KNOW YOUR PUMP
(By B.M.CHATWANI – Consulting Engineer, Pumps)

During my service from 1961, up till now, I have witnessed so many mistakes which we, water supply engineers make and go on repeating them, even after locating the mistakes & its effects on reliability, energy – efficiency of pumping system.

I have collected some of the major mistakes and penned – down in this article so that these are avoided in future design and rectified in the existing system.

A. MISTAKES RELATED TO FLOW (Q)

1. Generally we design pumping system on the basis of expected population in the coming 15 years and litre per capita per day sanctioned by the Govt. authority. Now we expect availability of power supply for 20 – 22 hours and design machinery accordingly. But in most of the rural areas such power supply is not available, it is only 10 – 11 (half of expected time) so our designed machinery is found smaller in size than required and then we add additional machinery. **BIG SIZE PUMPS ARE MORE EFFICIENT THAN TWO HALF SIZED PUMPS,** so initial design should be based on expected power availability in hours/day.
2. We are also conservative in making provisions for other uses such as fire – fighting, animals, leakages etc. We should be very pragmatic in estimating the requirements of flow rate for pumping systems.
3. **Optimal design of Delivery Pipe Line:** To gain maximum system efficiency it is must that Best efficiency point of pump & duty point of the system (on system head curve) coincide at the design flow rate. For this the size (dia.) of delivery pipe line should be neither too small nor too big but should be precisely calculated.
   The provision in water manual that delivery pipe should be one size higher than delivery nozzle of the pump and max speed in delivery line should not be more than 2.5 m/s. this provision is mainly when delivery lines are terminated in delivery headers in the pump house. But for delivery pipes terminating in the ESR or further up to destination, the max speed should be max 1.5 m/s as per O & M manual of CPHEEO (Operation & maintenance of water supply systems, MINISTRY OF URBAN DEVELOPMENT)
4. **Optimal design of suction pipe line:** as per water manual the size of suction pipe should be one or two sizes higher than suction nozzle of the pump and also the speed in the suction line should not be more than 2 m/s. In this whichever size is higher should be considered if awkward (Non – STD size such as 425 mm) size is arrived at, next standard size should be considered.
5. **Provision of Bell – mouth:** Always provide Bell – mouth in suction line and of the diameter by which speed in suction line is restricted to 1.5 m/s.
6. **Stream lined Cavitation free flow:** The design of sump should be as per H.I.S norms so that minimum submergence is achieved & cavitation is avoided. This is must for hassle free functioning of the pump set.
7. **Design of pumping station for multi pump system:** This should be as per HIS norms (Hydraulic Institute of state, USA) so that the less distance between two pump sets is not an obstacle in the flow rate of pumps.
8. **Flow controlled by throttling the valves:** This is most non technical method of flow control. A better way is to follow the system as given below –
   a. **Trim the impeller**
   b. **Replace the impeller**
   c. **Provide V.F.D**
   d. **Provide 2 or 3 small pump sets**

9. **Use of double suction impeller to reduce flow rate:** The pump efficiency is proportionate to the flow rate and pump efficiency is optional when specific speed is 170 rpm or is in the range between: **140 to 200 rpm.**

$$\textbf{Suction Speed} = \frac{3.65 \times RPM \times \sqrt{Q}}{H^{0.75}}$$

In calculation if suction speed crosses 170 rpm it is better to go for double suction impeller.

10. **Timely replacement of wearing rings:** the wearing rings on impeller and in the casing wear regularly when in use of pump. There is designed gap in between these rings and if the gap doubles those rings should be invariably replaced otherwise there will be recirculation of water in the pump casing, which will reduce the flow even when the power consumption does not reduce. This greatly reduces the pump efficiency.
11. **Measurement of flow rate:**
    a. Flow rate can be best measured by noting time to fill up E.S.R which is a callibrated body, 5 ml/ 10 ml etc
    b. Flow rate can also be measured with the help of portable ultra sonic flow meter if the pipe lines are not rusty.
12. **Ideal time for filling ESR:** In pump house, ideal time for filling ESR should be mentioned in board/wall & operator should alert Dept when it increases by more than 20%.

B. MISTAKES RELATED TO HEAD (H)

1. Water works engineers are always afraid of failure of transmission of water to the fag – end of the line thereby opt for higher head than calculated. This results in pumps running on the right side of the B.E.P as actual head is found less than calculated. Because of this mistake, pumps operate towards run-out side and create lot of vibrations & noise so operators throttle the line and bring pump to operate at designed head.
   This is not only wastage of energy but also reduces the life of pump itself. In such cases there are following solutions:
   a. **Trim the impeller**
   b. **Replace the impeller**
   c. **Replace the pump set**
2. **Multistage Pumps:** the pump efficiency varies in the specific speed range of 140 to 200 rpm and it is optimal at 170 rpm. The formula for specific speed is –

$$\frac{3.65 \times RPM \times \sqrt{Q}}{H^{0.75}}$$

So if specific speed is more than 200 rpm it is required to increase the number of stages to divide the head per stage.

3. **Head and pressure gauges**: The gauges are tell – tally instruments and are vital to inform whether pump is running at designed head or away from it.
   If head noticed is more than it reveals than there is some obstacle in the pipeline and pump is forced to develop more head to face that obstacle.
   If head it less than it means that there is some leakage in the line so head has gone down.
   These gauges are always neglected and are not kept in good working conditions and are also not calibrated regularly.
4. **Friction head in the line:** Total head on the pump consists of static head and friction head. As the static head cannot be changed due to fixed R.L of suction & delivery points only friction head can be reduced in order to reduce the total head.

The friction head can be reduced by:

a. **Increase the diameter of the delivery line**
b. **Using the pipes with inner smooth surface**
c. **Lowering water velocity in the line**
d. **Decreasing the length of pipe line (if possible)**
e. **Lessening the bends, elbows etc.**

5. **Ideal head at Delivery line pressure gauge:** This should also be mentioned on the board in Pump house for day to day guidance alongwith ideal flow and M.I.P (Motor Input Power) perhour.

C. MISTAKES RELATED TO SPEED (RPM)

Max permissible speed depends on suction specific speed which is given by the under mentioned formula:

$$\textbf{Suction Specific Speed} = \frac{3.65 \times RPM \times \sqrt{Q}}{NPSHR^{0.75}}$$

'S' should be 420 rpm as far as possible.
Q is cumecs (fixed).

NPSHR is a design parameter of the pump and is also fixed.

So the only changeable parameter is speed (RPM)

Generally up to 1800 m^3/hr, speed of 1500 rpm is kept
From 2400 – 3600 m^3/hr, speed of 1000 rpm is kept for single stage
From 2400 – 3600 m^3/hr, speed of 750 rpm is kept for 2 stages

D. MISTAKES RELATED TO EFFICIENCY OF PUMP SET

Efficiency consists of pump efficiency & motor efficiency.

1. Pump efficiency depends on Specific Speed formulae. Optimal pump efficiency is at 170 rpm within the range of 140 – 200 rpm.
   The efficiency given in water manual against specific speed is max achievable pump efficiency for design purpose. 2- 3 less points should be considered. Pump efficiency depreciates at 0.5 to 0.75 percentage points yearly due to the various reasons.
2. **Motor efficiency:** there are two types of motors available now. One is standard motors as per IS – 325 and the other is energy efficient motors (IS 12615). Energy efficient motors are a bit costlier than standard motors, but the extra cost is recovered within 1 to 2 years of its use.
3. **Overall Pump motor set:** This is multiplication of efficiency of pump and motor and is generally known as water to wire efficiency.
4. **Efficiency vs Operating cost:** Power consumed by pump motor set

   M.I.P $= \frac{Q \times H}{367.2 \times \eta_o}$ **Q - m^3/hr; H - Head; η_o– overall efficiency**

   It is established now that even one percentage point more overall efficient pump sets pay back its intial cost through capitalized cost of savings in energy. Moreover energy efficient pumpsets are more reliable, robust and hassle – free in operation. So only energy efficient motors should be preferred.

E. MISTAKES RELATED TO KW OF PUMP SETS (L.T. MOTORS ONLY)

Elect motors are avialable in some standard sizes only as mentioned below in KW ratings:

1.5, 2.2, 3.7, 5.5, 7.5, 9.3, 11, 15, 18.5, 22, 30, 37, 45, 55, 75, 90, 110, 132, 150, 160, 185 etc.

While designing the pump sets on the basis of design flow rate and head we find the required KW of Elect motor is little more than standard size and the gap in between the designed KW and next standard size is 15 to 25%, so we opt for the next STD size. It means motor is under loaded by that percentage. This reduces motor efficiency & power factor of the motor.

In such cases informatin regarding most suitable pump sets should be obtained from the pumps manufacturers.

We can not change the head but increasing the flow rate we can arrive at KW rating by which motor will be 90% loaded.
