TIP SHEET

- A firetube boiler provides comfort heating and process heating where higher temperatures and pressures are required
- A firetube boiler can burn an array of fuels, including natural gas, propane, light and heavy oil and bio-fuels
- A properly designed firetube boiler averages between 81 and 87% efficiency

Firetube Boiler Design and Engineering Part 1

The firetube boiler has been around for more than a century, powering the steamboats and steam locomotives that played a major role in the industrialization of America. Today, a broad range of industries count on the firetube boiler to provide comfort heating and process heating where higher temperatures and pressures are required.

A firetube boiler is called such because the flame and hot gases are inside the furnace and tubes, which are surrounded by water. This is the reverse of a watertube boiler design, in which water circulates inside the tubes that are heated externally by the flame.

There are different types of firetube boiler designs, including dryback and wetback with an integral or gun burner.

A dryback firetube boiler includes a refractory-filled rear door that can be opened to expose the entire rear tube sheet and affixed tubes. A dryback boiler with integral burner enables an operator to swing open the front door to easily gain access to the front tube sheet.

A wetback firetube boiler has a water-leg located between the turnaround plate and the rear tube sheet. This design element eliminates the heavy refractory rear door found in the dryback boiler and replaces it with a much smaller refractory-filled plug or access way.

With regard to the benefits of each design, the dryback firetube boiler has the distinct advantage of providing easy accessibility to the rear tube sheet for inspections, cleanings and tube/furnace repair. It reveals all passes in a boiler, including the second pass, which is the most critical in all types of firetube boilers. In a wetback boiler, access to the second pass is very confined, which is challenging during inspections and repairs, especially in smaller-horsepower models.

The main advantage of the wetback boiler is the elimination of the heavy rear refractory-filled door. This door is sometimes cumbersome to open and reseal, and it can be an ongoing inspection and possible maintenance issue as well.

The size range for horizontal firetube boilers is broad, between 100 to 2,500 BHP, which equates to between 3,450 and 86,250 lb/hr of steam per hour. At the top end of the range, firetube boilers can compete with smaller industrial watertube boilers. The design pressure for firetube boilers can go as high as 350 psig, but typically these boilers are in the 150 to 250 psig range.

In sizes exceeding 800 to 900 BHP, the wetback design is used because at this size, the refractory rear door on a dryback boiler is too big and heavy to maneuver.

Firetube boilers can have either an integral burner or a gun-type burner. An integral burner is a complete unit that includes a pressurized wind box, blower/fan assembly and burner assembly, all integrated together and mounted on the front of the pressure vessel.

The gun burner uses a different concept for air delivery. Rather than using a pressurized wind box and discharge fan as is the case with the integral burner, the gun burner draws the room air in and delivers it to a blast tube before the air is straightened and discharged across the fuel/air mixing device (called the diffuser).

As far as firing modulation for firetube boilers, smaller sizes (100 – 150 BHP) offer hi-lo-off firing in addition to full modulation. For boilers greater than 150 BHP, a modulating burner is standard. The two burner types vary in the degree of turndown capability. Four-to-one (4:1) is common, but 10:1 can be achieved too, especially in the larger sizes (over 200 BHP) when an application requires it. In facilities where large loads can vary, this broader modulating control is necessary to avoid excessive cycling.

With regard to fuel firing, the firetube boiler is quite versatile. It can handle an array of fuels, including natural gas, propane, light and heavy oil and bio-fuels such as landfill and digester gas, fats, oils and greases coming off the various processes.

Depending on the boiler capacity, fuel, firing rate and operating pressure/temperature, firetube boilers are very efficient. Properly designed firetube boilers average between 81 and 87% efficiency. Note that if FGR is used to reduce NOx emissions to below 20 ppm, this will likely impact the turndown of the burner, which may increase cycling. Frequent cycling can reduce efficiency by a significant amount.

All boilers are built in accordance with specific ASME standards. This code is very detailed as to how boilers are constructed. It includes parameters about boiler plate thicknesses, the type of welding to be applied, when stress relieving is necessary, when and what to X-ray, hydrostatic testing, etc. It also requires an independent inspector to be in the plant at all times to oversee specific boiler construction operations and ensure that the plant's quality procedures remain intact.

Next month's Tip Sheet will explain heat transfer and detail the engineering advances that are helping to optimize the firetube boiler to increase its efficiency and reduce its footprint.

To learn more about firetube boilers, watch the Firetube Boiler Design, Construction and Engineering webinar. To find an authorized Cleaver-Brooks service representative near you, visit cleaverbrooks.com.