8

Feed Water treatment

Course Contents

8.1 Necessary of Feed Water Treatment

Following are various reason which clearly indicate that feed water treatment is required in power plants before supply it into boiler.

- Natural water contains solid, liquid and gaseous impurities hence it cannot be used for steam generation in boiler.
- The boiler water needs to be alkaline and not acidic, so that it does not ruin the tubes.
- To prevent scale formation inside and outside the tubes.

8.2 Different impurities found in feed water and its effects

All natural waters contain various types and amounts of impurities. These impurities cause boiler problems and as such consideration must be given to the quality and treatment required of the water used for generating steam.

It is mainly classified in three parts

1. Undissolved and suspended solids.
2. Dissolved calcium and magnesium salts
3. Dissolved gases

Undissolved and suspended solids

i. **Turbidity and sediments**: It is suspended insoluble matter such as mud, sand etc. which settle down when there is no disturbance in water.

ii. **Sodium and Potassium salts:** They are alkaline in nature and accelerate the corrosion process.

iii. **Chlorides:** Increase the corrosive action in water.

iv. **Iron:** Ferrous bicarbonate is the most common soluble iron found in water. Such water becomes yellow in color and it is harmful as it forms soft scale.

v. **Manganese:** It is equally troublesome as iron.

vi. **Silica:** Natural water contains 1-100 ppm of silica. It accelerate hard scale in boiler tubes.

Dissolved calcium and magnesium salts

Calcium and magnesium salts are present in water in form of carbonates, bicarbonates, sulphates and clorides. The presence of these salts can be known as hardness of water. Hardness is further classified as temporary hardness and permanent hardness.

Temporary hardness is caused due to presence of dissolved bicarbonates of Calcium and magnesium and it is removed by boiling.

Permanent hardness is due to presence of chlorides, sulphides, nitrates of Calcium and magnesium. These salt cannot be removed by boiling and form hard scale on heating surface.

Dissolved gases

There are two gases which cause corrosion are oxygen and carbon dioxide which are present in dissolved form of water. Oxygen is corrosive to iron, Zinc, brass, and other metals.

Carbon dioxide is dissolved form in water forms weak carbonic acid. It cause corrosion of metal parts.

8.3 pH & its role in corrosion and scale formation.

pH value of water is the logarithm of reciprocal of hydrogen ion concentration in water. pH value varies from 0 to 14. pH value less than 7 indicates acidity of water and more than 7 indicates alkalinity of water.

Role of pH in corrosion

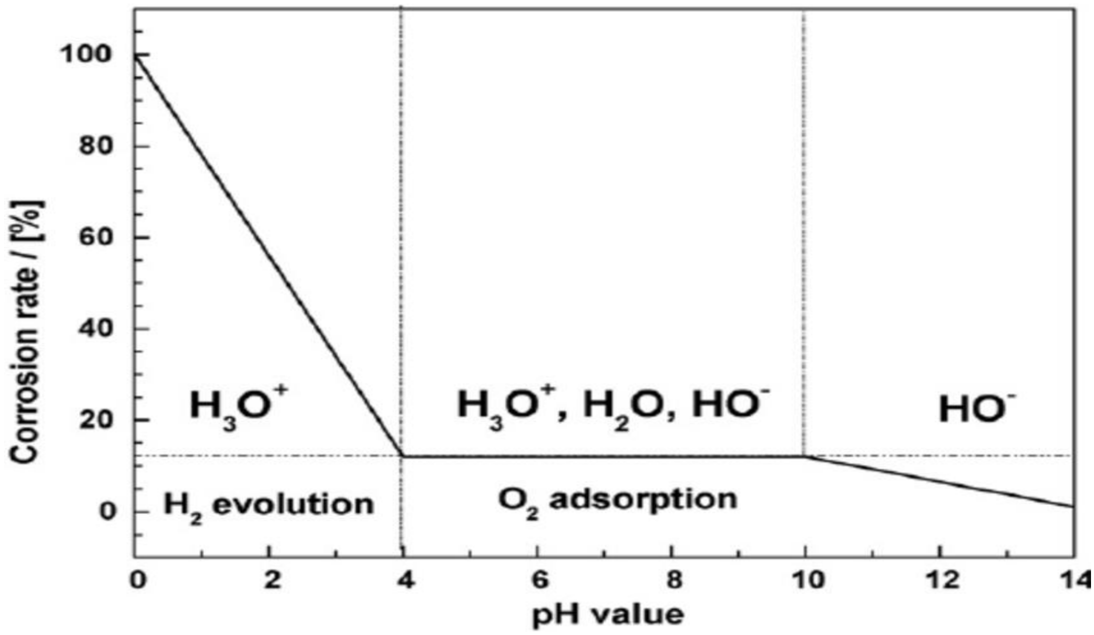

Figure 8.1 Role of pH in corrosion

The corrosion rate of iron in absence of oxygen is proportional to pH value upto 9.6. The pH value of water determines the solubility of iron and hence the rate of corrosion.

Corrosion rate increases due to presence of dissolved O2 and CO2 in water as concentration of H^+ ions increasing which increases the pH value of water.

Role of pH in Scale formation

Scale formation and corrosion are reciprocal phenomena. A decrease in pH value will make water more prone to corrosion whereas increase in pH value will increase the tendency of scale formation.
Calcium hardness, alkalinity and pH value are inter related variables in scale formation. Calcium carbonates is the most troublesome deposits responsible for scale formation.

8.4 Methods of Feed Water Treatment

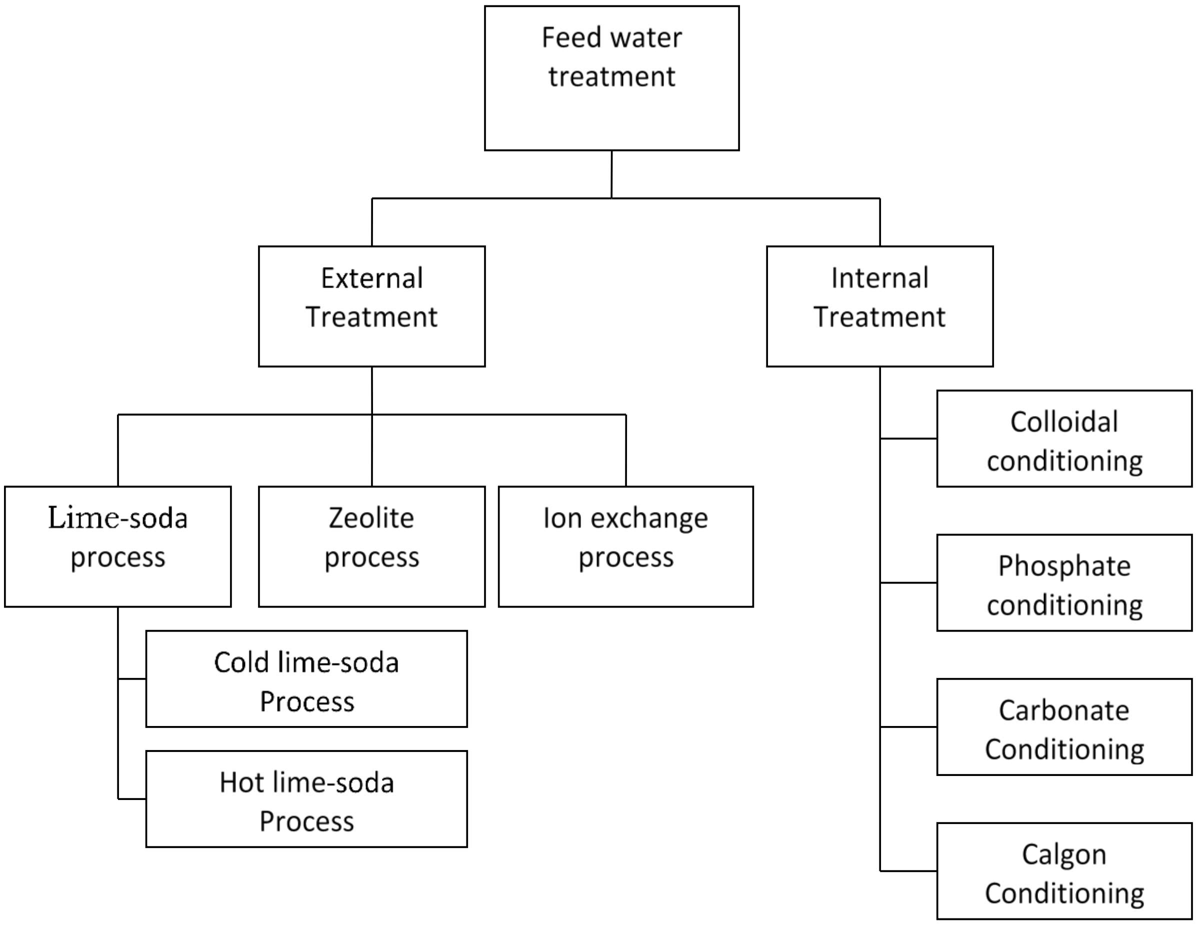

Figure 8.2 Methods of feed water treatment

8.5 Hot Lime soda Process

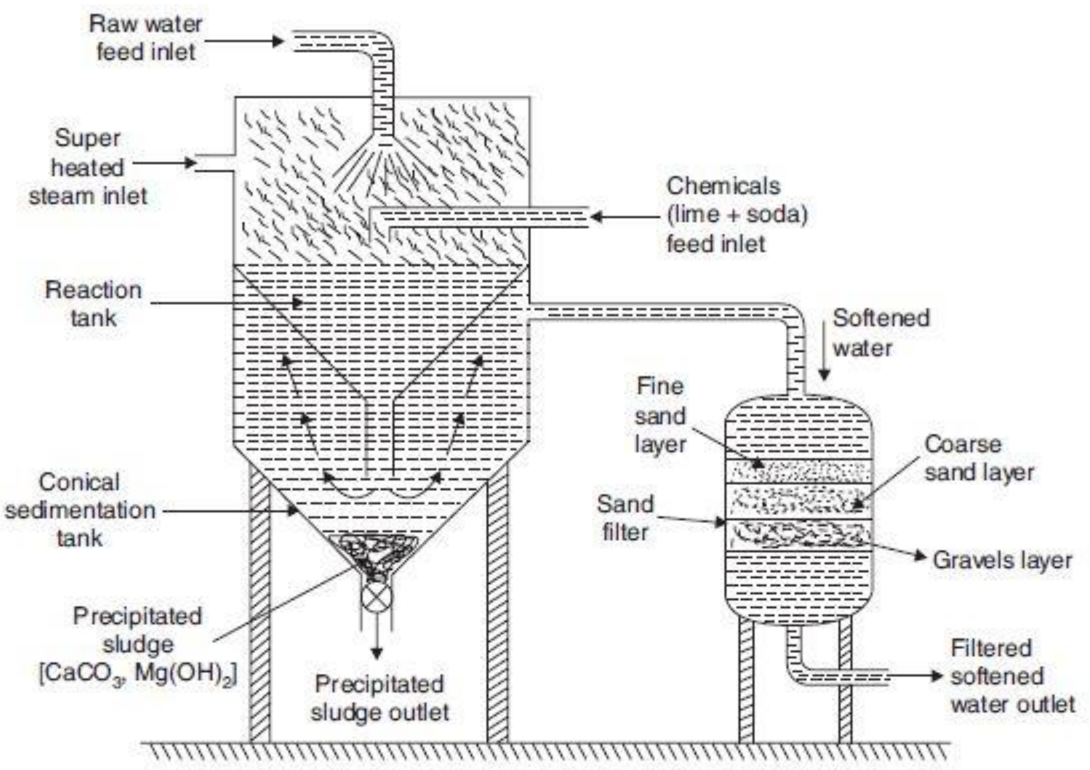

Figure 8.3 Hot lime soda process

Hot lime-soda plant consists essentially of three parts (a)'reaction tank' in which raw water, chemicals and steam are thoroughly mixed; (b)'conical sedimentation vessel' in which sludge settles down, and (c)'Sand filter' which ensures complete removal of sludge from the softened water.

In this method raw water and calculated quantities of chemicals (Lime + soda + coagulant) are fed from the top into the inner vertical circular chambers, fitted with a vertical rotating shaft carrying a number of paddles. As the raw water and chemicals flow down, there is a vigorous stirring and continuous mixing, whereby softening of water takes place.

Here the chemicals along with the water are heated near about the boiling point of water by exhaust steam.

Advantages of Lime soda process:

- It is a very economical.
- If this process is combined with sedimentation with coagulation, lesser amounts of coagulants shall be needed.
- The process increased the pH value of the treated water, thereby corrosion of the distribution pipes is reduced.

- Besides the removal of hardness, the quantity of minerals in the water are reduced.
- To certain extent, iron and manganese are also removed from the water.
- Due to alkaline nature of treated- water, amount of pathogenic bacteria's in water is considerably reduced.

Disadvantages of Lime soda process:

- Disposal of large amounts of sludge (insoluble precipitate) poses a problem. However, the sludge may be disposed of in raising low-lying areas of the city.
- This can remove hardness only up to 15ppm, which is not good for boilers.

8.6 Zeolite ion exchange Process

Zeolite is hydrated sodium alumino silicate capable of exchanging reversibly its sodium ions for Ca2+ and Mg2+, having the general formula $Na_2O.Al_2O_3.xSiO_2.yH_2O$ (where x=2-10 and y=2-6). Zeolite are two types,

1) Natural zeolites are non-porous for Ex; Natrolite Na2Al3O3.4sio22h2o
2) Synthetic zeolites possess gel structure. Synthetic Zeolites possess higher exchange capacity than natural Zeolites.

Process

For Softening of water by Zeolite process, hard water is percolated at a specified rate through a bed of zeolite; kept in a cylinder. The Hardness causing ions (ca^{+2}, Mg^{+2} etc.) are retained by the zeolite as CaZe and MgZe, while the outgoing water contains sodium salts. Reactions taking place during the softening process are,

$Na_2Ze + Ca(HCO_3)_2 \rightarrow CaZe + 2NaHCO_3$

$Na_2Ze + Mg(HCO_3)_2 \rightarrow MgZe + 2NaHCO_3$

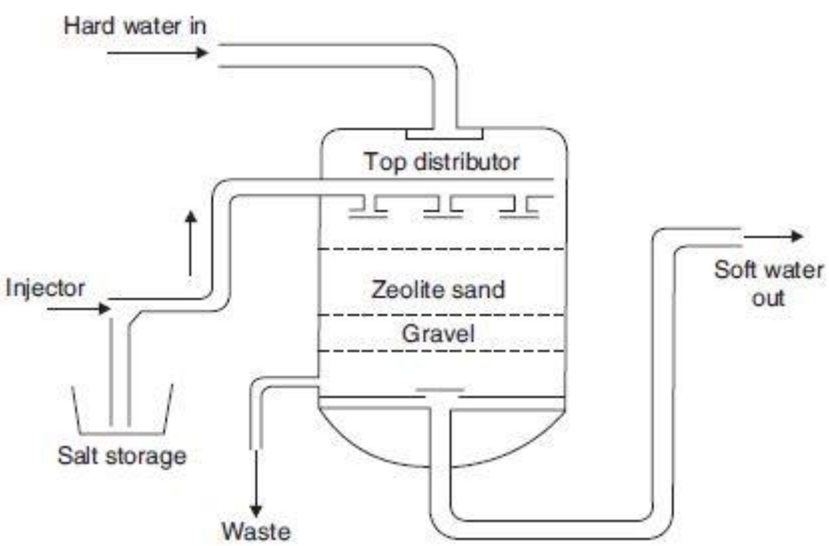

Figure 8.4 Zeolite ion exchange Process

Regeneration:

After Some time the zeolite is completely converted into calcium and magnesium Zeolites and it ceases to soften water i.e.; it gets exhausted. At this stage the supply of hard water is stopped and the exhausted zeolite is reclaimed by treating the bed with a concentrated NaCl solution,

$$CaZe \text{ (or } MgZe) + 2NaCl \rightarrow Na_2Ze + CaCl_2 \text{ (or } MgCl_2)$$

The washings are led to drain and the regenerated zeolite bed thus obtained is used again for softening process.

Advantages:

- If removes the hardness almost completely
- Equipment occupying a small space
- Requires less time
- It is quite clean

Disadvantages:

- Treated water contains more sodium salts than in time soda process
- The method only replaces Ca+2 and Mg+2 ions by Na+ ions leaves all the acidic ions.

8.7 Reverse Osmosis process

Reverse Osmosis is a technology that is used to remove a large majority of contaminants from water by pushing the water under pressure through a semi--permeable membrane.

Reverse Osmosis is the process of Osmosis in reverse. Whereas Osmosis occurs naturally without energy required, to reverse the process of osmosis we need to apply energy to the more saline solution. A reverse osmosis membrane is a semi---permeable membrane that allows the passage of water molecules but not the majority of dissolved salts, organics, bacteria and pyrogens. However, we need to ‘push’ the water through the reverse osmosis membrane by applying pressure that is greater than the naturally occurring osmotic pressure in order to desalinate (demineralize or deionize) water in the process, allowing pure water through while holding back a majority of contaminants. Following Figure shows the process of Reverse Osmosis. When pressure is applied to the concentrated solution, the water molecules are forced through the semi-permeable membrane and the contaminants are not allowed through.

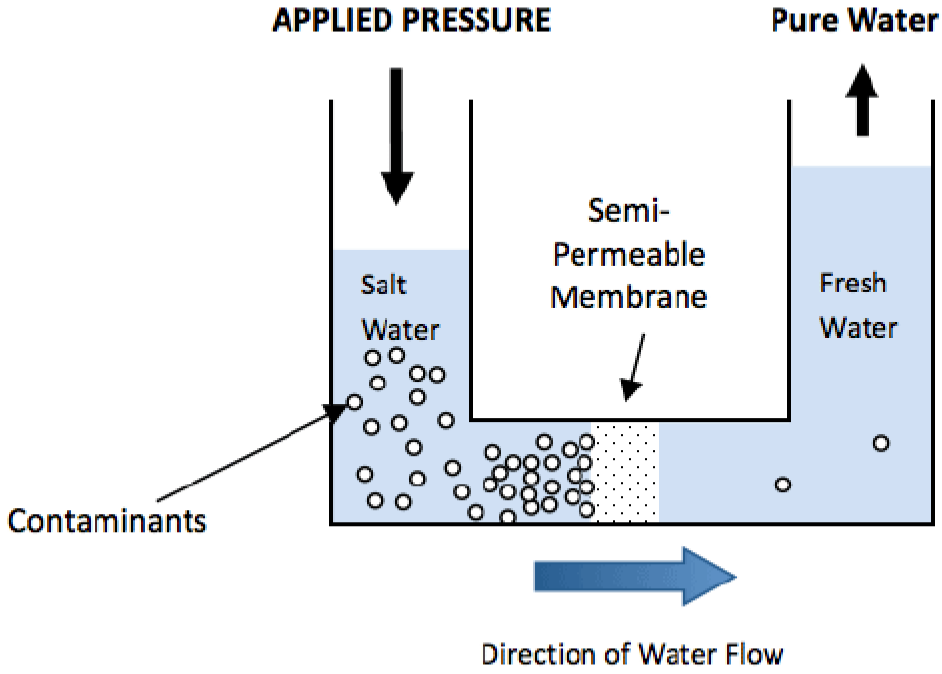

Figure 8.5 Reverse Osmosis process

Working

Reverse osmosis works by using a high pressure pump to increase the pressure on the salt side of the RO and force the water across the semi-permeable RO membrane, leaving almost all (around 95% to 99%) of dissolved salts behind in the reject stream. The amount of pressure required depends on the salt concentration of the feed water. The more concentrated the feed water, the more pressure is required to overcome the osmotic pressure.

In very simple terms, feed water is pumped into a Reverse Osmosis (RO) system and we end up with two types of water coming out of the RO system: good water and bad water. The good water that comes out of an RO system has the majority of contaminants removed and is called permeate. Permeate is the water that was pushed through the RO membrane and contains very little contaminants.

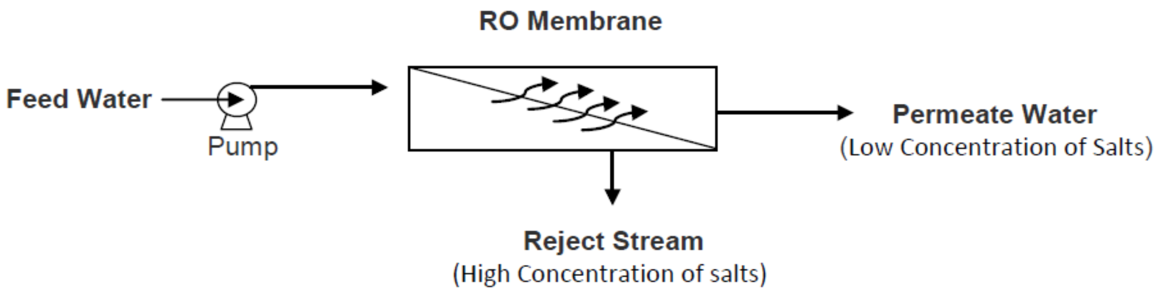

Figure 8.6 RO Pumping process

Figure 8.6 shows how an RO system works. As the feed water enters the RO membrane under pressure (enough pressure to overcome osmotic pressure) the water molecules pass through the semi---permeable membrane and the salts and other contaminants are not allowed to pass and are discharged through the concentrate stream, which goes to drain or can be fed back into the feed water supply in some circumstances to be recycled through the RO system to save water. The water that makes it through the RO membrane is called permeate or product water and usually has around 95% to 99% of the dissolved salts removed from it.

8.8 Sea water treatment using Reverse Osmosis

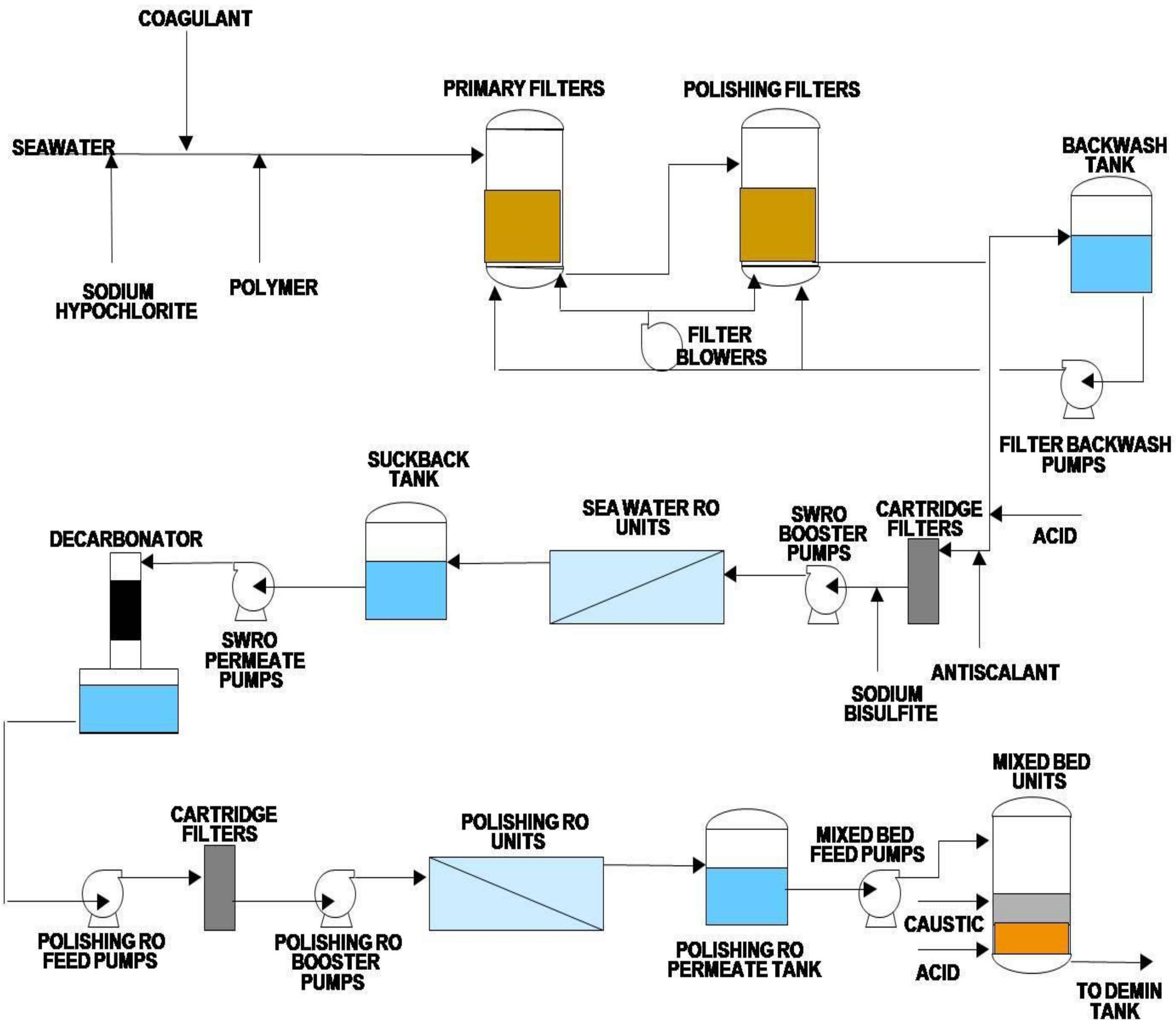

Figure 8.6 sea water treatment using RO

Above figure shows sea water treatment using reverse osmosis process. Depending on the clarity of sea water, pretreatment is required before passing it through RO system. Aluminum sulphate (coagulant) is added to precipitate colloidal material and color.

To reduce the pH value to around 6 and reduce calcium carbonate scaling, HCL or sulphuric acid is added to this water. The water is than filtered using filters commonly called as media filters. Water is than passed through cartridge filter to remove suspended matter. After it water passed through series of semi-permeable membranes to get pure boiler feed water.

The membrane of RO system consist of polymeric material film made of proper porosity and is made of material like acrylics, polyamides etc. As sea water is highly corrosive, the material for construction should be selected so that it can withstand corrosion.

This method is economically used when total dissolved solid present is the water is in the range of 2000 to 10,000 ppm or slightly more.