac{Q1}{Q2} = \frac{N1}{N2}$ I) $\frac{300}{Q2} = \frac{1750}{2000}$ Q2 = 342.86 l/s

II) $\frac{H1}{H2} = \frac{(N1)^2}{(N2)^2}$ II) $\frac{600}{H2} = \frac{(1750)^2}{(2000)^2}$

H2 = 783.67 m

III) $\frac{BHP1}{BHP2} = \frac{(N1)^3}{(N2)^3}$ III) $\frac{20}{BHP2} = \frac{(1750)^3}{(2000)^3}$

BHP2 = 30 BHP

***General Manager-Marketing, Sam Turbo Industry Limited, Coimbatore, Tamil Nadu.*

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.

Effects of Oversizing 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.

At design flow 350 m^3/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 m^3/hr and 45 m. But head at 350 m^3/hr is 32 m. The pump thus produces 45m and 350 m^3/hr but delivers only 32 m and 350 m^3/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.

Bearing Life

The B-10 life of antifriction bearings used in ANSI and API pumps is supposed to be 24000 and 40000 hrs, respectively. What this means is that 90% of the bearings should still be serviceable after approximately 3 years for ANSI pumps and 5 years for API pumps. In practice, this is not what happens. When one talks to maintenance people who do keep records, one finds that on the average, the life expectancy of the bearings falls short by as much as 50% or more. This is not because the pump manufacturers do not know how to size the bearings or too optimistic and cut corners. It happens generally because of one or two reasons.

1. The actual load on the bearings exceeds the predicted load
2. The load which the bearings can carry falls short of the basic bearing load rating because of bearings environment conditions

   The first can be caused by a variety of problems such as pump misalignment, excessive forces and moments excerted on the pump by the piping, pump cavitations, operation below recommended minimum flows, poor suction piping etc. The second stems from lack of lubricants, water contamination of lubricants ,inadequate cooling, excessive cooling. Of this list, water contamination in the lubricant is probably the greatest and most frequent offender. Figures are sited showing that as little as 0.002 % water contamination will reduce bearings life by a dramatic 48 %. There is no question that education of pump users in the proper lubricating practices is the only way to reduce the failure rate attributable to bearings.

This is a basic question and very difficult to answer. But the reason is simple.

Process: None employs a process or technology which is not tried out successfully or proved elsewhere in the country or abroad.

Product: An equipment installed is a product supplied by a vendor subjected to rigorous norms of selection, prequalification, fields record, capacity survey for quality and its compliance.

Hence, we have a proven process and product which should normally be in tune and harmony. Unfortunately, these two suffer from sickness of incompatibility.Only one treatment of this sickness is dispassionate and objective analysis of the symptom by the user and vendor together with mutual trust and confidence as well as the will to solve the problem.Pump manufacturers are often in an unenviable situation as though the pump forms literally heart of any process, it amounts to only a fraction of the capital investment and hence tends to be taken as granted.

Conclusion:

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. It is needless to mention that for any machine preventive and routine maintenance is mandatory for its successful operations.■

change.

Where,

Q = Capacity in l/s

H = Total head in metres

N = Pump RPM

BHP = Brake horse power (pump input)

Suffixes 1 & 2 indicate the initial and later values of the parameter.

It is observed (1) Q is proportional to N (2) H is proportional to the square of N (3) BHP is proportional to the cube of N (4) The efficiency remains almost constant.

2) With speed N held constant and impeller diameter change-

I) $\frac{Q1}{Q2} = \frac{(D1)}{(D2)}$ II) $\frac{H1}{H2} = \frac{(D1)^2}{(D2)^2}$

III) $\frac{BHP1}{BHP2} = \frac{(D1)^3}{(D2)^3}$ Where D = impeller dia in mm or cm

How to Develop Approximate System -Head Curves

A pump operating in a system must develop a total head which is made up of several components:

1. The static head between the source of supply an the point of delivery
2. The difference in pressures (if any) existing on the liquid at the source of supply and at the point of delivery.
3. The frictional losses in the piping, valves, etc., in the system.
4. Entrance and exit losses at he source of supply and at he point of delivery, respectively.
5. The difference in velocity heads at he pump discharge and at the pump suction

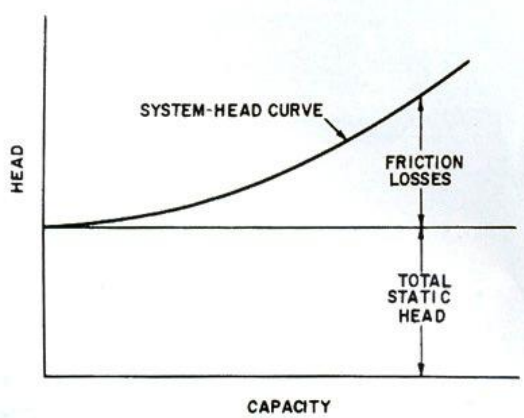

Fig. 3: Construction of system-head curve.

Because the first two components generally do not vary with flow, they can be lumped together into a single term and become the total static head. On the other hand, the remaining three

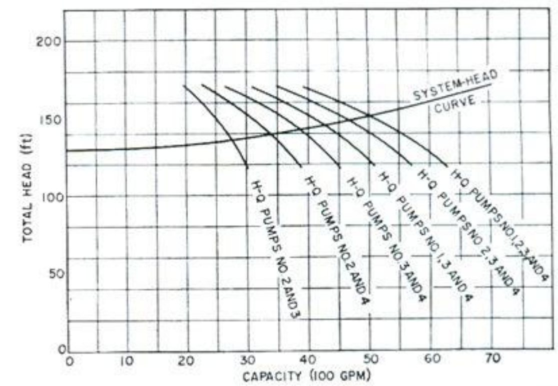

Fig. 4: Head-capacity curves superimposed on system-head curve.

components vary as a function (roughly as the square) of the flow through the system. They are frequently lumped together into a single term and considered as friction losses.

If the sum of the total static head and of friction losses for a series of assumed flows is plotted against flow (or pump capacity), the resulting curve is called the system-head curve. Such a curve is illustrated in Fig. 3. If either the static head or the pressure difference varies under certain conditions, it is necessary to plot two or more such curves. At least one of these curves should correspond to the minimum total static head and one curve to the maximum total static head.

To determine the capacity that a given pump or a group of pumps will deliver into the system, it is merely necessary to superimpose the head-capacity curve of the pump or pumps on the system-head curve. The intersection of the head-capacity and system-head curves will indicate the flow that will take place through the system (Fig.4).

Pump consumes too much power

System head is less than pump head, Specific gravity is more, Viscosity is more, Misalignment, Foreign matter in impeller, Rotating part rubbing in stationary part, Shaft bend, Gland too tight.

Delivers less liquid than expected

System head is more than pump head, less driver speed, air trapping in suction, clogging in suction pipe, more clearance between impeller and wear ring., NPSH(A) less than NPSH®,

Bearings have short life

Improper balancing of rotor assembly, misalignment, water contamination in lubricant, lack of lubrication, excessive lubrication, inferior quality of lubricant.

Pump is noisy

Cavitations, bearing worn out, misalignment, pump running close to shut off, improper balancing of rotor,

Pump vibrates

Improper foundation, misalignment, improper piping support, cavitations.