Bubbling Fluidized-Bed Technology Serves Combustion Need for Biomass

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Comparable to circulating fluidized-bed technology, BFB boilers are a good choice for mills burning wood waste, bark or sludge

Since the late 1990s there has been ever increasing interest in bubbling fluidized-bed (BFB) combustion. Some confusion remains between circulating fluidized-bed (CFB) combustion and the BFB process. BFB is the overwhelming combustion choice for wood waste, bark, and sludge.

The two fluidized-bed technologies are similar. Both use a bed of inert material (most typically sand) that is fluidized by high-pressure combustion air. The primary differences are that the BFB unit normally operates in a reducing atmosphere (less air than is needed for combustion), does not have as great an ability to absorb sulfur dioxide, and normally is used to burn lower-quality fuels with high volatile matter. Further, the BFB unit keeps most of the sand in the lower furnace.

Circulating beds fire fuels with high fixed carbon and circulate the hot gases, along with a high-density sand stream, through the entire furnace. By adding materials high in calcium (such as limestone), the CFB will efficiently absorb sulfur dioxide, reducing overall emissions.

If coal is the desired fuel, BFB technology is not the first choice, and a mill should consider CFB technology. If biomass and other high volatile/lower carbon-containing fuels (such as tire derived fuel or TDF) are used, then BFB technology should be considered as the preferred combustion process.

Environmental Advantages

The BFB is very well suited for burning renewable biomass (green power) at much higher moisture contents and even finer fuel sizing than is typically possible using stoker combustion. NOx emissions are lower than are possible using stoker combustion without any post-combustion control, such as selective non-catalytic reaction (SNCR). The reduced emission is due to a significantly lower primary combustion zone stoichiometry. Table 1 shows emission predictions of a typical southern U.S. wood waste-fired BFB boiler.

If the boiler is regulated to a lower NOx emission level than is possible through staging combustion, then a post-combustion NOx reduction process must be added. This can take the form of SNCR or a selective catalytic reduction (SCR) system. SNCR injects ammonia into the furnace where it reacts with NOx to form harmless nitrogen (N_2) and water vapor.

SCR is located after the final particulate matter control device. Ammonia is sprayed upstream of the catalyst for a similar reaction and NOx reduction. SCR technology can reduce NOx to a greater degree than SNCR, but the flue gases must be reheated using a duct-style burner before the proper reaction will occur. SNCR is also less efficient in reducing NOx.

NOx reduction from an SNCR is in the 50% to 55% range, while an SCR can reduce NOx up to 90%. The issue with the SNCR is finding the proper temperature window in the furnace or convection pass, mixing the reagent with the flue gases to ensure the reagent finds NOx compounds to react with and reduce the NOx level. This is not the case with SCR technology. Based on experience in utility applications, Babcock & Wilcox is adding SCR catalyst systems following the final paniculate removal device {electrostatic precipitator, baghouse, etc.) in industrial applications.

Some states have passed legislation to designate BFB as the best-available control technology (BACT), and it is now required in these states for biomass firing to be considered renewable or green power.

Candidates for BFB Retrofits

Can any boiler be converted to bubbling fluidized-bed combustion? Mills that want to change their method of firing solid fuels ask this question regularly. There are many existing power boilers operating in which mills want to increase capacity, reduce emissions, and/or eliminate dependence upon higher-priced fossil fuels (oil, natural gas, or coal).

However, not all power boilers are good candidates for BFB conversion. The best candidates are existing wood-fired stoker boilers, combination wood and fossil fuel boilers, and chemical recovery boilers.

Normally, the boilers originally designed solely for gas or liquid fuel firing are not good candidates. Likewise, pulverized coal (PC) fired boilers are not good candidates without major modification to the convection passes. These boilers are normally designed for high flue gas velocities. PC fired boilers can be modified more easily than gas and oil-fired boilers because they normally require less modification to the convection pass to reduce velocity to a desired level.

How BFB Combustion Works

Similar to stoker-fired boilers, the bark or other solid fuel is introduced into the BFB furnace through air distributive-type feeder spouts (Figure 1). The fuel drops into the bubbling fluidized bed where it is combusted.

The bed typically operates in a reducing atmosphere of 30% to 40% of theoretical air. This reduces the bed (combustion) temperature, which results in a reduction in nitrogen oxides (NOx). This is a major advantage of the BFB over stoker firing. Bed temperature control is imperative to prevent bed agglomeration, good NOx control, and fluidization. Thermocouples located in the lower furnace help the operator control bed temperature by identifying where rocks may have accumulated or identifying changes in fuel characteristics that require more or less combustion air or flue gas recirculation.

The fluidized-bed material is composed of specially sized silica sand or a specially sized fired refractory. High-pressure fluidizing air is introduced to the bed through a system of closely spaced bubble caps (see photo). The air exiting the bubble caps is at high pressure (up to 60 in. water column) and actually changes the characteristics of the bed media from a static condition to a violent fluidized condition. This can be visualized as a pot of boiling water.

Bed fluidization permits the fuel particles to be in continuous contact with the bed media in order to burn the particles to completion. The resultant ash becomes fly ash and is caught in the baghouse, precipitator, or scrubber. Mechanical dust collectors, sand classifiers, and ash reinjection, common with stoker-fired boilers, are not used with BFB units.

The BFB fuel can be fired at moisture contents as high as 62% without supplemental fossil fuel firing, assuming reasonable fuel heating value. This is another advantage of BFB versus stoker firing.

Once the furnace gases reach the overfire air zone, there is no real difference between BFB and stoker technologies. Either technology can be thought of as a burner; both are primary combustion methods.

Other Considerations for BFB

In addition to fuel flexibility, moisture content, and reduced NOx emissions, the mill should consider BFB combustion for reduced overall maintenance. The maintenance of the upper furnace and convection pass is not different between a well-run and tuned stoker and a properly designed BFB.

The primary maintenance difference is avoiding the rebuild of the stoker equipment. Stoker maintenance can be a considerable expense. After many years of experience firing biomass and other fuels in a B&W BFB, there has been no reported BFB maintenance beyond some refractory repair on the lower furnace walls. The bubble caps have not experienced any problems that require replacement. The lower furnace pressure parts are protected from erosion by refractoiy. The convection pass of the boiler is engineered for low flue gas velocity, and no sand or ash erosion has been noted. Therefore, maintenance is significantly reduced in a BFB compared with a stoker-fired boiler.

The BFB should have an "open bottom" arrangement. This means that there is room between the bubble caps and fluidizing air header pipes for rocks and debris that enter with the fuel to be removed through the sand hoppers. In the BSiW design, the bed media is contained in hoppers below the fluidizing air zone. Once the bed media gets below the bubble cap elevation, the bed material is no longer in the combustion zone, and it begins to cool. With large hoppers, there is enough residence time for the bed media and debris to cool to the point that the hoppers do not require insulation or lagging, and normal conveyers can be used to transport the media to a screening and recycle system for reuse. Some operating BFB's have water-cooled screw conveyors, but these increase maintenance costs.

The BFB can be a small bottom-supported unit similar to the one shown in Figure 2. These bottom-supported units can be sized for 250,000 to 300,000 pph steam or smaller. The advantages include reduced building steel and building size. The BFB can also be a larger top-supported unit (Figure 1) for greater steam flow requirements or retrofits of existing top-supported units.

Recovery boilers that are retrofit with BFB technology burning biomass may experience large steam flow increases due to the furnace volume and good convection pass velocity. Some mills with multiple recovery boilers have elected to convert one of the recovery boilers to biomass using BFB technology.

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