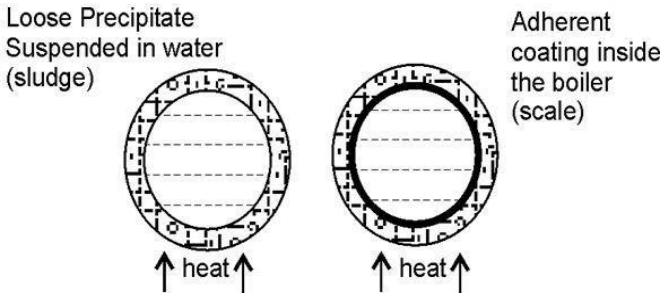
SCALES AND SLUDGES:

In boiler, water is converted to steam. During this process, when the volume of water decreases, a saturation point is reached and all the dissolved salts precipitate out. Depending on the physical and chemical nature of the impurity (salt) it may form a loose, slimy, non- adhering precipitate (Sludge) or hard strongly adhering precipitate (Scale)



Sludge

Loose, slimy and non-adhering precipitate due to presence of salts like $MgCl_2$, $MgSO_4$, $CaCl_2$, $MgCO_3$. It forms in colder portions of boilers and the portion where water flow rate is low.

Disadvantages:

1. Sludges are poor conductor of heat.
2. Excess of sludge formation decreases the efficiency of boiler.

Prevention and removal

1. By using softened water
2. By performing frequent blow down operation

Scale

Hard, adherent coatingdue to presence of salts like $Mg(HCO_3)_2$, $Mg(OH)_2$,

$Ca(HCO_3)_2$,,$CaSO_4$

Prevention and removal

i) By dissolving in acids like HCl, H_2SO_4

ii) B applying external and internal treatment.

iii) Removed by scrapping, wire brushes etc.

PRIMING & FOAMING

- ✓ During the production of steam in the boiler, due to rapid boiling, some droplets of liquid water are carried along with steam.
- ✓ Steam containing droplets of liquid water is called wet steam. These droplets of liquid water carry with them some dissolved salts and suspended impurities.
- ✓ This phenomenon is called carry over. This leads to priming and foaming.

Priming:

When steam is produced rapidly in boilers the steam velocity suddenly increases and some droplets of liquid water are carried along with steam. Steam containing droplets of liquid water is called wet steam. The process of wet steam formation is called Priming.

Priming is caused by

- Presence of large amount of dissolved solids.
- High steam velocity.
- Sudden boiling.
- Improper boiler design.

Priming can be prevented by

- Using treated water.
- Controlling the velocity of steam.
- Fitting mechanical steam purifiers.
- Maintaining low water level.
- Good boiler design.

Foaming: Oil or any other polymeric substance present in boiler feed water, reduces surface tension of water forming bubbles which do not break easily in boilers giving a foam appearance. This process is called foaming.

Foaming is caused by

- Presence of oil & grease.
- Presence of finely divided sludge particles.

Foaming can be prevented by adding coagulants like sodium aluminate, ferrous sulphate etc.

CAUSTIC EMBRITTLEMENT:

Caustic embrittlement means intercrystalline cracking of boiler metal. Boiler water usually contains a small proportion of Na_2CO_3. In high pressure boilers this undergoes decomposition to give NaOH. This NaOH flows into the minute hair cracks and crevices, usually present on the boiler material, by capillary action and dissolves the surrounding area of iron as sodium ferroate. This causes embrittlement of boiler parts, particularly stressed parts like bends, joints, rivets, etc., causing even failure of the boiler.

$Na_2CO_3 + H_2O \rightarrow 2NaOH + CO_2$

$Fe + 2\ NaOH \rightarrow Na_2FeO_2 + H_2\uparrow$

Caustic embrittlement can be prevented by

i) using sodium phosphate as softening agent instead of sodium carbonate.

ii) by adding tannin, lignin to the boiler water, which blocks the cracks.

BOILER CORROSION:

Boiler corrosion is decay of boiler material by chemical or electrochemical attack of its environment.

Boiler corrosion is due to presence of

- Dissolved oxygen
- Dissolved carbon dioxide
- Dissolved salts like magnesium chloride

1. **Dissolved oxygen (DO):**

   When water containing dissolved oxygen is fed into boilers the following reaction occurs corroding the boiler material (rust formation)

$$2Fe + 2H_2O + O2 \rightarrow 2Fe(OH)2 \downarrow$$

$$4Fe(OH)_2 + O2 \rightarrow 2 [Fe_2O_3. 2H_2O]$$

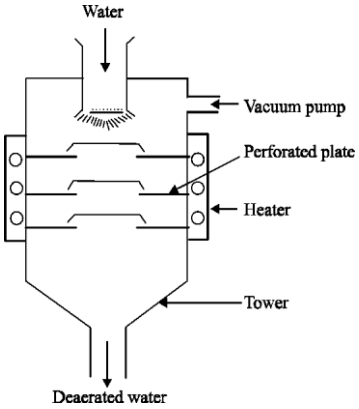
D. O. oxygen can be reduced

i) By adding hydrazine / sodium sulphite

$N_2H_4 + O_2 \rightarrow N_2 + 2H_2O$

$2Na_2SO_3 + O_2 \rightarrow 2Na_2SO_4$

ii) By mechanical deaeration method.



2. Dissolved carbon dioxide:

When water containing bicarbonates is heated, carbon dioxide is evolved which makes the water acidic. This is detrimental to the metal. It leads to corrosion called of boiler material.

$$Ca(HCO_3)_2 \rightarrow CaCO_3 + H_2O + CO_2 :$$
$$CO_2 + H_2O \rightarrow H_2CO_3$$

Prevention methods for removing dissolved carbon dioxide:

By treatment with ammonium hydroxide:

$$2NH_4OH + CO_2 \rightarrow (NH_4)_2CO_3 + H_2O$$

Can be removed by mechanical deaeration method along with oxygen.

3. Dissolved $MgCl_2$:

Acids produced from salts that are dissolved in water are mainly responsible for the corrosion of boilers. Salts like magnesium and calcium chloride undergo hydrolysis at high temperature to give HCl, which corrodes the boiler. Presence of HCl is more damaging due to chain reaction.

$$MgCl_2 + 2H_2O \rightarrow Mg(OH)_2\downarrow + 2HCl$$
$$Fe + 2HCl \rightarrow FeCl_2 + H_2\uparrow$$
$$FeCl_2 + 2H_2O \rightarrow Fe(OH)_2\downarrow + 2HCl$$

$MgCl_2$ can be removed by

i) internal conditioning and ii) external conditioning

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