Corrosion Problems in Low Pressure Boiler in Small & Medium Paper Mills

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Introduction

All the small medium Paper Mills having low pressure Boilers operate at pressure upto 17 bars with steam capacities upto 10 T/hr. The small medium Paper Mills mostly use direct water from river, lake or underground water. The importance of this water is mostly due to its universal solvent property and high physical chemical and biological stability. This water causes many effects in boiler but here I will discuss about corrosion problems.

These small & medium Paper Mills have to work under certain draw backs, such as, no Research & Development unit. They don't care about corrosion problem. It is my intention to discuss about corrosion problem which will help to avoid the problem. The corrosion problems are not new to paper industry but this is not discussed at large. By taking some extra care and work, Boiler efficiency can be improved.

Corrosion can be defined as the destruction of metal by a chemical or electro chemical reaction induced by environmental condition. The major corrosion process in cooling system is of an electro chemical nature. The metal surface involved are lowered with innumerable small anodes and cathodes which are developed from surface irregularities, stress or compositional difference.

A difference in electro potential developes between these two portion of the metal when they are immersed in water. This potential difference causes a flow of electrons. The metal ons go into solution in the anodic region (lower potential). The electrons released at the anode migrate to the cathode and form hydroxyl ions in the presence of oxygen in the water. The mettaic ions that have gone into the solution at the anode combine with the hydro ions produced to form $Fe(OH)_2$ which by further oxidation is connverted to Fe_2O_3,

Water used in boiler from river, lake or ground well have Typical Characterstics, which show in Table 1.

Sl. No.	Characterstics	River water	Lake water	Ground water
01	Turbidity	20—3000	5—500	0—10
02	pH	7.0—8.0	7.5—8.5	7.5—8.5
03	Alkalinity as Caloz PPM	30—350	As River Water	150—450
04	Hardness as Caloz PPM	30—350	—do—	100—1000
05	Chlorides as Cl-PPM	5—100	—do—	2—150
06	Sulphates as Sou PPM	5—80	—do—	2—150
07	Silica as SIO_2 PPM	5—40	—do—	10—50
08	Dissolved CO_2 PPM	0—2	—do—	5—40

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CAUSES OF CORROSION :

Corrosion in boiler system is principally caused by gases such as O_2, or CO_2. CO_2 causes growing or channeling attack on a metal surface while pitting is typical oxygen. The corrrosion reaction can be expressed as under.

At the anode the metal dissolves in to water giving free electron say $Fe \longrightarrow Fe^{++} + 2e$

The electrons are carried to cathode by the circuit (metal) at cathode the electons react to give.

$$\tfrac{1}{2}O_2 + H_2O + 2e \longrightarrow 2OH.$$

The Fe^{++} ions migrate towards cathode and OH ions migrate towards anode, as the penetrating power of OH ions is higher than Fe^{++}. They react to give.

$$Fe^{++} + 2OH\ (\cdot) \longrightarrow Fe\ (OH)_2\ \text{rust.}$$
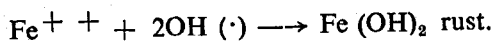
$Fe(OH)_2$ is further oxididised to $Fe\ (OH)_3$. The following factors are responsible for the formation of an electro chemical cell which induces the corrosion.

(1) Dissolved Oxygen (2) Dissolved CO_2 (3) pH (4) Temperature (5) Dissimilar metal joints (6) Dissolved solids (7) Flow rates (8) Metal composition. (9) Stress (10) Stability of protective metal oxide film.

CONTROL OF CORROSION :

(1) Dissolved Oxygen :-

The presence of oxygen in boiler system may be due to :

(a) Improper removal of O_2—low or non existant residuals of the O_2 scavengers in boiler water,

(b) Air drawn in at pumps and open collection vessels.

(c) Vacuum created in the system lines which are inintermittent operation.

Removal of O_2 :—For corrosion to occur the presenee of O_2 in the liquid phase is necessary. Dry steam containing O_2 is non corrosive but the condensate formed from such steam is very corrosive. O_2 acclerated the reaction of iron & water. It can react with ferrous hydroxide forming hydrated ferric magnetite.

The reaction is generally localised and forms a pit in the metal if the pit becomes progressively anodic in operation severe attack occurs at the cathodic surfaces. O_2 reacts with H_2 and depolarises the surface permitting more iron to dissolve gradually creating a pit,

For high pressure boilers practically complete removal of dissolved oxygen (0.006) PPM or less is necessary and this effected by means of deaerators for low pressure boilers open heater can be employed. In any case this must br followed by addition of an oxygen scavenger to remove any residual O_2 or O_2 which may be accidently introduced.

Chemical Oxygen Scavengers — Sodium Sulphite and hydraulic have been used in boiler plants for many years. Sodium sulphite is frequently feed to the feed water tank or to the storage section of deaerating heater to react with dissolved O_2 as follows :—

$$O_2 + 2Na_2SO_3 \longrightarrow 2\ Na_2SO_4$$
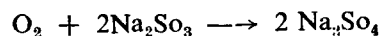
It is only at boiler operating temp. that the above reaction takes places rapidly. The reaction is much slower at lower temperature and the use of an instant O_2 scavengers is neceaary to ensure a complete reaction,

Fig. 1 shows the reaction rates for catalysed and an catalysed sodium sulphite at $20°C$:
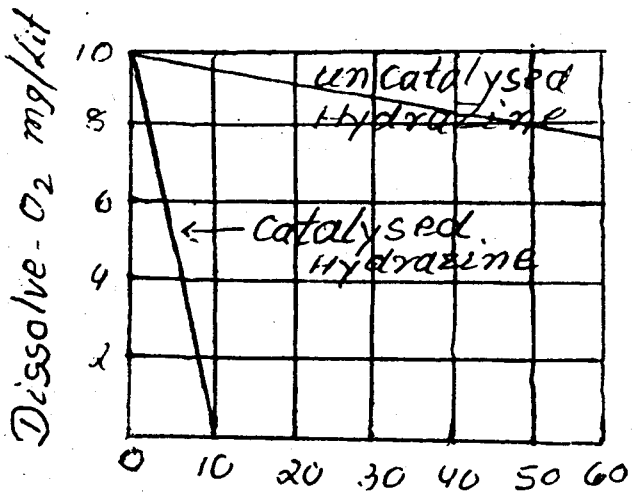

Fig No- ①
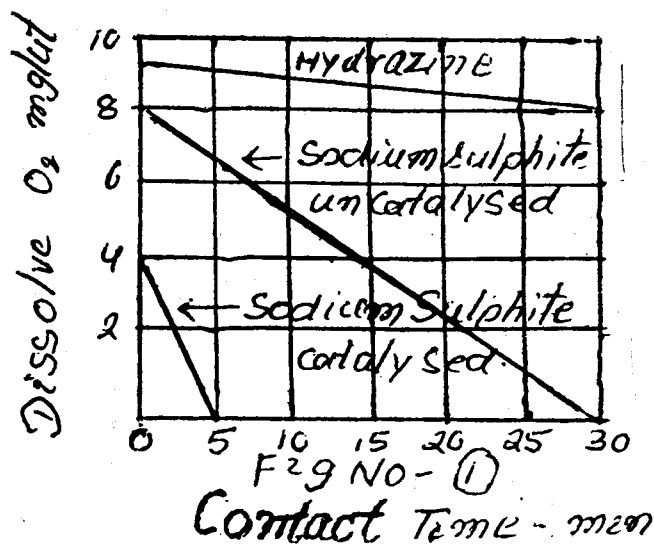
Fig - 2
Contact time - min

The use of catalysed (hydrazine) or sulphite mini-mise the formation of pre boiler corrosion products which can enter the boiler with the feed water and cause more serious problem.

The relative merits and demerits of hydrazine and sodium sulphite with dissolved O_2 increase the mineral solid contents of boiler water and a higher blow down rate is required, The reaction products of hydrazine with dissolved O_2 do not introduce any mineral solids in to the boiler water 'organically catal-ysed hydrazines also prevent deposits while dealing with a high level of iron and copper in the feed water. The chemical volatalised at boiler temp. above 11°C and passes out with the steam into the post boiler section to provide protection against O_2 attack caused by air leakage.
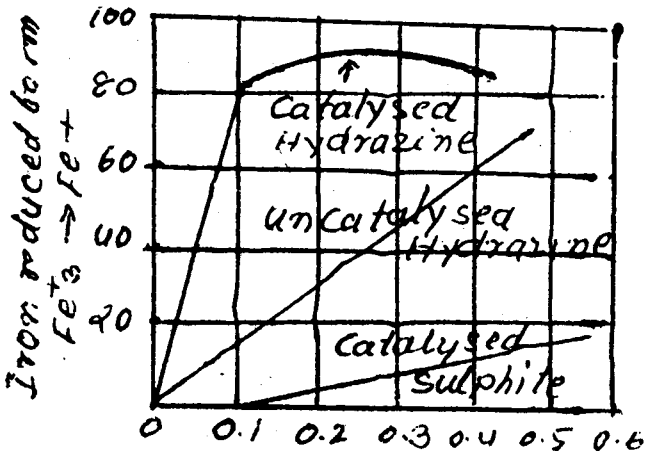
Hydrazine reacts with iron oxide to form passive magnetite and reduces capric oxide to passive caprous oxide, Magnetite acts as a barrier against further corro-sion and the metal pick up condensate is greatly reduced.

Ability of catalysed hydrazine to reduce ferric iron to ferrous (Fig, 3) demonstrate the ability of cata-lysed hydrazine to reduce ferric iron to ferrous iron.

In order to be effective the dosage of O_2 scavan-gers on the feed water must be such that result in the recommended reserve of the chemical in the boiler water to reserve acts a safety factor against accidental O_2 increase into the Boiler.

O_2 Dissolved CO_2 Gas

CO_2 is due to the decomposition of

(a) Natural alkalinity in the make up water
$2HCO_3 \longrightarrow CO_3 + CO_2 + H_2O$.

(b) Carbonate based treatment chemicals
$CO_3 + H_2O \longrightarrow CO_2 + 2 \ (OH)$

(c) Condensate Line corrosion products;
$Fe \ (HCO_3)_2 \longrightarrow Fe \ (OH)_2 + 2CO_2$.

Neutralisation of carbonic acid gas : Carbonic acid in the condensate causes corrosion in the post boiler section. For neutralising the CO_2 in the condensate the addition of alkaline salts such as Caustic Soda in the feed water does not help since the salt do not vola-tise and go into the steam phase.

(3) **pH** : Low pH accelerate the pH so by adding alkaline chemicals pH can maintain.

Fig - 3

Hydrazine contain in feed water ppm($SO_3 \times 10'$)

(4) **Temperature** : High temperature zone becomes anodic so it can be control by good operating the boiler.

(5) **Dissolved solids :**

(6) Dissimilar Metal joints, stress Flow rates, Metal conposition Stability of protective metal oxide does not cause more problem in forming corrosion. These can remove by taking some extra work & care.

SELECTION OF CHEMICALS FOR TREATMENT (BOILERS)

No universal guide lines can be laid down 'since the characteristics of water, boiler construction, cost of chemicals etc vary in every case. The following points may be useful.

(a) Capital cost of water treatment plant.

(b) Operating cost of water treatment plant including cost of regenerants.

(c) Operating cost of chemical treatment.

(d) Anticlpated saving in blow down.

(e) Total water usage and cost.

CONCLUSION : Although this short article on corrosion problem & solution, it needs to be borne in mind that in practice these problems has a profound influence on the extent of the other. Corrosion is more likely to occur for instance, beneath, fouling deposits, where the penetration of inhabitor is impaired. Depletion of O_2 at the metal surface beneath the fouling gives rise to marked difference in electro potential compared with unfouled areas resulting in severe pitting attack beneath the fouling. As another instance sedementation fouling provides an ideal substance for the attachment of biological slimes & corrosion products.

Effective corrosion prevention can only be achieved when the problems are correctly diagnosed and the appropriate treatment prescribed and continuously applied.