Engineering Chemistry

CYC 102

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Overview

- Scale Deposits in Boiler
- Reasons of scale formation
- Sludge Formation in Boilers
- Comparison of scales and sludges
- Caustic embrittlement
- Prevention of caustic embrittlement
- Summary

Scale Deposits in Boiler

On continuous evaporation of water in boiler the concentration of soluble matters increases progressively which leads to the deposition of salts.

Scale formation

- Precipitate forms a hard and adherent coating on the inner walls.
- It formed by the substances like $Ca(HCO_3)_2$, $CaSO_4$ and $Mg(OH)_2$.
- Scales formation can be prevented by:

✓ External Treatment Of Boiler Feed Water,

✓ Internal Treatment Of Water In Boiler

✓ Blowdown Process

Reasons of scale formation

- **Decomposition of calcium bicarbonate**

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

✓ In low pressure boilers, $CaCO_3$ causes scale formation.

✓ In high pressure boilers, $CaCO_3$ becomes soluble.

$CaCO_3 + H_2O \rightarrow Ca(OH)_2 + CO_2$

- **Decomposition of calcium sulphate**

The solubility of CaSO4 in water decreases with rise of temperature

- **Hydrolysis of magnesium salts:**

Dissolved magnesium salts undergo hydrolysis forming Mg(OH)2 precipitate.

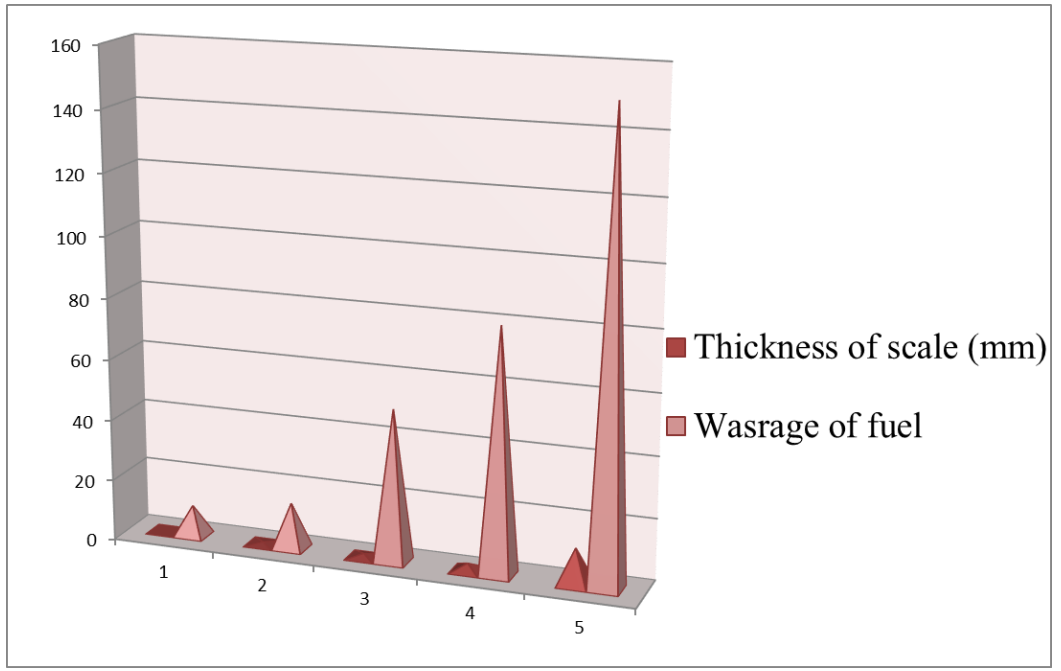
$MgCl_2 + 2H_2O \rightarrow Mg(OH)_2 + 2HCl$

- **Presence of silica**

Silicates deposits like $CaSiO_3$ and $MgSiO_3$

Problems Caused by Scale in Boilers

- Overheating and failure of boiler tubes.
- Increased fuel bill by decreasing the operating efficiency
- thermal damage
- unscheduled down-time
- increased cleaning time and cleaning costs
- reduced working life of a boiler



Thickness of scale (mm)	0.325	0.625	1.25	2.5	12
Wastage of fuel	10%	15%	50%	80%	150%

Sludge Formation in Boilers

- **Sludge**

✓ precipitate is soft, loose and slimy

✓ formed by the substances like $MgCl_2$, $MgCO_3$, $MgSO_4$ and $CaCl_2$.

✓ greater solubility in hot water than cold water.

✓ It is formed at comparatively colder portions of the boiler

✓ collects in the area where flow rate is slow.

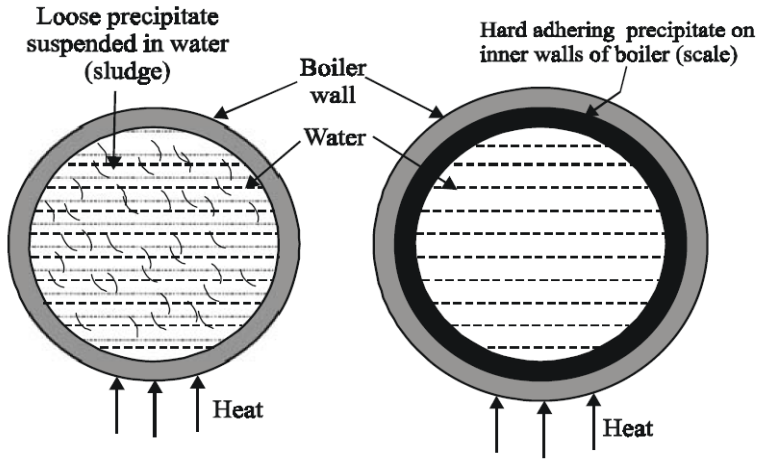
- **Disadvantages**

✓ As the sludge is poor conductor of heat, it causes loss of heat.

✓ The working of the boiler is disturbed because of chocking of pipes by the sludge.

Comparison of scales and sludges

S. No.	Sludge	Scale
1.	A loose, slimy and non-adherent precipitate	hard and adherent coating
2.	$MgCO_3$, $MgCl_2$, $MgSO_4$ and $CaCl_2$	$Ca(HCO_3)_2$, $CaSO_4$, $Mg(OH)_2$
3.	Poor conductors of heat and decreases the efficiency of boiler	Decreases the efficiency of boiler, crack developed leads to explosion
4.	Prevention: Using softened water	 Using HCl, H_2SO_4
	By drawing off a portion of concentrated water frequently.	Internal and external treatment, by applying thermal shocks, scrapers, wire brush, etc.



Caustic Embrittlement

- Formation of brittle and in crystalline cracks in the boiler shell is called caustic embrittlement
- Due to the presence of alkali-metal carbonates and bicarbonates in feed water.
- Lime soda process, residual sodium carbonate makes the water caustic.

$$Na_2CO_3 + H_2O \longrightarrow 2NaOH + CO_2$$

$$Fe + 2NaOH \longrightarrow Na_2FeO_2 + H_2$$

Sodium ferroate

- It occurs at the stressed parts like bends, joints, rivets, etc.

Prevention of caustic embrittlement

- Using sodium phosphate as the softening agent instead of Na_2CO_3.
- Adding chemicals such as tannin, lignin to the boiler water. Prevents infiltration and block the hairline cracks.
- Adjusting pH of the feed water carefully between 8 and 9.
- Adding sodium sulfate to boiler water-prevents infiltration by blocking hair cracks.

Summary

- Rapid evaporation of boiler feed water causes deposits.
- Scale and sludge are the main categories
- Both can be prevented and treated
- Caustic embrittlement caused to increased caustic nature of boiler water.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Thank You!