Experiment No.4

STUDY & DEMONSTRATION OF DIFFERENT NON CONVENTIONAL PUMPS SUCH AS AIR LIFT PUMP, JET PUMP, DEEP WELL PUMP, HYDRAULIC RAM ETC

Name of the student:

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Experiment No : 05

1. **Title** : Study & demonstration of different non conventional pumps such as Air lift pump, Jet pump, Deep well pump, Hydraulic ram etc

AIR-LIFT PUMP

These pumps are used to lift water from low level to high level. The energy input to the pump is in the form of compressed air energy.

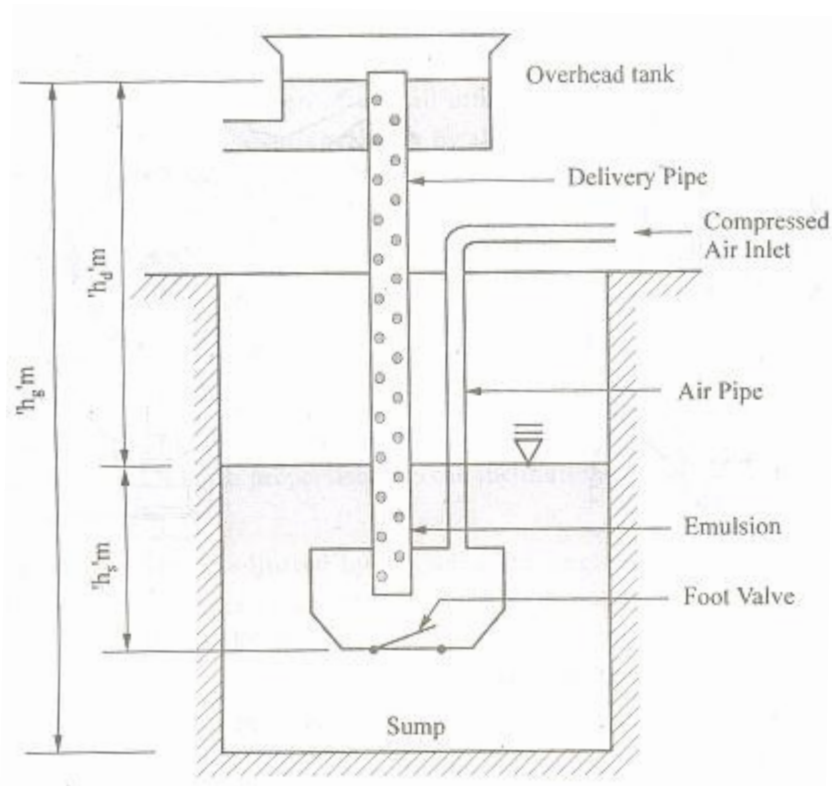

Fig. 9.16 : Typical air lift pump

The compressed air is supplied from an air compressor and air pipe to the lower box. The box appears to the sump through the foot valve. There stands upright a delivery pipe opening in the overhead tank. The air pump is submerged below the sump level by 'hs' m.

When the compressed air is supplied through the air pipe, a series of bubbles is injected into the water in the lower box. These bubbles mix up with water. The air having low density rises upward into the delivery pipe carrying water with it to some distance. The air gradually separates itself from the liquid and forms a pure air section. This air section acting like piston pushes the water column above it upwards towards the overhead tank. Some air dissolves with water, while the rest of the air releases to the atmosphere from the exposed water level in the over head tank. The lifting of water through the delivery pipe is due to the low density of the air-water mixture (if assumed homogeneous) and the density of water in the sump.

m_w	=	Mass flow rate of water (kg/s)
m_a	=	Mass flow rate of air (kg/s)
ρ_w	=	Density of water (kg/m3)
ρ_{em}	=	Density of emulsion (air-water mixture), (kg/m3)

Pressure of water in the lower intake section of pipe = ρ_w x g x hs (Pa)

While pressure at the bottom of the emulsion column pipe = ρ_{em} X g X (hs + hd) (Pa)

Thus, for the emulsion to rise, $\rho_w \times g \times hs > \rho_{em} \times g \times (hs + hd)$

Hence, the air lift head 'hd' is given by, $hd = hs\,(\rho_w/\rho_{em} - 1) - h_{loss}$

where h_{loss} are hydraulic losses, if any, in the pipe.

It is seen that greater the air lift head 'hd' required, greater is the submergence of the air pipe.

ξ = Immersion ratio = hs/ hd'

It is found that :

i)Amount of air required varies inversely as immersion ratio ξ.

(ii) For a given mass flow rate of air supplied, quantity of water lifted reduces with lower immersion ratio ξ . Thus, small immersion ratio ξ with large quantity of water results in uneconomical operation of the pump. Usually, ' ξ ' should be arranged between 1 and 3.

(iii) When ' ξ ' is constant, as amount of air supplied increases, the flow' rate of water increases and attains a maximum value. Further, increase of air supply decreases the quantity of water raised. Thus, the air lift pump should be so designed and operated as to achieve minimum specific air consumption.

$$m_{asp} = ma/ mw \quad \text{kg of air/kg of water}$$

JET PUMP

A jet pump differs from all other pumps considered as it does not have moving parts. The jet pump consists of a supply pipe which supplies water under some head. The supply pipe is fitted with a nozzle which discharges the water supplied in the form of a high velocity jet into the mixing chambers. The absolute pressure in the first mixing chamber is low due to which water from the sump is drawn in. The jet entrains liquid sucked into it imparting some of its energy to the latter. The combined stream then passes through a diffuser wherein the stream gains pressure head at the cost of its kinetic energy and the stream reaches the required elevation.

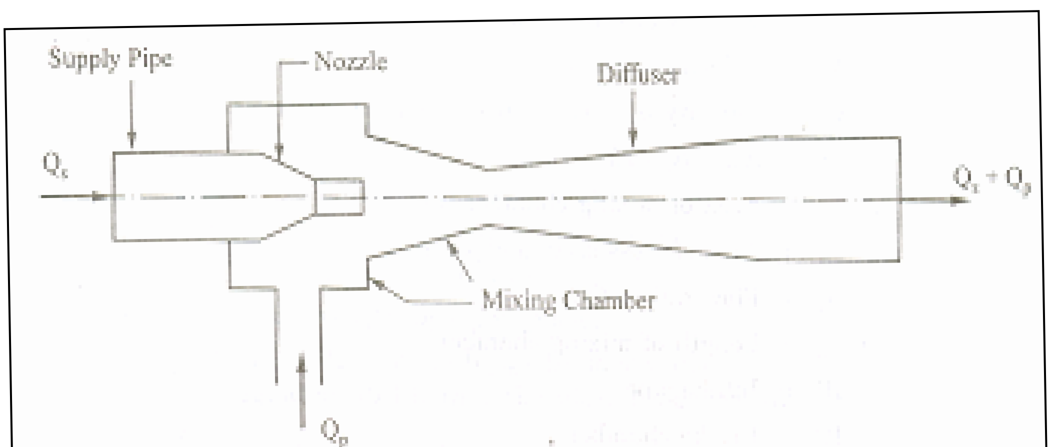

Fig. 9.19 : Jet pump

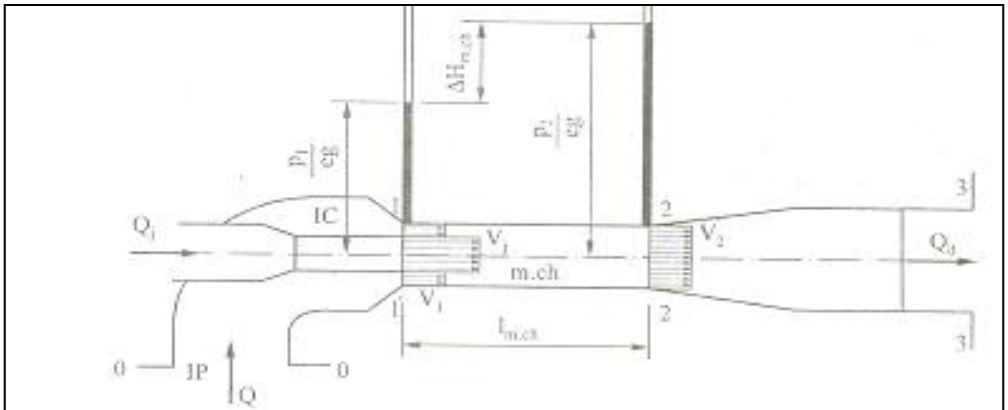

Fig. 9.20 : Jet pump parameters

Let,

Q_i = Flow rate from supply nozzle (m^3/s)

Q = Flow rate from intake pipe (m^3/s)

Q_d = Flow rate discharged from the diffuser (m^3/s)

Hydraulic Ram :

The Pump is used to lift small quantity of water through a grater height using the energy of a large quantity of water flowing down through a small head.

Construction of a Hydraulic Ram

It consists of a supply tank situated at an elevation of 'h' m above the valve box. It is connected to the valve box through a lung drive (supply) pipe fitted with a control valve close to the valve box. The valve box is a small fabricated metal chamber. It houses two main valves, viz. the spring loaded waste water valve and the delivery valve. The waste water valve opens inside with respect to the valve box, while the delivery valve opens outside towards the air vessel.

Above the delivery valve is placed one large air vessel containing water column up to some height. A long. delivery pipe runs from the bottom of the air vessel to the overhead tank. A small sniffing valve (or air release valve) is also placed on the valve box opening towards the valve box. All these valves operate only due to the appropriate pressure difference prevailing on either sides.

Principle of Operation

Before the control valve is opened, the drive pipe is full of water column at rest. The valve box is partly full of water. The waste water valve is open due to the low pressure in the valve box and atmospheric pressure on the other side. The delivery valve is closed due to low pressure from the valve box side and the high pressure on its top due to the head of water column in the delivery pipe and the pressure of air entrapped above the water column in the air vessel.

When the control valve is opened, the long water column in the drive pipe starts accelerating, its velocity increases under the supply head. Water level in the valve box rises gradually and some water starts flowing out of the waste water valve. For some time, the inflow of water to the valve box increases, while the water column in the drive. pipe accelerates, than the outflow of water through the waste water valve. Due to this, the pressure in the valve box gradually increases. When the pressure in the valve box exceeds the pressure on the waste water valve, the waste water valve suddenly closes.

Due to the sudden closure of the waste water valve, the pressure in the valve box rises further. At the same time, the water column in the drive pipe starts decelerating. Its momentum is destroyed which further augments the pressure in the valve box. This high pressure from the valve box side forces the delivery valve to open. A large quantity of water rushes towards the air vessel and some water enters the delivery pipe as well. The water entering the air vessel increases the pressure of air entrapped above the water level.

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A heavy outward rush of water from the valve box decreases the pressure in the valve box below the atmospheric pressure. The reduction of pressure in the valve box opens the waste water valve. At the same time, the delivery valve closes preventing the back flow of the water delivered. The water column in the drive pipe once again starts accelerating and the cycle continues.

Opening and closing of a waste water valve generates an audible sound known as the 'beat',

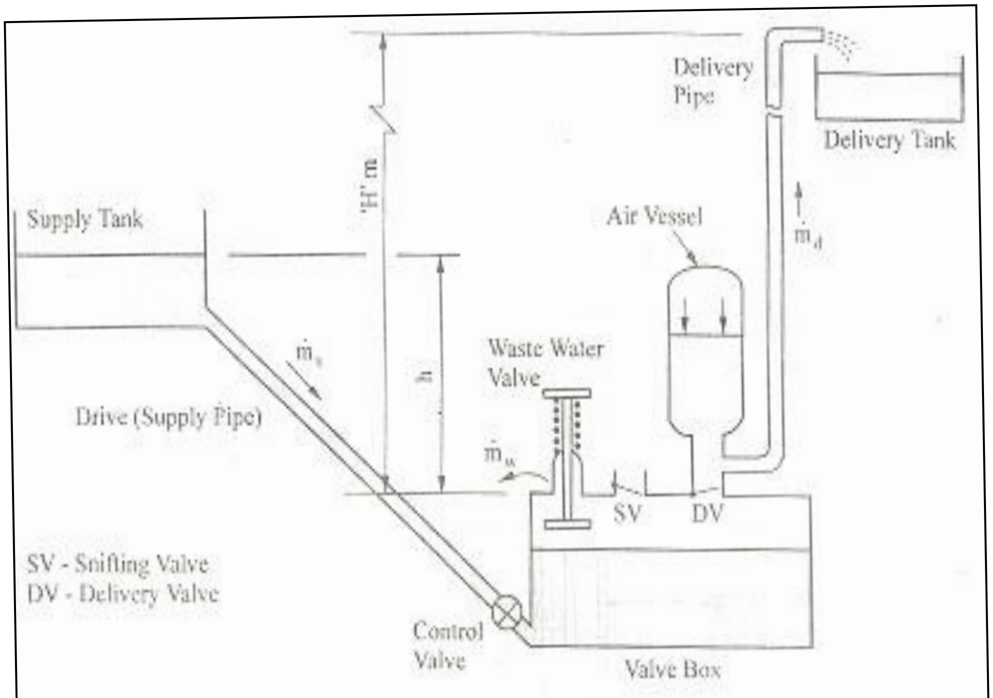


Fig. 9.23 : Hydraulic Ram

Energy Analysis and Performance Characteristics

m_w = Mass flow of the waste water (kg/s)

m_d = Mass flow of the water delivered (kg/s)

m_s = Mass flow of water supplied (kg/s)

h = Head of water supplied (m)

H = Head of water delivered (m)

Then **ms = (m_w + m_d) kg/s**

I. **D'Aubuisson's Analysis**:

Energy utilized/s = Output of the hydram

= m_d x g x H (N-m/s)

Energy supplied/s $= m_s \times g \times h$ (N-m/s)

$= (m_w + m_d) \times g \times H$ (N-m/s)

Hence, *D'Aubuisson's* efficiency,

$$\eta_D = \frac{m_d \times g \times H}{(m_w + m_d) \times g \times H \text{ N-m/s}}$$

D. Rankine's Analysis:

Rankine argued that the output of the hydram is not correct as given by equation of D'Aubuissons, since the water lifted or delivered was already having a head 'h'. He proposed a modified expression for efficiency as under:

Rankine efficiency -

$$\eta_R = \frac{m_d \times g\,(H - h)}{m_w \times h \times g}$$

It is found that the performance of the hydraulic ram depends upon the amount of water wasted. It is also dependent upon the resistances of the valves and the supply pipe. Wastage of water increases when the waste water is kept open for a longer time.

As the lift of the waste water valve is increased, its time of opening is more, it increases the delivery head due the greater pressure developed in the valve box. But with increase of lift of waste water valve, the wastage of water is also more.

Higher delivery head gives higher efficiency, while the increase in wastage is found to reduce the efficiency. Increase of delivery head is found to increase efficiency only up to a certain delivery head. Further, increase of delivery head reduces the efficiency. The efficiency is found to be higher only at low or moderate delivery heads.

The efficiency is also influenced by the ratio *l*/*h*. Longer length of the drive pipe, *'l'* gives larger momentum of the water column, with higher frictional losses. Usually, *'l/h'* ratio of 2.5 to 3 is recommended. But ratios of the order of 25 - 30 have been in use.

The ratio 'H/h' also influences the efficiency. When this ratio is 4, an efficiency of about 75% is achieved. Further increase of 'H/h' ratio reduces the efficiency.

The layout of a supply or drive pipe has also a significant role on the performance of the hydram. It is so designed as to have minimum losses, to avoid cavitations. Steeper the driver pipe, the number of beats are more, the ram operation 'is rough and a possibility of bursting due to excessive pressure built-up in the valve box. In practice, an inclination of 1 : 9 to 1 : 4 is recommended. For a straight vertical supply pipe, a provision of a safety valve is necessary.

Advantages of Hydraulic Ram :

(1) It does not need electrical energy.

(2) It requires negligible maintenance.

(3) No lubrication is necessary.

(4) Absence of moving parts, no need of foundation.

Disadvantages ;

(1) Quantity of water wasted is considerably more than the quantity of water delivered.

(2) Operation is noisy.

(3) It cannot operate with suction lift. It needs suction head.

VERTICAL TURBINE PUMPS (DEEP WELL PUMP)

These pumps are now-a-days extensively used for pumping water from deep well. These pumps are usually multi-stage type with capacity ranging between 50 lps to 10,000 lps and head 30 - 65 m per stage. The vertical turbine pump mainly consists of pumping unit, driving unit, discharge pipe connection and bearings. The vertical turbine pump can be wet-pit type or dry-pit type.

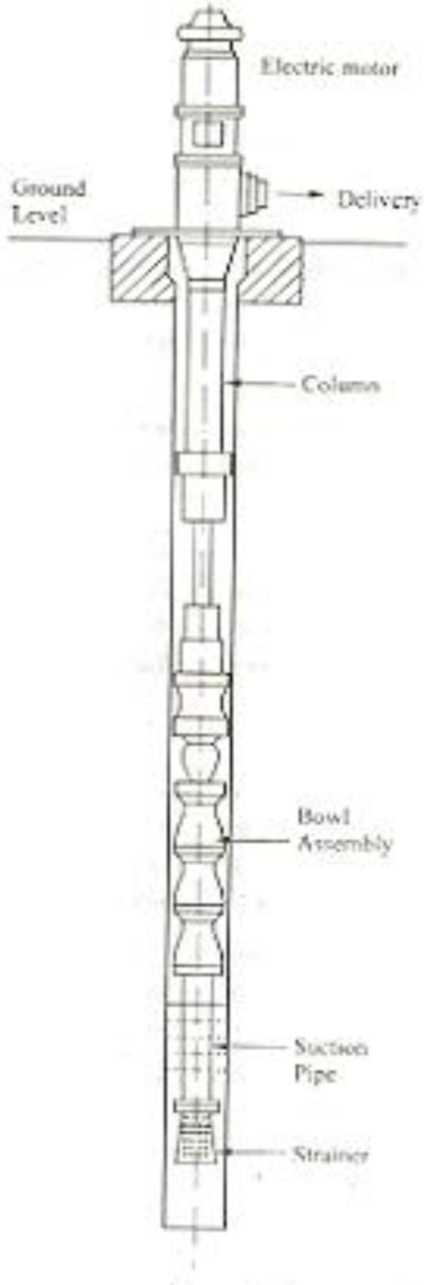
These pumps are best suited where sump level fluctuates widely, e.g. high-low tides, flood conditions, level fluctuation due to other nearby pumps. These pumps have high specific speed and hence compact size.

Construction: The pump unit consists of individual stages Le. casing with diffusers, impeller etc. bolted together. All impellers are fitted on a common shaft supported between bearings. Each impeller discharges to a .bowl having diffuser vanes. The upper bowl is connected to the column pipe with a taper pipe. Water enters the first impeller through a bell mouth.

The column unit connects the pump unit tQ the driving unit. The length of the column unit is so adjusted to provide the required submergence above the bell mouth, to avoid cavitations and vortex. The column unit consists of column pipes, line shafts, shaft inclosing tubes, coupling and bearings. The function of the column pipe is to support the rotor and to provide flow passage for the liquid being pumped.

The driving unit supports the suspended column unit. The pump unit is submerged while the driving motor is at the floor level. It consists of a discharging head, a: motor stool, a thrust bearing housing, a stuffing box, the driving shaft, coupling etc.

Discharging heads are provided for pumps delivering below ground level.



Deep well pump

Conclusion:

Signature of Staff

(Prof. A.B VERMA)