Improving irrigation water use efficiency

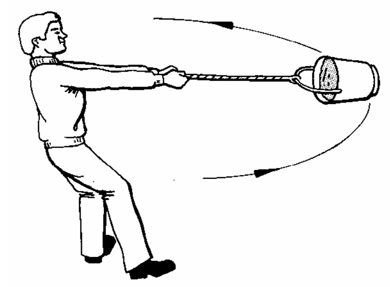
Pumps

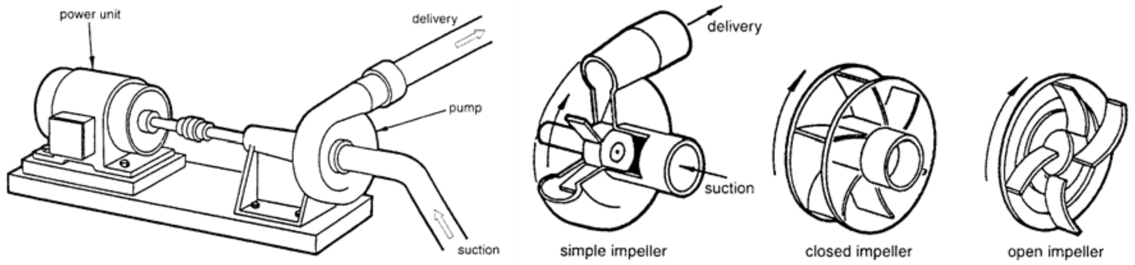
Pumps are a means of adding energy to water. Combustion engines and electric motors convert fuel energy into useful water energy to provide the pressures and discharges needed to distribute water in pipe systems.

Centrifugal pumps

Centrifugal pumps are ideally suited to irrigation schemes where there is a requirement for relatively small discharges at high pressures.

To understand how centrifugal pumps work consider first how centrifugal forces occur. Most people will, at some time, have spun a bucket of water around at arm's length and observed that water stays in the bucket even when it is upside down. Water is held in the bucket by the centrifugal force created by spinning the bucket. The faster the bucket is spun the tighter the water is held. Centrifugal pumps make use of this idea. The bucket is replaced by an **impeller** which spins at high speed inside the pump casing. Water is drawn into the pump from the source of supply through a short length of pipe called the **suction**. As the impeller spins, water is thrown outwards and is collected by the pump casing and guided towards the outlet – the **delivery** side of the pump.



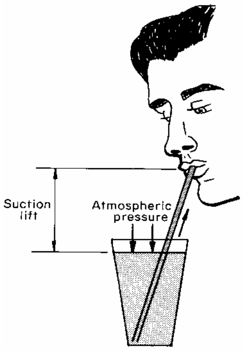


Centrifugal pumps are very versatile and can be used for a wide variety of applications. They can deliver water at low heads from just a few metres up to 100m or more. The discharge range is also high, from a few litres per second up to several cubic metres per second. Higher pressures and discharges are achieved by running several pumps together either in series (to increase pressure) or in parallel (to increase discharge). An alternative is to use a multi-stage pump.

Suction lift

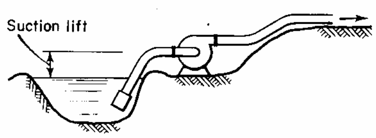
An aspect of centrifugal pumps which is not always fully understood and which can seriously impair efficiency is the suction side of the pump. Pumps are often located, for convenience of use, above the water source and so water is sucked up a short length of pipe into the pump. The difference in height between the water surface in the sump and the pump is called the **suction lift**.

When a pump is operating it draws water from the sump in much the same way as you would suck up water through a drinking straw. But you do not actually suck up the water, you suck out the air from the straw and create a vacuum. Atmospheric pressure does the rest. It pushes down on the water surface and forces water up the straw to fill the vacuum. So atmospheric pressure provides the driving force but it also puts a limit



on how high water can be lifted in this way. It does not depend on the ability of the sucker. At sea level, atmospheric pressure is approximately 10m head of water and so if you were relying on a straw 10.1m long for your water needs then will die of thirst! The shorter the straw the easier it is to get a drink.

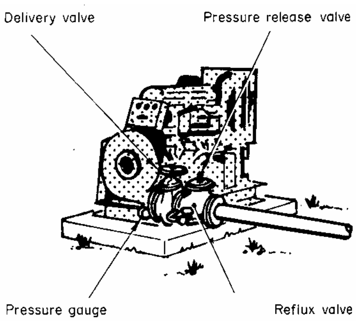
This same principle applies to pumps. Ideally it should be possible to lift water by suction up to 10m. But because of friction losses in the suction pipe and the practical problems of maintaining a vacuum a more sensible and practical limit for pumps is 3m.



Not all pumps suffer from suction problems. Some pumps are designed to work below the water level in the sump and are called **submersible pumps**. These are often used in deep boreholes and are driven by an electric motor, which is also submerged and connected, directly to the pump drive shaft. The motor is well sealed from the water but being submerged it helps to stop the motor from overheating.

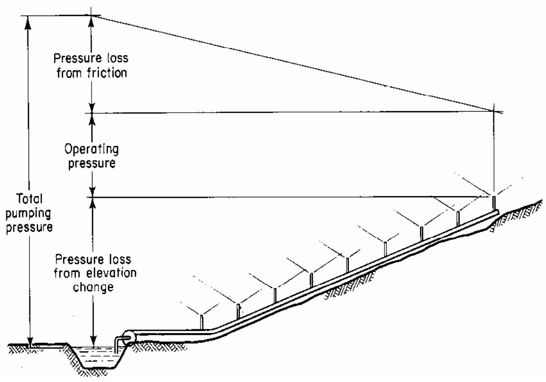
Centrifugal pumps will only work when the pump and the suction pipe are both full of water. Taking out the air and filling the pump and suction with water is a process known as **priming**. A small hand pump, located on the pump casing, is used to evacuate the air. Pumps located below the sump do not require priming. They naturally fill with water under the influence of gravity.

Delivery



The delivery side of a pump comprises pipes and fittings to connect the pump to the main pipe system. A sluice valve is connected to the pump outlet to control pressure and discharge. It is closed before starting both to prime the pump and to stop surging once the pump starts running. Once the pump is running the valve is slowly opened to deliver the flow. A reflux (non-return) valve allows water to flow one way only – out of the pump and into the pipeline. When a pump stops suddenly water can flow back towards the pump causing a rapid rise in pressure rise, which can seriously damage both the pump and the pipeline. The reflux valve helps to prevent damage by closing and stopping this reverse flow from reaching the pump. A pressure relief valve can also be fitted to avoid excessive pressures that can also damage the pipe system.

Pumping pressure requirements



The pumping pressure must take into account:

- Suction lift
- Recommended pressure at sprinkler/raingun
- Pressure losses in the mainlines, laterals, and hose reels in the case of rainguns
- Changes in ground elevation.

All these values must be added together to arrive at the pressure required at the pump:

Pumping head (m) = suction lift (m)
+ pressure at sprinkler/raingun (m)
+ pressure losses in pipe system (m)
+ changes in ground elevation (m)

Notice how all the various pressure components are measured in metres head so they can be added together. Allowances must also be made for various fittings such as valves, pipe bends etc. It is usual to add on 10 percent of the final pressure to account for these.

Pump performance

Pump Size (mm)	Discharge (l/s)
25	0 - 5
50	5 - 15
75	15 - 25
100	25 - 35
125	35 - 50

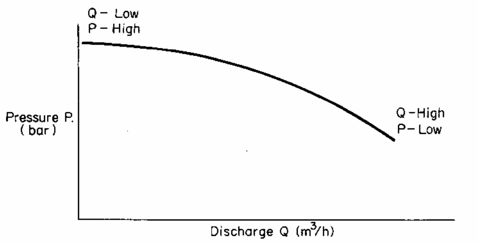
Small centrifugal pumps are sometimes characterised by the power of their drive motors e.g. 3HP pump or a 5kW pump; or by their delivery diameter e.g. 50mm pump. The table provides some guidance for selection but a more detailed assessment of pump performance is needed for larger pumping installations.

Pump performance is described by pressure and discharge, power needs, and efficiency.

Pressure and discharge

Centrifugal pumps are designed to deliver a wide range of discharges depending on the pressure required and the speed at which it rotates.

When a pump starts up it takes a little time for it to reach its normal running speed. During this time the delivery valve should be closed and there is no flow in the pipeline. Pressure gradually builds up inside the pump casing. A common misconception is that this will cause the pressure to go on rising until eventually it bursts the pump casing.

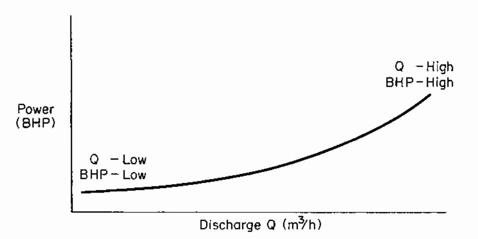


This is not so. The pressure depends only on the speed of the pump. The faster it rotates, the higher will be the pressure it produces. Once the pump reaches its design speed the pressure stabilises.

As the delivery valve is opened the pump starts to discharge into the pipeline. As the flow increases so the pressure decreases. The diagram shows this trade off between pressure and discharge. If a high pressure is required then only a small discharge will be available. If a high discharge is required then the pressure will be less.

Higher pressures and discharges can be obtained by increasing pump speed.

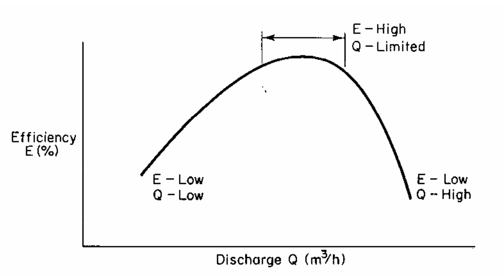
Power



A pump needs power to rotate the impeller and this is measured in kiloWatts (kWatts) or Horse Power (HP). The amount of power required varies with the pump discharge. When the pump starts and there is no flow, only a small amount of power is needed. But as the delivery valve is opened and the flow starts, the power required increases. More power is also required if higher pump speeds are needed.

Efficiency

The efficiency of a pump measures how well the mechanical power supplied by the power unit is converted into water power in the pump.



Centrifugal pump efficiencies vary from 30% to 80% depending on how they are used. There is only a small range of discharges at which the pump will have the highest efficiency. If the pump operates above or below these values it will be less efficient and more energy will be wasted during operation.

All centrifugal pumps have characteristics like these but different pump sizes and shapes produce different pressures, discharges and power requirements. Information on pump performance is normally provided by the manufacturer. The task is to select a pump whose performance closely matches the needs of the irrigation system. Obviously the pump must be able to produce the required pressure and discharge but for best performance this should be near to the point of highest efficiency. In this way the power supplied will be used most efficiently.

Melvyn Kay