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Case Study On Erosion Failure Of CFBC Boiler

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Abstract

This work is concerned about erosion failure analysis of CFBC boiler, in which gas–solid two-phase mixtures flowing upwards through the fast beds. As we know that boilers are used in process industries for steam generators as well as in power plants for power generation. And Failure of boiler tube leads huge loss for industries in terms of production, So in this paper we analyze main causes of erosion in CFBC boiler with the help of Case study also Using CFD codes we can predict fluid flows inside the furnace.

Keywords- *CFBC, Erosion, Two phase flow, CFD*

1. Introduction

Erosion is process in which material removed from the surface layers of an object impacted by a stream of abrasive particles. Erosion is localized phenomena in which small volume of the target material that are eventually removed. The magnitude of the wear is calculated by the volume or mass of the material that is removed by the action of the impacting particles. Removal of material due to cutting wear. Mainly material is removed by following phenomena.

- Removal of material due to repeated plastic deformation.
- Effect of temperature on the tensile properties of the material.

The phenomena are applicable to erosion at ambient temperatures, where the effect of temperature may be ignored. The relative contribution of two phenomena is difficult to predict due to the many process and material parameters that are involved in it. The effect of temperature on the erosion behavior of boiler components is of practical importance and an attempt has made functionally correlate the tensile properties of these materials at elevated temperatures. The following material parameters considered for Predicting erosion rate in the boiler components.

- Ash particle velocity
- Ash particle impingement angle
- Mass fraction of silica contained in the ashample
- Average density of ash particle
- Density of the steel component,
- Yield stress of the steel component and

1.1 .Main causes of erosion

Erosion is mainly associated with solid fuel fired boilers. The cause can be defective design, improper erection, operation & maintenance. Remedies could be available for many cases. In coal fired power plants, 20% of the ash produced in the boilers is deposited on the water walls, economizers, air heaters and super-heater tubes. This deposited ash is subsequently discharged as slag during the soot-blowing process. The rest of the ash is entrained with stream of flue gas leaving the boiler. These ash particles collide with the boiler steel components and cause surface erosion. In advanced stages of erosion, the components get deformed, and may fail once they lose their structural integrity. Such erosion, together with the processes of fouling and corrosion, and shortens the life of boiler components. Once this happens, the power station unit has to be shut down in order to replace the damaged components. The resulting penalty not only the cost of replacing the components but also the cost of power production loss It is desirable; therefore, to be able to predict the rate of erosion of the coal-fired boiler components in order to plan systematically for the maintenance or replacement of these components and avoid production loss.Various investigators have addressed the problem of solid particle erosion Many parameters are now known to influence erosion behavior. The magnitude and direction of an ash particle's velocity relative to the target metal surface constitute essential data needed for evaluating erosion of the surface due to particle impact. Magnitude and direction of a particle's rebounding velocity depend upon the conditions at impact and the specific particle surface material combination. Restitution behavior is a measure of the momentum lost by the particle at impact as such and it corresponds to the work done on the target surface, which, in turn, is a measure of the extent of erosion suffered by the material of the target surface Followings are the main causes of erosion.[2],[3]

- Causes attributed to design
- Causes attributed to erection
- Causes attributed to operation

- Causes attributed to maintenance.

2. Case study

It consists of CFBC boiler of 88kg/cm2 operating pressure and 510 0 C superheated steam temp. Superheated steam from the boiler used for production of paper as well as for power generation The boiler is a new kind mixed fuel boiler with high efficiency and low pollution which adopts circulating fluidized bed combustion technology with wide range of many kinds of fuel, such as lignite, Indian ,imported and others with lower calorific value. Its combustion efficiency is as high as 92-94%, especially it can burn high sulfur content fuel. By feeding limestone into the boiler, it can obviously reduce the discharge of SOx and NOx, and reduce corrosion of sulfur on devices and pollution of flue gas. Ash residue is active enough to be used as aggregate of materials such as cement. The boiler is a natural circulating water-tube boiler and which adopts circulating combustion system formed by vortex cyclone separator. Its furnace is of membrane wall structure; its separator is of high-temperature adiabatic type. The super heater system is composed of screen, high and low temperature ones, between which two-grade vertical spray desuperheater is arranged. At the back-end surfaces, two grades of economizer, primary and secondary air preheaters are arranged.

3. CFBC Technology

In these fluidized bed principal the particles are suspended in a stream of upward flowing air which enters from the bottom of the furnace through air distribution nozzles. High velocity air 4-6 m/s is used in these for fluidization of bed. Hot primary air from PA fan is used for this. The balance of combustion air is admitted above the furnace as secondary air obtained from SA fan. Fluidized bed is extended throughout the furnace. So, some solid bed material along with some Uncombusted fine fuel particle and ash is escaped from bed or carried over and passed with flue gas. These solid particles are then collected by a solid separator (Cyclone separator). In Cyclone the heavier particles are separate from the gas and falls to the hopper of the cyclone and circulated back to the furnace through Loop seal.

4. Failure history review

Boiler was commissioned in November 2007. The Chronology of failures is as below.

- Jan 2008- Again feed water tube leakage in left cyclone
- March 2008- Pendant SH & furnace wall tube leak- location of FW tube not known.
- Aug 2009- Pendant SH tube leak.
- November 2011- control room side waterwall leak at kick off zone.
- Jan 2012- Control room side furnace wall tube leakage in kick off zone.
- March 2012- front waterwall panel tube leak.
- Aug 2012- front waterwall panel tube leak
- Dec 2012- Front waterwall tube 32, 33 replaced – not leaked.
- July 2012- major refractory work done kick off zone refractory done, loop seal, cyclone, cyclone outlet roof refractory done.
- Nov 2013 – rear wall panel tube leakage

For about three years there were no erosion related tube failures. There was a time metal spray was redone insitu. This was not successful. The erosion pattern was haphazard. Almost for five years there was no problem in the panels. During the first 1.5 years, Indonesian coal was fired. Subsequently various combinations of fuels were fired. Major refractory damage started occurring in the year 2011. The visit was made in Feb 2012. In July 2012, refractory was redone. After this failure rates have gone up. In the mean time fuels have also changed. The records have to be correlated. The worst fuel for this boiler is lignite of 40% Moisture. A life of 4 – 5 years was very good even though the fuels used were different from design fuels. The recent failures were due random erosion experienced. But however the thinning is distributed. Almost all the recent failures were in the rear wall. Hence in 2014 shut the rear wall up to 2.5 m from kick off zone was replaced.

4.1 Operational history

It is important to note that the boiler was run on excess air in the initial days due to higher side particles. Nearly after 1 year only, it was learnt that the coal particle sizing was wrong and the excess air was brought down. The boiler was operated with higher gas velocities for a period of one year. Once particle size was brought down, the boiler was run at least for one full year on Indonesian coal.There were no erosion related failures at that time. The erosion rate is governed by iron content, ash generated, ash shape, ash bulk density, ash fusion temperature, operating temperature and flue gas generation as well. The high flue gas flow is indicated by ID fan damper opening and power.

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4.2 Erosion pattern due to overloading

Due to overloading the erosion pattern has to be uniform. In all the rear wall tubes, where the dust slip is expected to be more both at 3 O and 9 O clock position gross erosion must be seen. In this installation localised spot erosion is seen. This can be due to the improper bond of the metal spray done at factory.

Fig 1 Shows erosion observe on kick off zone

5. Coal analysis

Carbon (C)	%	30.09	48.49
Hydrogen (H)	%	3.9	0.88
Sulphur (S)	%	2.55	0.6
Oxygen (O)	%	6.58	5.88
Moisture (M)	%	40	12
Ash	%	16.88	32.15
GCV	(Kcal/Kg)	3850	3520

Table 1 : Ultimate analysis of coal

5.1 Nature of Indian coal

As per ultimate analysis of Indian coal it contains high ash. So, the ash input to furnace is high. Indian coals have high amount of ash and stones as compared to lignite this calls for frequent bed draining in order to control the stones. Usually +3 mm particles are more and they fail to burn completely as the oxygen cannot diffuse in to the coal particle. Stones are harder in nature and cause more erosion.

The loop seal sealing is easily achieved in Indian coal due to high ash generation. The air flow required at loop seal is more in order to have higher transfer rate to main furnace. The ash has to be drained from loop seal also in case the fly ash is very high. Stones can cause high erosion rate.

5.2 Nature of Lignite

Lignite do have high iron. It has alkalis as well, which brings down the ash fusion temperature. Bed temperature has to be less than 874 deg C. Otherwise fusion and deposition on furnace refractory will be experienced Lignite cause fouling of final SH, secondary SH and economizer. Lignite pose flow problems at bunker. Lignite is known to slag due to its iron content. Fused ash causes high erosion rates. The ash fusion temperature of lignite is low in general.

6. CFD analysis

Erosion is mainly observed in furnace kickoff zone so lower furnace is considered for analysis. We know that CFD is a research tool used now a days to predict the fluid flow in boiler. In this case study we have to calculate velocity, Static pressure and Temperature distribution of flue gas along furnace using FLUENT software. And meshing done with the help of GAMBIT, After analysis we have to compare Velocity, Pressure and Temperature distribution along the furnace for two types of coal used i.e. Lignite and Indian coal. For this two mixed flow model is used. The grids are selected for all the meshes for doing CFD analysis. As the furnace for which analysis is carried out, quadrate type mesh is selected. This specifies that the mesh is composed primarily of quadrate mesh elements. The qualities of the created mesh are checked.

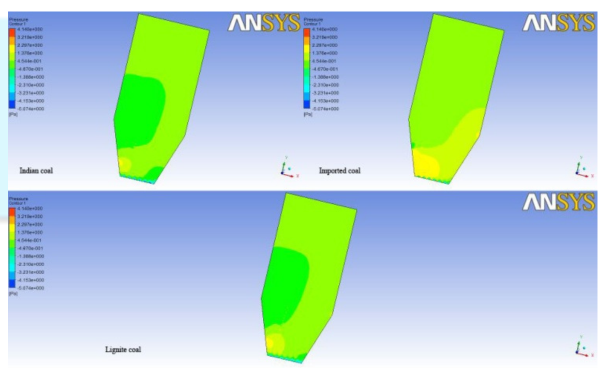

Fig 2 Shows Pressure distribution (Pa)

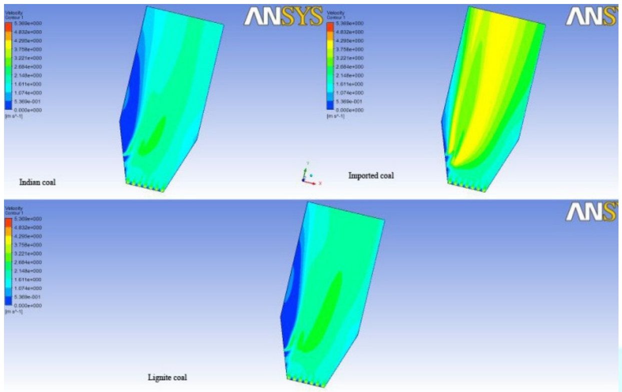

Fig 3 Shows Velocity distribution (Pa)

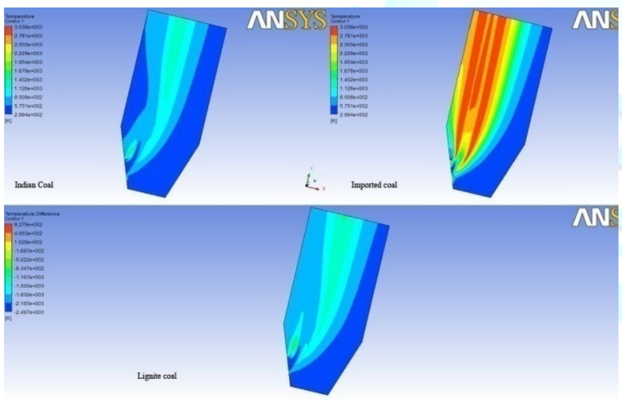

Fig 4. Shows Tempreture distribution (Pa)

7. Results and discussions

The non uniform bed temperatures along the furnace height indicate the inadequate upper bed Inventory. When the inventory is less, the gases do not flow in equal velocity at the entire cross section. It can cause gas flow one sided and can cause dust to fall back on other side. This is called internal Circulation within the furnace. No uniform bed temperatures are in the indications for uniform wear out of the tubes at kick off zone. If a loop seal is not having a sufficient material at the down leg side, the gas flow partly takes place through the loop seal the loop seal temperature will be close to furnace bottom temperature. The material transfer rate is a function of the air flow to the riser section. High ash coals need more air. Low ash coals need less air. Once the loop seal is not proper, furnace inventory is reduced and the bed temperature increases. The situation can happen due to failure of air nozzles loop seal. There are many air nozzle failures seen in the bed. The causes of localized erosion can be categorized seeing the failures in many installations. In CFBC boiler, the bed ash slips back to bed because, the operating regime is fast fluidization and not pneumatic transport.

- When the panel tubes have a butt joint the joints are to be ground flush. If not flushed the tubes erode due to diversion of the flowing material towards the fin to tube area
- When the fin to fin joint is not flushed ground, the bed material gets diverted towards the tube.
- When the boiler tube dia is higher, the bed ash flows more towards to the fin to tube valley area.
- When the tubes are out of verticality in water wall plane itself, it erodes in one sided manner.
- When the tubes are projected towards to the furnace, the tubes erode on both sides of the fin -tube valley.
- Localized large weld beads due to manual welding process cause diversion of bed ash towards the fin-tube valley area and cause erosion. Fin to fin longitudinal weld bead at field joints cause diversion of bed material towards to the tube to fin valley area.
- Short kick off bends are seen to erode the tubes faster. Long distance between kick off bends are better.
- The kick off zone refractory shape is important. Extra projections cause fast erosion of the tubes.
- Hard refractory is good for protecting the tubes. But when the shape is not properly maintained by templates / shuttering, this can cause faster erosion.
- Corner tubes erode due to preferential downward flow of particles along the corner.
- Less upper furnace inventory can cause high rate of attrition. It is this factor that leads to high erosion of furnace tubes.

8. Conclusion

In this work, we study about case study of CFBC boiler whose tube failure is due to erosion. And we try tofind out its causes, as we know Lignite contains 2.55 % sulfur, it breaks bond between refractory so, erosion is mainly found due to refractory failure. When we fire lignite internal circulation within furnace so back flow occurs. And furnace bed temperature not maintained it causes uniform erosion pattern at kick off zone. There are many more solutions available to avoid erosion; anti abrasive coating is one of them. Also in this case it is required to remove excess refractory from kick off zone and at time of erection of panel butt joints of fin are required properly round flushed, due to these flow of material gets diverted and tube eroded.

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