How to Avoid and Overcome Corrosion Problems in Kraft Recovery Boilers

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SUMMARY

The paper details the corrosion problem in recovery boiler of kraft mills due to black liquor and different gases present in the recovery boiler system. How to avoid such corrosion by adjusting operational variables in safe limited have been suggested.

INTRODUCTION

B & W organisations have put in considerable research efforts and engineering efforts to study and combat corrosion problems associated with recovery boiler. In the discussions that would follow, we would briefly review the nature of the problems followed by how the constructional features incorporated in modern B & W units have virtually eliminated corrosion of lower furnace, upper furnace, superheater and economiser and associated auxiliary equipment. These features have increased the plant life considerably. They have also made it possible to propose recovery boilers operating at high pressures to meet growing need of 'back-pressure generation'.

This happy situation is of special importance in India particularly in view of continued power shortage situation and recent change in Govt. Policy permitting in-plant 'back-pressure power' generation. Steam pressures in most of the present day recovery plants in India are in the region of 30-45 Kg/cm^2 g and in view of the above, the demand for plants operating at 64 kg/cm^{2}g or 85 kg/cm^2 g or higher pressures is likely to rise.

It will be of interest to you know that pulp and paper mills in the U.S.A. are for most part convinced that the operating pressure and temperature of B & W recovery units should be established to satisfy the steam-power balance of the kraft mill and that use of superheater outlet pressures in excess of 70 kg/cm^2 g has dominated the scene.

CORROSION IN LOWER PORTION OF FURNACE (HEARTH)

Liquid smelt is very corrosive and corrosive actions start at temperatures as low as 300–325°C. Therefore, for unprotected tubes operating pressures in the region of 64 kg/cm^2 g probably would have been the upper limits to achieve safe and economic life of the plant. In addition the feed water would have to be sufficiently clean to prevent scale formation on the water side to avoid undue increase in surface temperature to prevent corrosion.

This situation is not acceptable and B&W use closely studded tubes covered by plastic chrome cre (PCO) for the hearth portion which is likely to come in contact with molten smelt. In course of service the studs attain equilibruim length of around 12-15 mm depending on operating condition. Too long studs do not serve any useful purpose as they eventually in the course of 6–12 months attain equilibrium lengths. The round studs provided hold PCO in position and even when PCO is gradually washed awy, provide a holding surface for solidified smelt layer which prevent pressure part of the tube coming in direct contact with corrosive liquid smelt. Plain tubes suffer from disadvantage that occasionally the solidified smelt peals off exposing the tubes to fresh attack and are therefore not used in the lower part.

CORROSION IN UPPER PORTION OF FURNACE

A) GAS SIDE TUBE CORROSION

The rate of corrosion in this part mainly depends on the amount of hydrogen sulphide in the flue gas and ratio of hydrogen sulphide and oxygen. Highest corrosion rates are encountered when this ratio is nearly 1.0. The trick of the trade lies in avoiding formation of hydrogen sulphide and keeping oxygen level as high as possible. The rate of corrosion decreases with increase in oxygen and water vapour. Further gas attack begins at tube wall temperature of 300–325° Cand reaches maximum rate at 400°C. A thin protective layer does not prevent corrosive action of these gases but thicker layer (2-3 mm) prevent the corrosive influence.

Excess oxygen adjacent to furnance walls forms Fe_3O_4 which sets up high resistance to corrosion. Reduction efficiencies of around 93–95% are easily obtainable with the oxygen present in such case, but higher reduction efficiencies can increase corrosion risk due to lack of oxygen.

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Let us examine how above observed facts are put to use to avoid corrosion. Reduction of hydrogen sulphide level is achieved by *avoiding* (a) use of fuel oil which promotes sodium salt sublimation and sulphur loss due to higher bed temperatures (b) suspension buring (c) black bed condition and *achieving* stable combustion on the hearth by controlled even distribution of black liquor char on the hearth with the help of properly designed spray nozzles. Spraying on walls minimises possibility of in-flight combustion which promotes H_2S formation.

Use of high pressure secondary air penetrating deep into the furnace to avoid lack of oxygen and consequent hydrogen sulphide formation and low pressure primary air flushing the wall help in maintaining excess oxygen near the wall without affecting reduction efficiency.

(B) TUBE BACK SIDE CORROSION

With tangent wall construction the gases containing sodium hydroxide and other chemical fumes penetrate into the crevices between tube and casing where sodium hydroxide and other vapours condense due to considerably cooler tube surface. This again causes vacuum, which sucks up additional sodium hydroxide etc., and vapour transfer into closed space goes on. Melting point of pure sodium hydroxide is about 319°C but additional components such as, sodium carbonate and sodium sulphate lowers it still further and sodium hydroxide in the crevices appear liquid smelt at higher boiler pressures and reacts with iron to form Na_2FeO_2 and in presence of excess oxygen Na_2FeO_4. These compounds are colourless or olive green or red. Some compounds like chromate and chlorides have a catalytic effect on this reaction.

B & W combat this kind of corrosion by use of membrane construction or gas tight welding on finned tube construction thus removing the source of trouble. The constructional precautions and use of proper refractories have almost eliminated outer corrosion on furnance wall tube thus enabling use of higher pressures upto 105 kg/cm² g.

To sum up the question of furnace wall corrosions of all kinds, it can be stated that with B & W's method of construction furnace wall corrosion problems are not there and we have no reservations about designing recovery boilers to operate at pressures to about 105 kg/cm² g. Operating experience on B & W units in excess of 64 kg/cm² g is considerable and is especially mentioned here to decipate any reservations on operating pressures in excess of 64 kg/cm² g.

SUPERHEATER TUBE CORROSION

Corrosion rates increase with metal temperature. Parallel steam flow and high steam mass flow rates through the tubes are provided to minimise metal temperatures for given superheater outlet steam conditions. We generally recommend that the superheater temperature control range be kept to the bare minimum required for the job so that unduly large superheater is not required to be installed. Larger the surface installed higher is the likely steam temperature at higher loads in the tube legs exposed to corrosive gases and higher will be the metal temperature. Generally, the tube thicknesses installed are higher than those required to resist pressure.

ECONOMISER CORROSION

Due to high water film heat transfer coefficient as compared to the gas film coefficient the metal temperature of tube is generally only few degrees above water temperature. If this temperature is less than acid dew point of the gas, acid will condense on the tube and would cause corrosion. Therefore, we normally recommend that the feed water inlet temperature to the economizer be over 121°C and preferably near 149°C with high sulfidity operations. The water inlet passes are generally provided with thicker tubes as an additional safeguard.

ELECTROSTATIC PRECIPITATOR CORROSION

To prevent corrosion present-day practice is to choose temperature of gas entering ESP as 163°C at 100% MCR. This leaves some margin in hand to overcome operational deviations. The thermal efficiency is only slightly sacrificed due to this factor as major losses in recovery unit are due to chemical reactions.

I.D. FAN AND FLUES CORROSION

On units having cyclone evaporator and ESP as back end equipment, I.D. Fan corrosion does not pose any serious problems. On units provided with venturi scrubber scheme where gas temperature is nearly 82°C it is common practice to use either heavy gauge material or corrosion resisting material for fan runner. The flues after venturi scrubbers are made of 10 mm thickness instead of usual 6 mm thickness.

WASH HOPPERS

Which come in direct contact with black liquor and hot gases are made of stainless steel.

PUMP AND HEATER PARTS

Parts in direct contact with B.L. are made of stainless steel.

PIPING

B.L. & G.L. piping is usually made of M.S. as it is not economical to use high alloy piping for this duty and as they can be easily replaced.

MIXING TANK & G.L. TANKS

They are also made of M.S. for economic reasons and are made of extra thick plates.

SOOTBLOWER CORROSION

Deposits will form on the soot blower lance tube during its travel in and out of the boiler, and the wallboxes will become plugged with salt cake, causing corrosion, if no preventative measures are taken. A steampurge line connected between the wallbox and the soot blower valve has been added to eliminate these problems by blowing steam into the wall box and on the lance tube during the sootblower operation. Further, air provided by sootblower seal air fans prevents corrosion of lance and poppet valve seat when sootblowers are not working.

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