Environmental Friendly Technologies for Heat Recovery from Waste Fuels and Process/Industrial Wastes

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Heat recovery from low-grade waste fuels and various industrial/process wastes assumes great importance in the present scenario with increase in global prices for oil and coal due to increasing demand and limited supplies. Firing of low-grade waste fuels/process wastes gives double benefit, firstly the available energy is recovered efficiently and secondly the waste material is disposed off in environmental friendly manner. In both of these cases the energy which was otherwise going to waste is recovered and put to proper use and conserves the main source of energy which would have been otherwise used.

This paper discusses on technologies, operating experience boilers for firing various waste fuels for effective and economical generation of power/steam.

INTRODUCTION

Manufacturing and processing industries generate many types of solid, semisolid and liquid wastes (paper sludge, packing waste, palm shell/ kernel, DOB, spent grain, etc.) Frequently these wastes contain considerable amount of combustible mater, which can be burned to recover the heat for use. Similarly various types of fuels are used in industries and part of the fuel is rejected in the process (e.g. washery rejects, char fines, coke fines, run off mines, off gases, refinery waste oils, etc.), which are not suitable for that process. These fuels can be put to use with better technologies and the heat can be recovered for use.

Thermax Limited has wide experience in firing the various fuels employing different firing technologies. Thermax is offering unique hopper bottom AFBC boiler technology and internal circulating CFB boiler technology for heat recovery from these wastes.

Waste charecteristics related to use as fuel in boiler

Hetrogenous nature of the waste and variation in the properties is the major consideration for using these material as fuel for boiler. The following are the concern areas,

- Higher moisture,
- Low heat content
- High inert content
- Presence of Potassium and sodium in fuel
- Presenceof corrosive elements like Cl, S etc.
- High variation in the fuel properties
- Irregular and difficult sizing of the fuel
- Materials not easy to convey /feed
- Emission of pollutants after burning

  Fouling nature

Many of the wastes and waste fuels contain Potassium and Sodium. When they are to be used as fuel in the boilers for steam generation, the main characteristic of the ash contents high amount of alkalies mainly potassium and sodium oxides. These alkalies causes agglomoration and sintering of ash and leads to clinker formation when fired on grates where combustion temperatues exceeds more than 1000°C.

In the Fluidised bed combustion, the bed temperaures are maintained in the range of 700°C to 850°C The low temperature operation greately helps in minimising the agglomeration process (below ash fusion temperature of ash).

Further with controlled draining of bed material & make up with suitable bed material, ensure the alkali concentration in the bed at a lower level & thus reduces agglomeration & Fouling characteristics of ash.

HOPPER BOTTOM AFBC TECHNOLOGY

Hopper bottom AFBC is unique design developed by Babcock & Wilcox USA that can handle difficult, agglomerating, high ash low GCV fuels (high fouling biomass, paper sludge, lignite, char, washery rejects, etc.). This design has open hopper at bottom of the combustor instead of bedplate, with wide pitched air nozzles. Open hopper allows uniform draining of agglomerate / clinkers. This design has ease on multiple fuel firing through over bed and under-bed feeding.

Research and Development
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There are may units in operation firng various fuels as listed below supplied by babcock & Wilcox USA and Thermax in India and south east Asia.

- Paper Mill Sludge,
- Bark,
- Sewage Sludge
- Used packaging and waste plastic
- Industrial and domestic wastes
- Coffee waste
- Spent grain
- Washery rejects
- Char
- Agricultural and forest wastes, etc.

Design feature Hopper bottom AFBC Technology

The schematic of this design is shown in Figure-1, In the fluidised bed combustor airflows upwards in the suspended stream of bed material (mixure of fuel ash + crushed refractory) at a velocity of approx. 2 meter per second, ensures emense mixing of fuel and air. The uniform temperature distribution in the bed and agitating characteristic of fluid bed ensures optimum combustion.

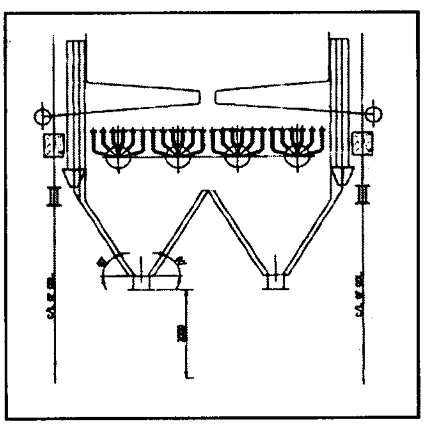


Figure 1 : Schematic view of Open Hopper Bottom Fluid Bed

In the conventional fluid bed boiler with distributor plate, the air nozzles are fixed on a carbon steel plate parting the plenum chamber and the combustor. In the Open Hopper Bottom design, bubble caps are fixed on large diameter pipes. This arrangement allows particles to settle down in the hoppers which can be removed from the bottom drain. A table shows the advantages of Open Hopper Bottom design over conventional Distributor plate Fluid bed for partucular application of Biomass firing.

Comparision of Open Hopper Bottom design with regular bed plate design

Comparison is given in Table-1 and the arrangement of both is as shown in Figure-2

Table -1 : Design Comparison

Sr. Open Hopper Bottom AFBC	Distributor plate AFBC
1. Large particles / stone which comes along with fuel due to large volume handling can settle into the hopper	Large particle / stones remains on the bed plate and tend to defluidise
2. Continuous slow draining of bed ash possible hence alkali concentration can be maintained at minimum level.	Draining cycle is intermittent-high quantity bed ash drain is required to mainatin low concentration of alkai
3. The ash retention time in hopper is high resulting into cooling of ash hence no separate ash cooler is required.	Separate ash cooler due to sudden draining of bed.
4. Gives better advantage of slupming of bed . Due to continuous slow draining possible, accumulation of fuel over the slump bed is avoided.	Intermittent fluidisation is required during ash draining.

Operating experience:

There are many installation of hopper bottom design to name few are

- JOCL,
- SARO Power
- Nestle
- Bhushan

Figure below shows general arrangement for biomass waste fired Open Hopper Bottom BFB Boilers.

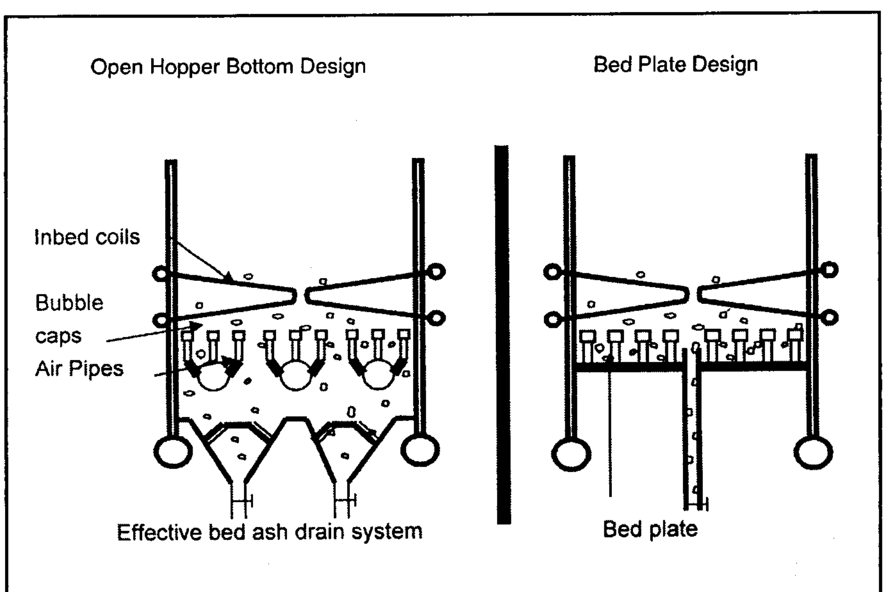


Figure- 2: Schematics of both designs

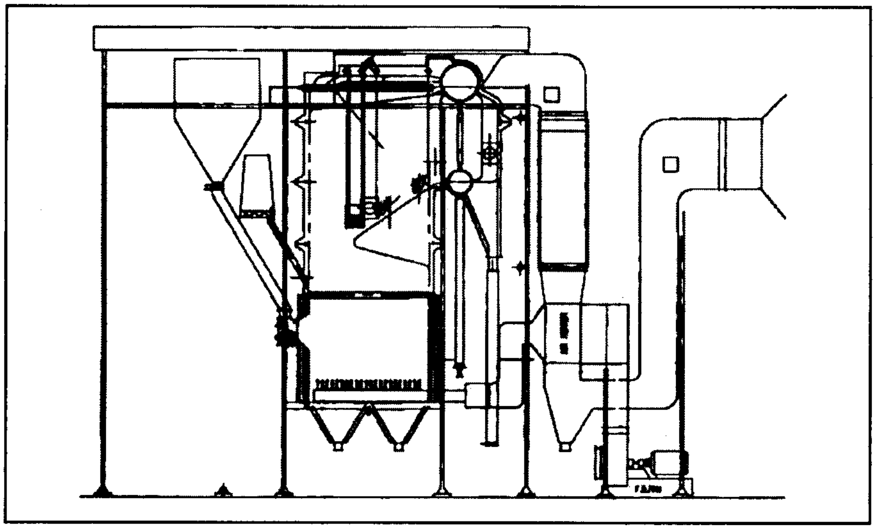


Figure- 3: General Arrangement of Open hopper bottom AFBC Boiler

THE INTERNAL CIRCULATING BOILER DESIGN (IR-CFBC)

This is another technology for efficient burning of low grade fuels for achieving high combustion efficiency and low pollution. It has wider fuel firing range,

Volatile matter	-	4 - 40%
Ash	-	0 - 60%
Heating value	-	> 1500 Kcal/kg (2700 BTU/lb)
Moisture	-	< 55%

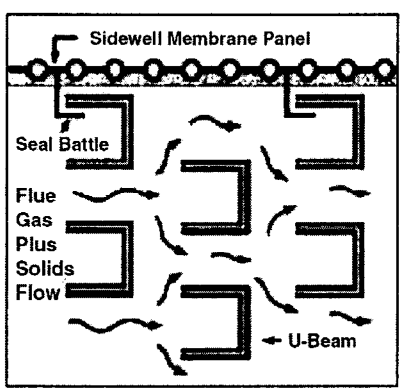
Two-Stage Particle Separation for Superior Combustion Efficiency

Babcock & Wilcox's unique IR-CFB boiler design employs a patented two-stage particle separation system to provide high-solids loading and a uniform furnace temperature profile (U.S. Patent Number 5,363,812, issued Nov. 15, 1994). The benefits of this technological break-through include superior combustion efficiency, low emissions and improved overall plant performance.

Our two-stage system includes a primary U-beam impact separator and a secondary ESP dust collector (Ist field) which work together to provide combined particle collection efficiency in excess of 99.8 percent. The U-beams, a staggered array of stainless-steel channels at the furnace exit plane, (refer to figure-4) capture nearly all of the solids suspended in the flue gas leaving the furnace and internally re-circulate these solids to the lower furnace. ECO/APH hopper and ESP Ist field captures the finer material that passes through the U-beam particle separator and returns this material to the lower furnace in a controlled manner through recycle ash hopper. Being able to regulate the secondary recycle system provides the operator with unprecedented control over furnace temperature, resulting in improved boiler performance and load response.

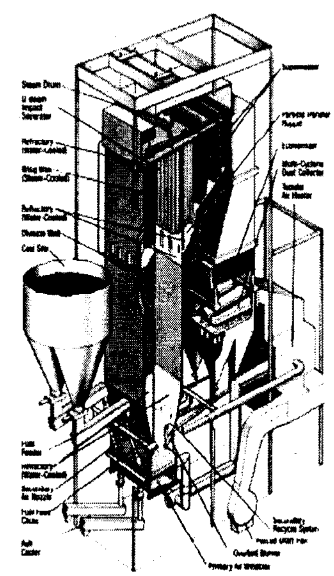
Compact, Economical Design

B&W's two-stage particle separation system results in a compact, simplified boiler arrangement. The entire U-beam particle separator is tucked into cavity at the furnace exit. Compared to cyclone CFB designs, the IR-CFB requires significantly less building volume and by relying on internal re-circulation, the IR-CFB design eliminates J-valves, loop seals and high-pressure blowers which are required with other CFB designs. With the IR-CFB, compact and simple means economical.



Plan view of the U-beam impact separator.

Plan view the U-beam impact separator
Fig. 4 : U-beam Particle Separator



IR-CFB technology offers

- ***High combustion efficiency***
- ***Compact, economical design***
- ***Higher reliability & availability***
- ***Lower maintenance costs***
- ***Reduced erosion***
- ***Fuel flexibility***
- ***Low emissions***

Figure-5 : IR CFB general arrangement

Higher Availability, Lower Maintenance

For the last 50 years, one goal of boiler manufacturers has been to eliminate thick, uncooled refractory and hot expansion joints from their designs, in order to reduce the expense and lost time associated with refractory maintenance. B&W's engineers were the first in the CFB industry to achieve this goal through the development of the IR-CFB boiler. The furnace, U-beam separator and super- heater enclosures

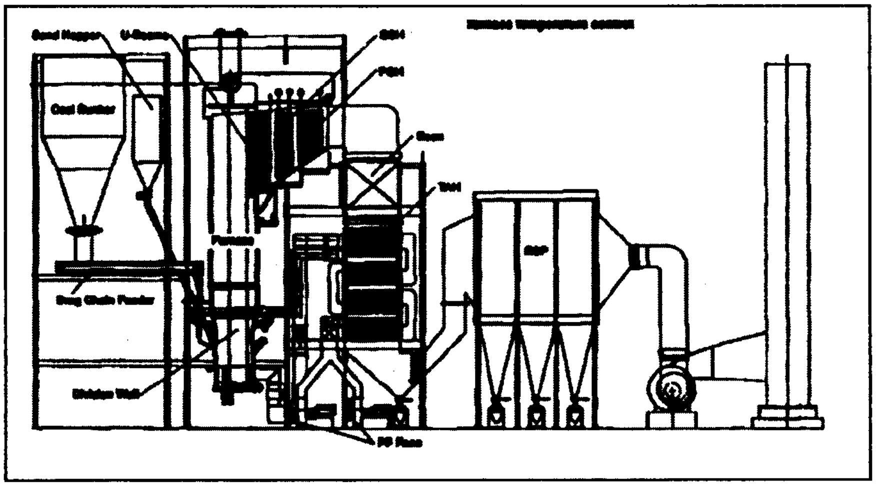


Figure 6 : KCIL IR-CFB

are constructed entirely of top-support, gas-tight, all-welded membrane tube walls which do not require hot expansion joints. The small amount of refractory that is used in the IR-CFB is applied to selected areas of the water-cooled enclosure surface in a thin layer which is only 16-25 mm thick in the lower furnace (refer figure-4) and never more than 76 mm thick elsewhere. As a result, B&W's IR-CFB requires less than one-fourth of the total refractory found in a hot cyclone CFB design and less than one-half of the refractory used in a water-cooled or steam- cooled cyclone CFB unit. This construction has significantly reduced the need for refractory maintenance in B&W's operating CFB units

CFBC boiler experience

There are many units in operation supplied by B&W and Thermax. TBW commissioned first IR-CFB in 1997 at Kanoria chemicals Ltd. (Renukoot, UP, INDIA). This boiler is designed to fire high ash low sulfur coal to generate 105 TPH steam at 66Kg/cm2 and, 485 deg.cel.

Secondary ash is recycled from APH/ ESP hoppers to furnace. It has two fuel feed points on front wall and four secondary solids re-injection points on rear wall in the primary zone. Boiler has two furnace bed drains and two fluid bed bottom ash coolers. Sand feed system is provided to make-up (for emergency use only) and start-up inventory in the furnace. Boiler has two 15.12 Mkcal/hr over-bed burners (oil-fired) located at the boiler rear wall, for start-up on coal.

The bubble caps for primary air distribution are installed between the boiler tubes that form the bottom of the furnace. The balance of combustion air is admitted as over fire air through nozzles at two levels in the front and rear walls of the furnace for staged combustion. The primary and secondary air is supplied by separate fans. KCIL boiler is balance draft with an ID fan installed.

Boiler has vertical pendant type superheater banks located within the water- cooled, gas-tight membrane enclosure. A horizontal economizer is located downstream of the superheater. Underneath the economizer, is a three-pass tubular air heater with flue gas outside the tubes. An electrostatic precipitator for is installed for final particulate control. Boiler is equipped with a DCS system to monitor and operate the unit.

CONCLUSION

Open hopper bottom AFBC and the internal circulating CFB are well-demonstrated technologies and are implemented for firing various low grate fuels, wastes etc. in economical manner. These technologies can burn the waste to generate steam or power, saving the consumption of captive power from grid.

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