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A CASE STUDY ON OPERATION AND MAINTENANCE OF BOILER

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ABSTRACT

Coal fired boiler system generates approximately 38% of the electric power worldwide and will continue to be major contributors in the future. New pulverized coal fired systems routinely installed today generate power at net thermal cycle efficiency ranging from 34% to 37% (higher heating value) while removing up to 97% of the combined, uncontrolled air pollution emissions. A new generation of pulverized coal fired boiler technology is currently under development which will permit generating efficiencies in excess of 42%. This paper highlights some of today's design improvements which target reduced emissions and expanded operability, and explores some of the boiler design implications for the ultra-supercritical conditions needed to achieve the high cycle efficiencies for the future.

Keywords: Boiler Accessories, Boiler Efficiency, Boiler Mountings, FBC Boiler

I. INTRODUCTION

1.1 Definition

It is a closed vessel in which steam is produced from water by combustion of fuel. Boiler is an apparatus in which thermal energy released by combustion of fuel is transferred into water which vaporizes and gets converted into steam at the desired pressure and temperature.

1.2 Boiler Mounting

Mountings are the components used for the safety of boiler, the boiler requires the following mountings a feed check valve to prevent the return of water from the boiler in base the feed pump is to operating, a steam stop valve to regulate the flow of steam from the boiler, safety valve (at least two) to protect the boiler from pressures higher than the designed valve, a blow off valve to empty the boiler when needed and to discharge the mud and sediments that are in the boiler. Water level indicator to show the water level inside the boiler, a pressure gauge to indicate the pressure of steam in the boiler, fusible plugs to protect the boiler against low water lever.

1.3 Boiler Accessories

Accessories are the auxiliary plants required for steam boilers for their proper operation and for the increase of their efficiency. According to the principle of operation the steam separator is classified as follows:

- Impact or baffle type
- Reverse current type
- Centrifugal type

1.4 Boiler Efficiency

Boiler efficiency is the ratio of heat actually utilized in generation of steam to the heat supplied by the fuel in the same period.

Boiler efficiency= m_a $(h-h_f)/c$

Where, m_a = mass of water actually evaporated into steam per kg of fuel at the working pressure

C = calorific value of the fuel in kj/kg.

1.5 Heat Losses In A Boiler Plant

The following heat loss occurs in a boiler plant:

- Heat loss of flue gases
- Heat loss due to incomplete combustion
- Heat loss due to un burnt fuel
- Convection and radial losses

II. MECHANISM OF FLUIDIZED BED COMBUSTION

When an evenly distributed air or gas is passed upward through a finely divided bed of solid particles such as sand supported on fine mesh, the particles are undisturbed at low velocity. As air velocity is gradually increased, a stage is reached when the individual particles are suspended in the air steam- the bed is called "fluidized". With further increase in air velocity, there is bubble formation, vigorous turbulence, rapid mixing and formation, of dense defined bed surface. The bed of solid particles exhibits the properties of a boiling liquid and assumes the appearance of a fluid- "bubbling fluidized bed".

At higher velocities, bubbles disappear, and particle is blown out of the bed. Therefore, some amounts of particles have to be re circulated to maintain a stable system- "circulating fluidized bed". Fluidization depends largely on the particle size and the air velocity. The mean solids velocity increases at a slower rate than does the gas velocity. The difference between the mean solid velocity and mean gas velocity is called as slip velocity. Maximum slip velocity between the solids and the gas is desirable for good heat transfer and intimate contact. If sand particles in a fluidized state is heated to the ignition temperature of coal, and coal is injected continuously into the bed, the coal will burn rapidly and bed attains a uniform temperature. The fluidized bed combustion (FBC) takes place at about 840 to 950 degree Celsius. Since this temperature is much below the ash fusion temperature, melting of ash and associated problems are avoided. The gas velocity is maintained between minimum fluidization velocity and particle entrainment in the gas stream.

FBC boilers combustion progress requires the **three "T"s that is time, temperature and turbulence.** In FBC, turbulence is promoted by fluidization. Improved mixing generates evenly distributed heat at lower temperature. Residence time is many times greater than conventional grate firing. Thus an FBC system releases heat more efficiently at lower temperatures.

2.1 Types of Fluidized Bed Combustion Boilers

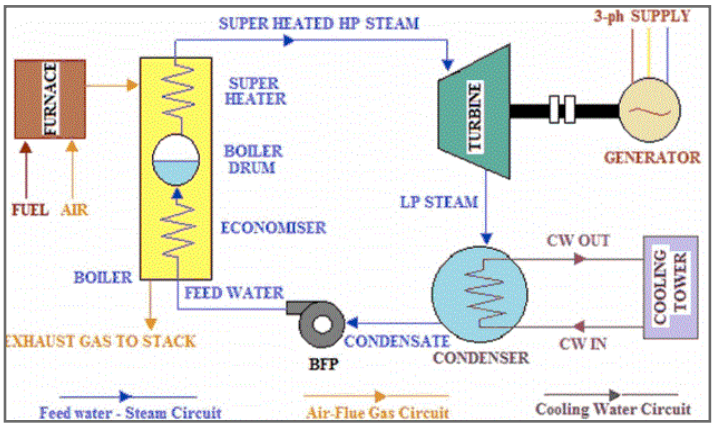
There are three basic types of fluidized bed combustion boilers:

- Atmospheric classic fluidized bed combustion system (AFBC)
- Atmospheric circulating (fast) Fluidized bed combustion system (CFBC)
- Pressurized fluidized bed combustion system (PFBC)

2.2 General Arrangement of AFBC Boiler

AFBC boiler comprises of following systems:

- Fuel feeding system
- Air distributor
- Bed & in-bed heat transfer surface
- Ash handling system



2.3 Advantages of Fbc Boilers

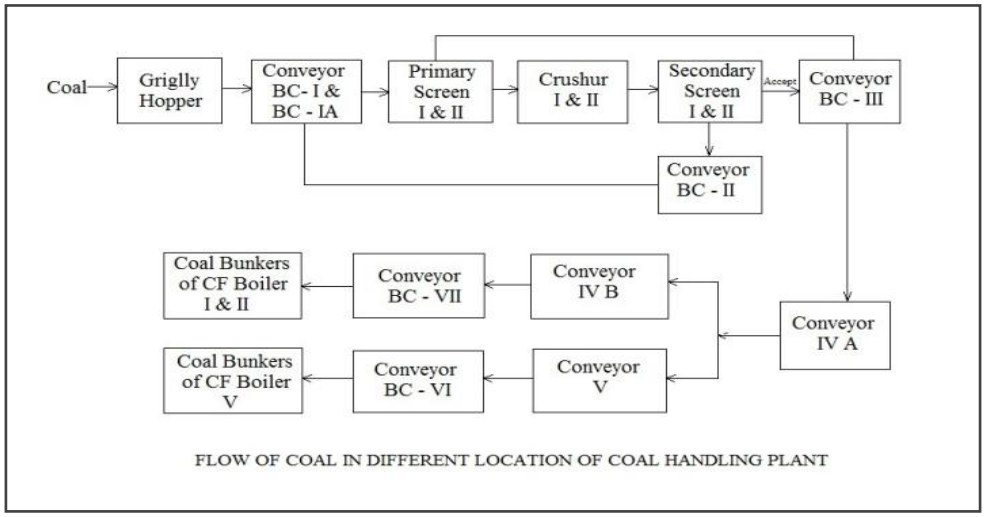
- High Efficiency: FBC boilers can burn fuel with a combustion efficiency of over 95% irrespective of ash content. FBC boiler can operate with overall efficiency of 84% (plus or minus 2%)
- Reduction in Boiler Size: High heat transfer rate over a small heat transfer area immersed in bed results in overall size reduction of the boiler.
- Ability to Burn Low Grade Fuel: FBC boiler would give the rated output with inferior quality fuel. The boilers can fire coals with ash content as high as 62% and having calorific value as low as 2,500 kcal/kg.
- Pollution Control: SO_2 formation can be greatly minimized by addition of limestone or dolomite for high sulphur coals. 3% limestone is required for every 1% sulphur in the coal feed.
- Low Corrosion and Erosion: The corrosion and erosion effects are less due to lower combustion temperature, softness of ash and low particle velocity (of the order 1m/sec)
- Less Excess Air: Higher CO_2 in Flue Gas: The CO_2 in the flue gases will be of the order of 14-15% at full load. Hence the FBC boiler can operate at low excess air only 20-25%.
- Simple Operation, Quick Start-Up: High turbulence of the bed facilitates quick start-up and shut down. Full automation of start up and operation using reliable equipment is possible.
- Provision Of Automatic Coal And Ash Handling System: Automatic system for coal and ash handling can be incorporated making the plant easy to operate comparable to oil or gas fired installation

- High Reliability: The absence of moving parts in the combustion zone results in a high degree of reliability and low maintenance cost.
- Reduced Maintenance: Routine overhauls are infrequent and high efficiency is maintained for long periods.

III. OPERATION AND MAINTENANCE OF BOILER

3.1 Coal Handling Plant

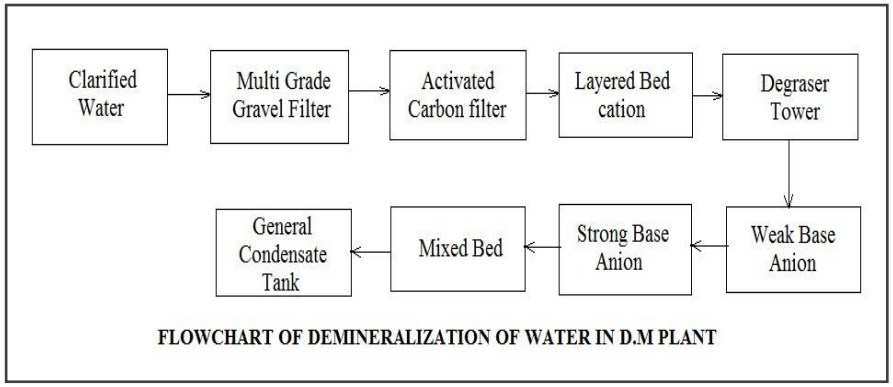
In coal handling plant, raw coal that is brought from outside & bamboo dust is supplied to griggly hoper whereby help of vibratory machine it is crushed into smaller parts. Then some amount of bamboo dust is also mixed with charcoal and supplied to primary screen I & II with the conveyor belt I & IA. In primary screen I&II coal size is checked (i.e. round 6-10 mm). If the required size is obtained then it goes bunker of CF boiler. If size condition is not satisfied then the coal goes to crusher I & II. When size is maintained if the coal size is not obtained to the required size, then it goes to the secondary stages of coal sizing. The acceptable coal size is send to the boiler through the help of conveyor belt IV.



FLOW OF COAL IN DIFFERENT LOCATION OF COAL HANDLING PLANT

3.2 Demineralization of Water

It means water is free from all minerals. This is done to various defects happens such as boiler corrosion, formation of sludge and scale which may decrease the volume or capacity of the boiler due to deposition of minerals on the walls of the boiler. It is to remove mineral content of water, in this system raw water enters the hydrogen zeolite exchanger (cation removal) at the top and flows to the anion exchanger and degasified and finally passes through silicon absorber.



FLOWCHART OF DEMINERALIZATION OF WATER IN D.M PLANT

IV. STARTING OF THE BOILER – LIGHT UP PROCEDURE FOR COLD CONDITION

- Preparation of furnace when the furnace is empty, check the following:
  - Air Nozzle – nozzles hole are to be clean. Nozzle top to be intact.
  - If nozzle are not clean the ore to be cleaned with air hose
  - Coal feed nozzle – the top refractory is to be there
- Check the following:
  - All the access doors to be closed
  - All personnel to be cleared
  - All foreign material are to be removed from furnace & pressure parts
  - Starting equipment & interlock are ok
  - Check the following equipment for adequate lubrication and readiness for services
    - ID fan
    - FD fan
    - PA fan
    - Feed pump
    - Fuel feeder
    - Dynamo drive system
  - Banker (coal) to be full with 0-6 mm size coal and gates below the banker are in open position and coal is available at feeder inlet
  - Check instrument air above 3 kg/cm^2 pressure is available for instrumentation and control.
  - Start first ID fan with suction damper in closed position
  - Start FD fan with suction dumper in closed position

4.1 Charging Bed Material

- Keeping the individual damper of 3 compartments in open position, furnace draft is to be maintained at 5 mm to 7 mm by slightly opening the ID fan damper
- Open the furnace man hole and with 2 mazodoors the bed materials is to be charged into the furnace, care to be taken that no empty bag slips into the furnace. After completely charging the material it should be leveled by properly operating dampers of ID & FD fans, then close dampers. Open the main holes on both sides of the furnace.
- Take a 24v hand lamp inside and measure the height of the bed in each compartment. The height of bed in each compartment should be 300 mm to 310 mm. Then come out of the furnace and keep the hand lamp on the bed coils(glowing)

4.2 Lighting Up of Boiler

- Before lighting up of boiler fill the boiler with feed water up to half steam drum level, at the time of taking water ensure that all air vents are in open position and all drains are in closed position. Confirm the level of water in the drum by seeing gauge glass levels.
- Keeping lighting swabs ready
- Keep open the furnace door and open the ID fan suction damper
- Light up one swab watch stick, light up all swabs one after one throw, then in all directions in the startup compartment

- In each compartment two thermocouples are provided to indicate feed temperature
- It is important to increase air flowing radually to increase the top level temp. to 800 to 850 degree
- When the bed temperature rises above 600 degree switch on PA fan, the coal transport lines are to be closed and coal feed drain lines to the cleared
- Adjust PA fan suction damper to maintain header pressure in between 750 mm and 950 mm water column. Open the fuel transport air damper of the startup compartment. The coal feed shall be kept at minimum at the beginning.

4.3 Boiler Trip Due to Power Failure

If boiler trips due to power failure, take the following action:

- Start stand by feed pump (on second power sources)
- Restore drum water level by controlling feed water on manual mode. If instrument air is not available first close the isolation valves of the inlet of feed control valve and regulate feed water through by pass valve, keep a constant watch on gauge glass level
- Close the inlet damper of ID and FD fan
- Close the butterfly damper of wind box
- Close all steam outlets from boiler so that boiler is not depressurized immediately

4.4 Boiler Hot Startup Procedures

- Open the startup vent valve slightly
- Close all the compartment damper
- Start the ID fan, FD fan, PA fan
- Open slightly the wind box damper of no 1 so bed I fluidizes with minimum air ensure that fluidization is uniform and satisfactory
- Adjust the ID fan damper to maintain the furnace pressure
- Adjust the FD fan & PA damper to get the required fan pressure
- Start coal feeding without delay otherwise bed may cool down rapidly
- Gradually increase the coal feeding observing the rise in bed temperature
- Adjust the air flow and coal feeding observing the rise in bed temperature
- Take bed no 2 and other beds on line and connect the boiler process
- Take feed water control and furnace draft on auto mode
- Charge the ESP if the flue gases temperature is ok
- Put the boiler into auto mode
- Start ID fan, FD, fan PA fan
- If the bed level is too high drain the bed and bring down the bed height to around 300 mm by fluidizing the bed-1, spread some charcoal over the bed no-1, ignite the same
- Repeat the cold startup procedures listed in this manual and established the boiler.

4.5 Boiler Normal Shut Down Procedure

- Gradually reduce the steam load by reducing to the coal flow to the furnace
- Gradually reduce the air flow also to avoid fast cooling the bed
- Reduce the firing rate slowly to maintain the temperature drop around 250 per hour
- Cost of coal feeding to the combustor
- Do's connect the boiler from range when steam pressure drop less than the required pressure for process
- Open the startup vent slightly and depressurized the boiler gradually (if required) otherwise close all the vent and drains fully without depressurizing
- Switch off the ID fan if required. Keep ID & FD fan dampers are opened to allow the gases to escape.
- When the boiler pressure drops to 2 kg/cm^2 open the air vent of drum
- Maintain normal water level in the boiler
- If surface is required to be cooled quickly, fan may be kept running for sometimes, please note that fast cooling leads for refractory damages, it is suggested to go for natural cooling.

V. DAILY MAINTENANCE CHECK LIST DURING OPERATION

- Check the correctness of water level in the control desk with direct level glass.
- Check the level indicator for proper illumination
- Check the combustor for proper fluidization through peep holes
- Drain the bed do check for unusual combustible in the bottom ash
- Check fan unusual noise for steam/pumps
- Check vibration in rotary equipment
- Check for air/gas leakage from dust & flue
- Check for hot spots bulging etc. on casting dusts etc
- Check the position of damper & cleanliness
- Check the bearing for lubrication & cooling water system
- Check all alarm annunciations with respect to set position
- Check for water, oil along with instrument air
- Check for any unusual smoke conditions

5.1 Do's For Fbc Boiler

- Clear the materials before closing the man holes of pressure parts furnace & ducting.
- Maintain all instruments in good worker condition
- All equipment interlocks should be always in line.
- Maintain normal water level in feed water tank, deaerater tab & boiler
- Maintain normal water quality as per the remedial limits.
- All dampers must be on smooth operation condition.
- Pressure rising from cold start must be done as per the cold start up curve.
- All the duct joints must be leak proof
- Use proper lubricants recommended by the manufacture regularly

- Boiler, piping, duct, feed water & oil tank must be properly emulated.
- Servicing of equipment should be done as per the manufacturer's schedule.
- Maintain proper operation log sheets regularly
- Maintain the air face from moisture & oily matter of the pressure as recommended.
- Come out regular closing of direct water level gauges glass on feed water tank, deaerater tanks & boiler drum.

5.2 Don't's For Fbc Boiler

- Don't by pan any instrument of safety interlock
- Don't throw water as boiler feed water.
- Don't throw big size, wooden logs inside the furnace for slow firing
- Don't start any fan with suction damper in open condition
- Don't start any pump with the delivery valve in open condition
- Don't run the boiler with furnace in pressurized condition
- Don't throttle the feed water pump balancing leak off value while the pump & in operation
- Don't operate the furnace wall header drain valves while the boiler is in operation
- Don't operate the boiler beyond the operation limits.
- Don't leave the furnace door open while the boiler is in operation
- Don't mix up different lubricants
- Don't by pass compressed air dryer, if any problem attend to it at the earliest
    - Don't throw water inside the hot furnace.

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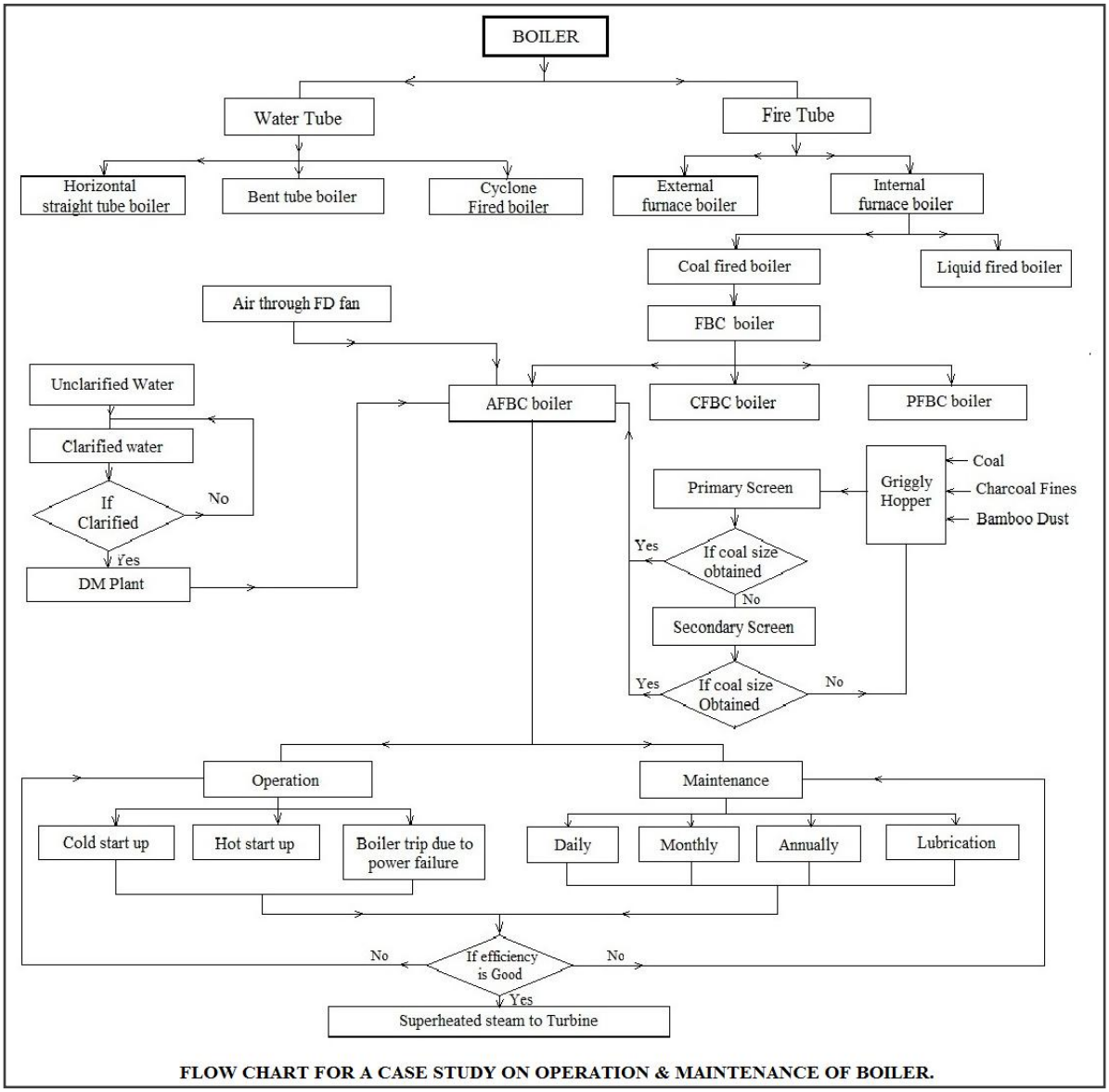

FLOW CHART FOR A CASE STUDY ON OPERATION & MAINTENANCE OF BOILER.

V. CONCLUSION

AFBC boiler generally comes under the category of FBC boiler in which the major portion fuel used in coal, bamboo dust and some amount of charcoal fines along with main fuel in order to increase the efficiency. Proper operation and maintenance of AFBC boiler are mostly required to increase its efficiency, longevity, and smooth running. In order to function properly the water that is used in boiler should be clarified and then it is demineralized to get free from all types of radicals like anion and cations which are made free from forming of scale deposition. Operation are carried out in different stages, like coal start up, hot start up and boiler trip due to various reasons like time consumption and fuel consumption the hot start up is more economic than cold start up. Cold start up condition requires preparation of furnace when furnace is empty, charging bed material, spreading of charcoal, feed water. But in hot start up condition does not require such process. Under any circumstances like pipe leakage or scale deposits the boiler is needed to shut down. So in order to avoid these

problems certain tests like hydraulic and hydrostatic tests are carried out. These tests happen to be the key note test for every boiler in any plant.

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